FLUKE®
Reliability

Root Cause Analysis

What is the most effective method?

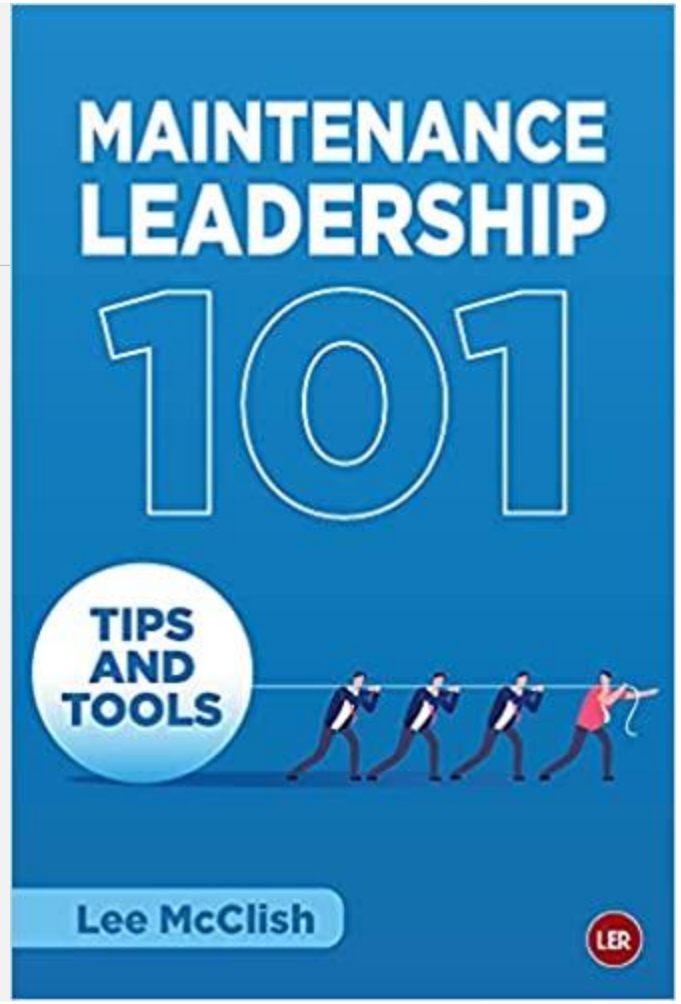
Best Practices Webinar Series

Meet the Speaker

Lee McClish

Director, Maintenance and Reliability

- Previous positions held with BASF, Graphic Packaging and Packaging Corporation of America as a Reliability or Maintenance Engineer and RCM or Production Manager.
- Served 30 years in the US Navy as a Submarine Officer.
- Holds a BSME, MBA, CMRP, CRL, CPMM.
- Author of the book “Maintenance Leadership 101” published through Reliability Web. Available on Amazon.



POLL QUESTION No. 1

How many companies have an RCA program?

(Click only one answer)

- Yes
- No

POLL QUESTION No. 2

How many RCAs are performed annually at your site/plant?

(Click only one answer)

- > 100
- 50 – 100
- 10 – 49
- 1 – 9
- 0

AGENDA

- Definitions
- Benefits
- Triggers
- Process
- Methods
- Examples

DEFINITION

Failure Analysis

Determining the physical root cause, typically at the component level, effecting the repair (changing the part) and stopping.

DEFINITION

Root Cause Failure Analysis

Comprehensive analysis down to all possible root causes; physical, human and latent, but focuses on the mechanical or electrical aspect of the incident.

DEFINITION

Root Cause Analysis

Full-blown analysis that identifies the physical, human and latent root causes. Removes the word “Failure” to reinforce the broadened definition of including safety incidents, quality defects, customer complaints and other similar events or processes.

POLL QUESTION No. 3

Do the RCAs provide value?

(Click only one answer)

- The results add a lot of value that improves our processes.
- The results are mixed depending upon who is responsible.
- We would like to experience the value, but very few are conducted.
- They seem to be more of an exercise with no value added.
- Our company doesn’t perform any.

BENEFITS

- Improve the safety and environment
- Greater equipment availability
- Improved material specifications, inspections, and procedures
- Avoidance of repeat failures
- Cost reduction

BENEFITS

- Development of reliability norms
- Establishment of training requirements
- Education of the team

PROGRAM GOALS

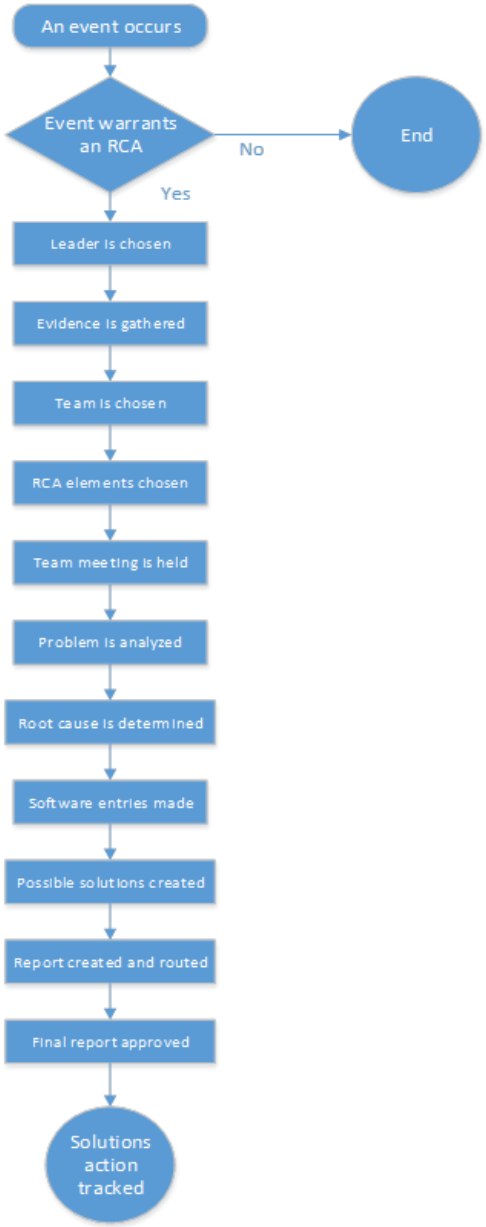
- Include all departments
- Add to HR goals
- What database to track
- How track value
- Format to inform customers

PROGRAM SETUP

- How owns the process
- Written policy/procedure
- Choose software
- Training investment

PROCESS FLOWCHART

Recommend this visual !



SOFTWARE EVALUATION

Company	Training details	Software	Software cost	RACI	Problem statement	Risk matrix	Time line	Causal factors	Root causes	Summary table	Ranking table	Recomm-endations	Tracking tool
ARMS Reliability	2 or 3 day course $1695. 7-8 people $11-12K	Apollo	Enterprise $19K for 3 seats Client hosted -		X		X	X	X	X	X	X	
Relibility Center	3 day course. $1645 10 students $15K	ProAct	Enterprise $27K for 5 seats Web based $15K		X	X		X	X	X		X	X
Sologic	2 day course. $1295	Causelink	Enterprise $18K for 3 seats Client hosted - $27.5K		X		X	X	X	X		X	
Tap Root	2 day course. $1295. 5 day advanced	Tap Root VI											
Kepner-Tregoe	2 day course. 20 students $13.5K	KT Cockpit			X		X	X	X	X			
Think Reliability	3 day course. $1695	Excel	Free with course		X		X	X	X	X			X
ABS Group	3 day course. $1395.	Excel	Free with course					X					
TONEX	3 day course. $3000. 10 students $25K	Excel tools	Free with course										
LCE	3 day course. $1895	A3 tool	N/A										
Quality One	2 day course. $1295	None	N/A										
SIX Sigma	3 day course. $1599	None	N/A										
ASQ	3 day course. $1599	None	N/A										
Process Imp	1 day course. $1250	None	N/A										

PROGRAM ESTABLISHMENT

1. Develop non-conformance cause codes – Fishbone input.
2. Document Facilitator expectations.
3. Document Team Member expectations.
4. Develop a guide for the software.
5. Create a RACI for the process.
6. Include a risk matrix in the procedure.
7. Include in solutions table the impact and effort ratings.

TEAM MEMBER EXPECTATIONS

1. Be on time.
2. Follow the agenda and leader guidance.
3. Listen to other participant’s ideas.
4. One person speaks at a time.
5. Separate facts from opinions.
6. Take on and deliver commitment.
7. Contribute!

NON-CONFORMANCE CODES

Machine, management, people, material, environment, method

Measurement	Inspection tool inadequate (e.g. insufficient accuracy)
	Uncalibrated inspection tool used
	Calibration error
	Instruments, displays, or controls were inadequate
	Transcription error while recording result
	Verification method (i.e. inspection, sampling) was inadequate
	Inspection criteria was inappropriate or unclear

RACI

Title	Originator of Incident	Department Manager	Reliability Engineer	Facilitator	Data Collector	Time Keeper	Computer Entry
Name							
Identify and quantify the problem	R/A						
Resources to solve the problem		R/A					
Execute the RCA process		I	I	R/A			
Data collection				A	R		
Time Keeper				A		R	
Computer entry				A			R

R = Responsible, A = Accountable, C = Consulted, I = Informed

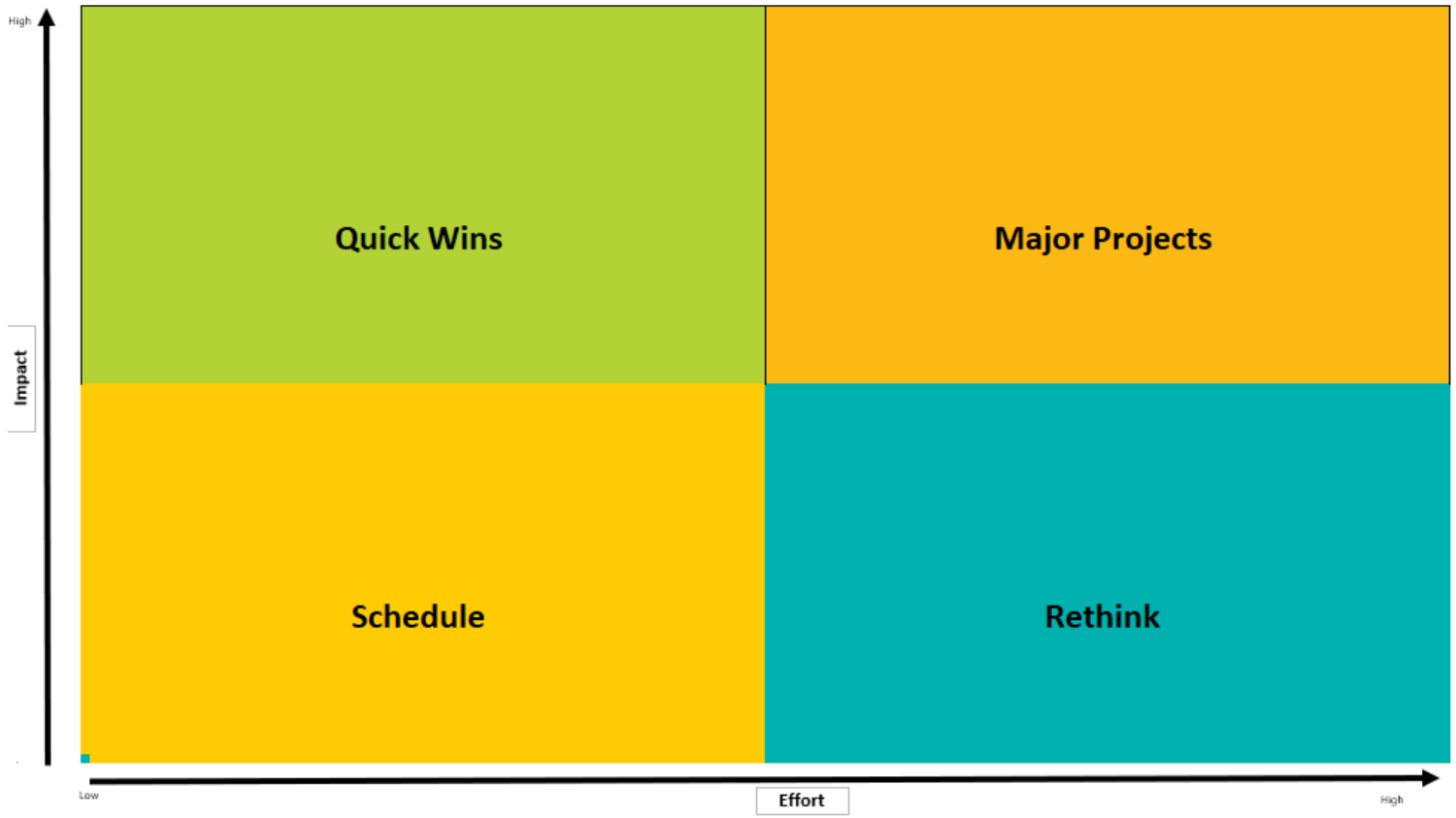
RISK ASSESSMENT TABLE

CONSEQUENCE	LIKELIHOOD 1	2	3	4	5
5	MEDIUM	HIGH	CRITICAL	CRITICAL	CRITICAL
4	LOW	MEDIUM	HIGH	CRITICAL	CRITICAL
3	LOW	LOW	MEDIUM	HIGH	CRITICAL
2	VERY LOW	LOW	LOW	MEDIUM	HIGH
1	VERY LOW	VERY LOW	LOW	LOW	MEDIUM

POTENTIAL SOLUTIONS TABLE

	SOLUTION	IMPACT (1-5)	EFFORT (1-5)	PRODUCT
1				
2				
3				
4				
5				

IMPACT AND EFFORT MATRIX



TRIGGERS

- Injury of any kind
- Exceed a permit
- Fire occurs
- Failure of critical equipment

TRIGGERS

- Impact on customer
- One-time cost > $15K
- Chronic failures

INITIALLY

- RCA is triggered
- RCA leader assigned
- Disciplined data collection Team is identified
- RCA elements chosen

PROCESS ELEMENTS

- Team meeting
- Confirm real problem
- ID of cause and effect relationships
- ID of latent root causes

PROCESS ELEMENTS

- Develop corrective action
- Consider countermeasures
- Database entry
- Effective communication
- Final report

SUCCESS FACTORS

- Proper participants
- Prompt first kick-off meeting
- Complete in < 1 month

SUCCESS FACTORS

- Management approval
- Assign/track action items
- Reasonable due dates based on priority
- Update RCA database

PROCEDURE

Not every failure requires an RCA. The cause(s) of some failures can be obvious. Likewise, the appropriate solution may also be obvious. While a root cause may seem obvious on the surface, there could be other contributing causes that may not be so obvious. Not uncovering those causes could lead to a less than effective solution and a repeat of the failure.

PROCEDURE

Root causes attributes:

- Have specific underlying causes.
- They can be reasonably identified.
- Solutions are feasible.
- Effective recommendations for preventing reoccurrences can be generated.
- Often there is more than one root cause.

PROCEDURE

Typical reasons RCAs fail:

- Inexperienced or ineffective facilitator.
- Reliance on assumptions about the likely root cause.
- Not allowing the facts to speak for themselves.
- No visibility into biggest problem areas. Wrong issues prioritized.
- Relevant experts not involved or available.
- Rushing to judgement.

PROCEDURE

Typical reasons RCAs fail:

- Poor team composition. Lack of communication.
- Lack of resources and management support.
- Action items lack accountability and often go undone.
- Location of applicable files unknown and get lost.
- Reinvent the wheel – problem was solved at another location.
- No method to track and share success.

PROCEDURE

When should a Failure Analysis be performed?

- A component failure
- An isolated incident
- High confidence the repair will solve the problem with little chance of reoccurrence.
- The cause is obvious.

PROCEDURE

Questions to ask. Consider performing a RCFA if any “Yes”:

- Is this a chronic failure/problem?
- Is a change to any internal procedures necessary?
- Is a change to our maintenance practices necessary?
- Is a change to our training program needed?
- Will visual management help prevent reoccurrence?

PROCEDURE

When should an RCA be performed?

- Trigger per RCA policy.
- Manager determines one is needed.
- Indicated on incident report as required Corrective Action.
- Chronic failure of a component or piece of equipment.
- Potential impact to a client.
- The failure is hidden to a technician.

PROCEDURE

Determination made how involved the RCA should be:

- Failure analysis is adequate. Documentation will be contained within the work order.

- If the cause is mechanical or electrical, and requires an RCFA, then the appropriate sections needing completed in the procedure should be determined at the onset of the RCA.

PROCEDURE

- Incident has contributing causes, such as: safety, environmental, quality defects, customer impact/complaints and chronic problems.

- A part could be sent out for a vendor evaluation – could be done for any level of RCA. Report should be attached to the RCA case.

- Software should be used for a RCFA or RCA. All failures requiring more than restoration action should be assigned a RCA number and entered into the RCA database.

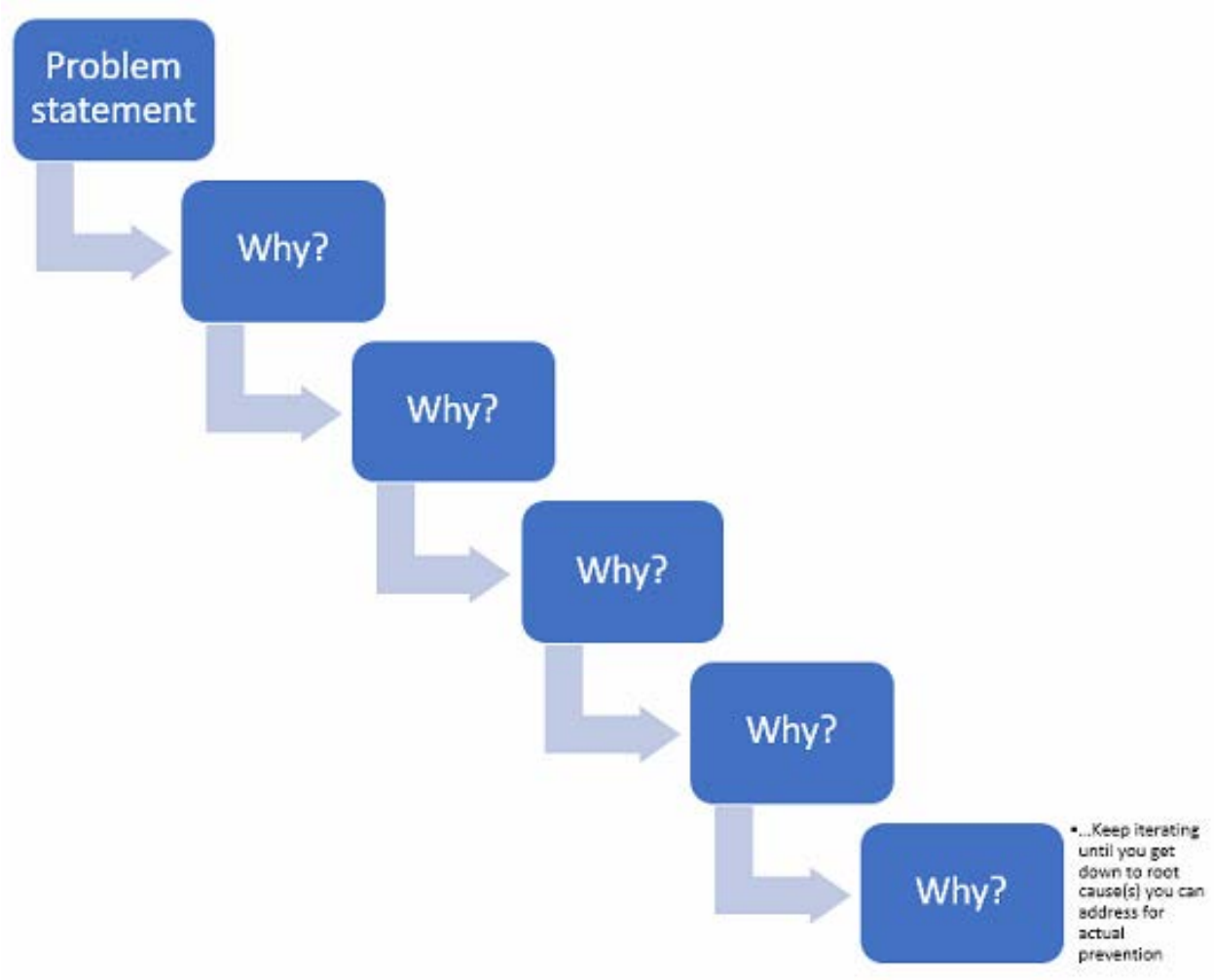
METHODS

1. Choose based on complexity of event

2. Proper software available

3. Adequate team training

METHODS - 5 WHYs



METHODS – 5 WHYs

1. Every problem has a cause behind it. A superficial analysis will only depict symptoms.
2. A persistent inquiry is required to find the real cause (the root cause) behind the issue so that lasting solutions can be determined and the problem doesn't resurface.
3. Symptoms of an actual issue that will resurface again if not properly identified.

BENEFITS – 5 WHYs

1. Help identify the root cause of a problem.
2. Determine the relationship between different root causes of a problem.
3. One of the simplest tools; easy to complete without statistical analysis.
4. Useful when problems involve human factors or interactions.
5. Useful in day-to-day business life

PROCESS – 5 WHYs

1. Why has the conveyor belt stopped?
   The main pulley rotating the belt is not rotating

2. Why is the main pulley not rotating?
   Because it’s not getting enough power from the motor

3. Why is it not getting enough power from the motor?
   Because the motor has stopped working

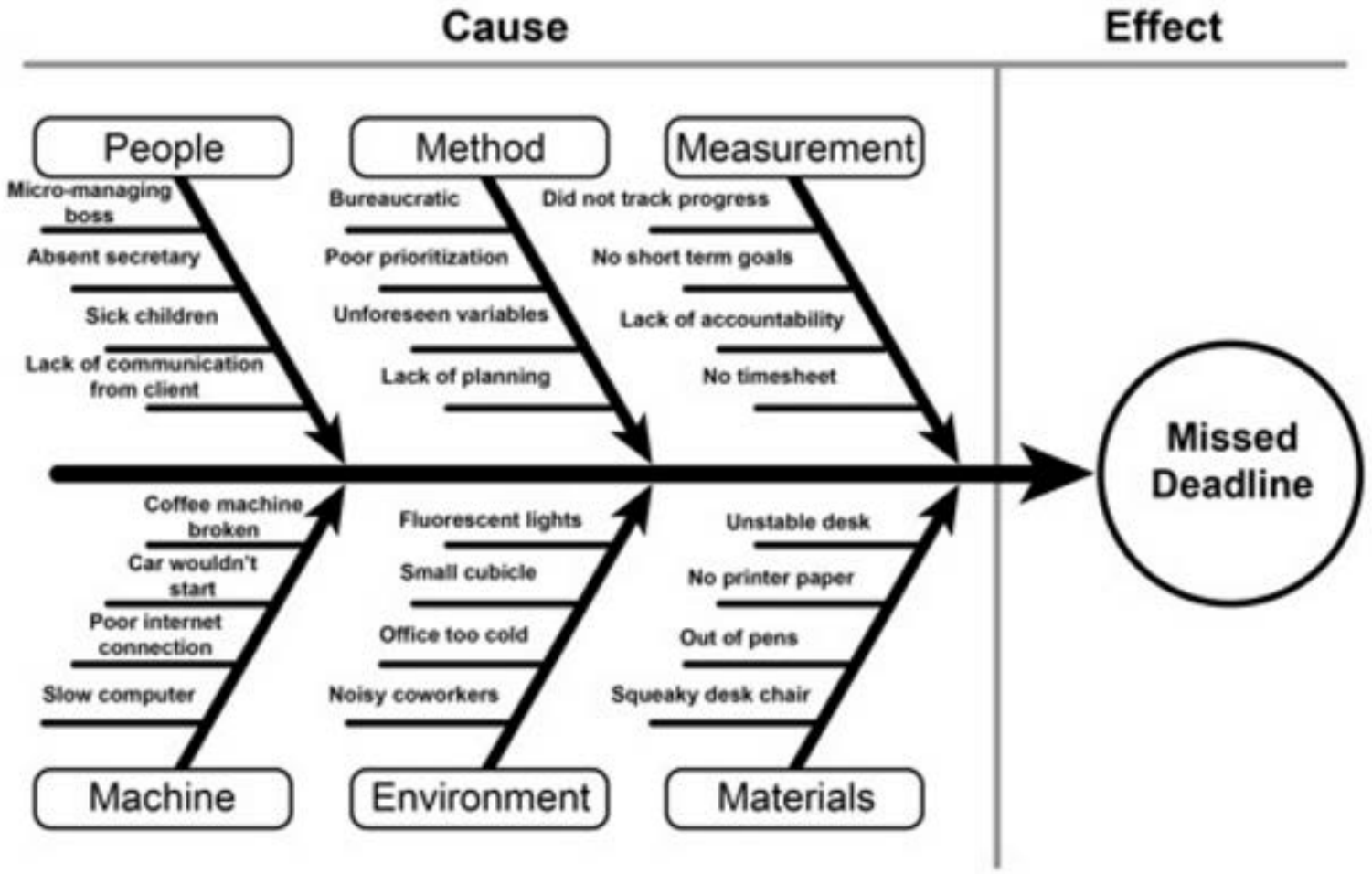
PROCESS – 5 WHYs

4. Why has the motor stopped working?
   The windings of the motor had burned out

5. Why have the windings burned out?
   The motor was loaded beyond its power capacity

6. Why was the motor overloaded?
   Although there were specifications about the permitted load, there were no instructions about the max load weight.

METHODS - FISHBONE



METHODS - FISHBONE

1. A fishbone diagram is a visual way to look at cause and effect and a great method for gathering data.

2. It is a more structured approach than some other tools available for brainstorming causes of a problem.

3. The problem or effect is displayed at the head or mouth of the fish. Possible contributing causes are listed on the smaller “bones” under various cause categories.

BENEFITS - FISHBONE

A fishbone diagram can be helpful in identifying possible causes for a problem that might not otherwise be considered, by directing the team to look at the categories and think of alternative causes. Include team members who have personal knowledge of the processes and systems involved in the problem or event to be investigated.

PROCESS - FISHBONE

1. Agree on the problem statement (the effect). Be as clear and specific as you can about the problem.

2. Agree on the major categories of causes of the problem; often include: equipment or supply factors, environmental factors, rules/policy/ procedure factors, and people/staff factors.

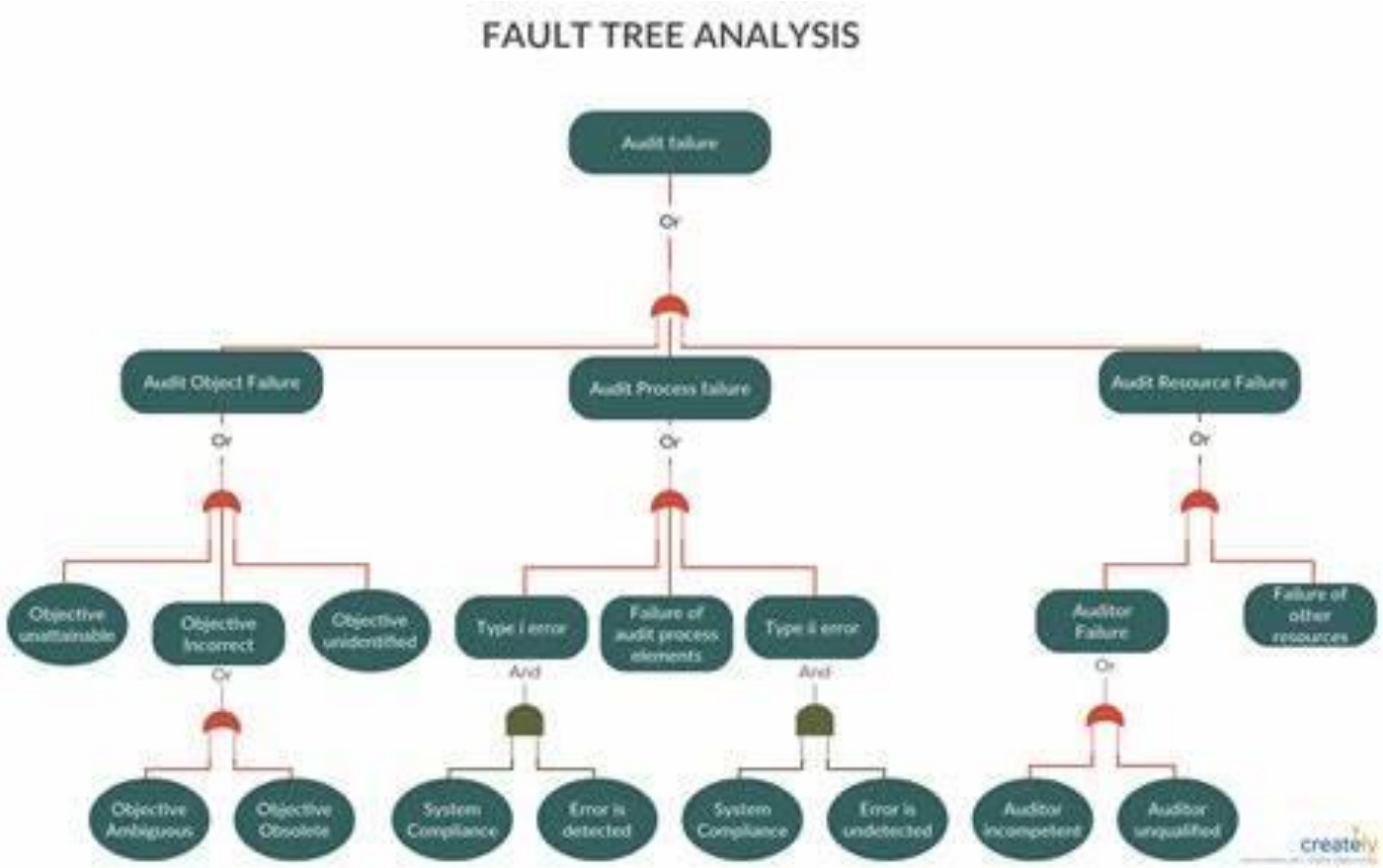
3. Brainstorm all the possible causes of the problem. Ask “Why does this happen?” Each idea is written as a branch from the appropriate category on the fishbone diagram. Causes can be written in several places if they relate to several categories.

PROCESS - FISHBONE

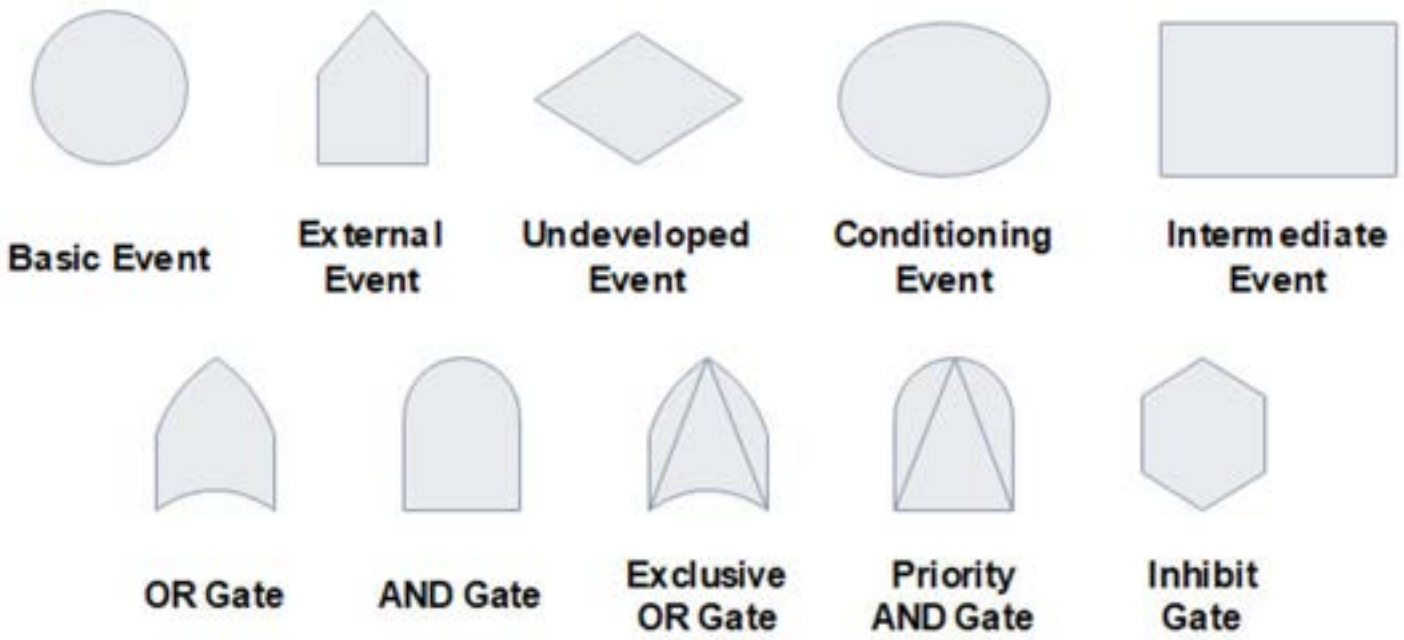
4. Again ask “Why does this happen?” about each cause. Write sub-causes branching off the cause branches.

5. Continue to ask “Why?” and generate deeper levels of causes and continue organizing them under related causes or categories. This will help you to identify and then address root causes to prevent future problems.

METHODS - FAULT TREE ANALYSIS



METHODS - FAULT TREE ANALYSIS



METHOD – FAULT TREE ANALYSIS

1. A deductive process used by developers or engineers to find out the root cause or human errors for different types of software, engineering facilities or hardware.

2. Usually starts at a single point (the undesired top-level event) and then goes downwards in the form of a tree (the top-down structure) with a number of blocks and symbols to show the relationship between events (mechanical components).

3. The definition of "Fault" in fault tree analysis indicates the occurrence of an undesired state for a component or system.

METHOD – FAULT TREE ANALYSIS

Primary Fault - A component failure that cannot be further defined at a lower level of a system.

Secondary Fault - A component failure that can be further defined at a lower level, but with limited details.

Command Fault - A state that is commanded by an upstream failure.

METHOD – FAULT TREE ANALYSIS

4. Used to determine the root causes of any failure of a safety observance, accident or undesirable loss event.

5. Primary methods of safety analysis by graphically representing the interactions of failures and other events within a system.

6. Provides graphical symbols while incorporating mathematical tools to emphasize critical areas.

BENEFIT – FAULT TREE ANALYSIS

1. Offers a well-structured, highly visual and comprehensive picture of your system.

2. Helps users or developers quickly understand the results based on the logical relationships in order to pinpoint drawbacks and errors in the design process.

3. Easy to adopt. Wide Applicability. Risk Estimation. For complex systems.

PROCESS – FAULT TREE ANALYSIS

1. Define and identify the fault condition (hazard) as precisely as possible based on the aspects such as the amount, duration, and related impacts etc.

2. Using technical skills and existing facility details to list and decide all the possible reasons for the failure occurrence.

3. Break down the tree from the top level according to the relationship between different components until you work down to the potential root cause. The structure of your fault tree analysis diagram should be based on the top, middle (subsystems), and the bottom (basic events, component failures) levels.

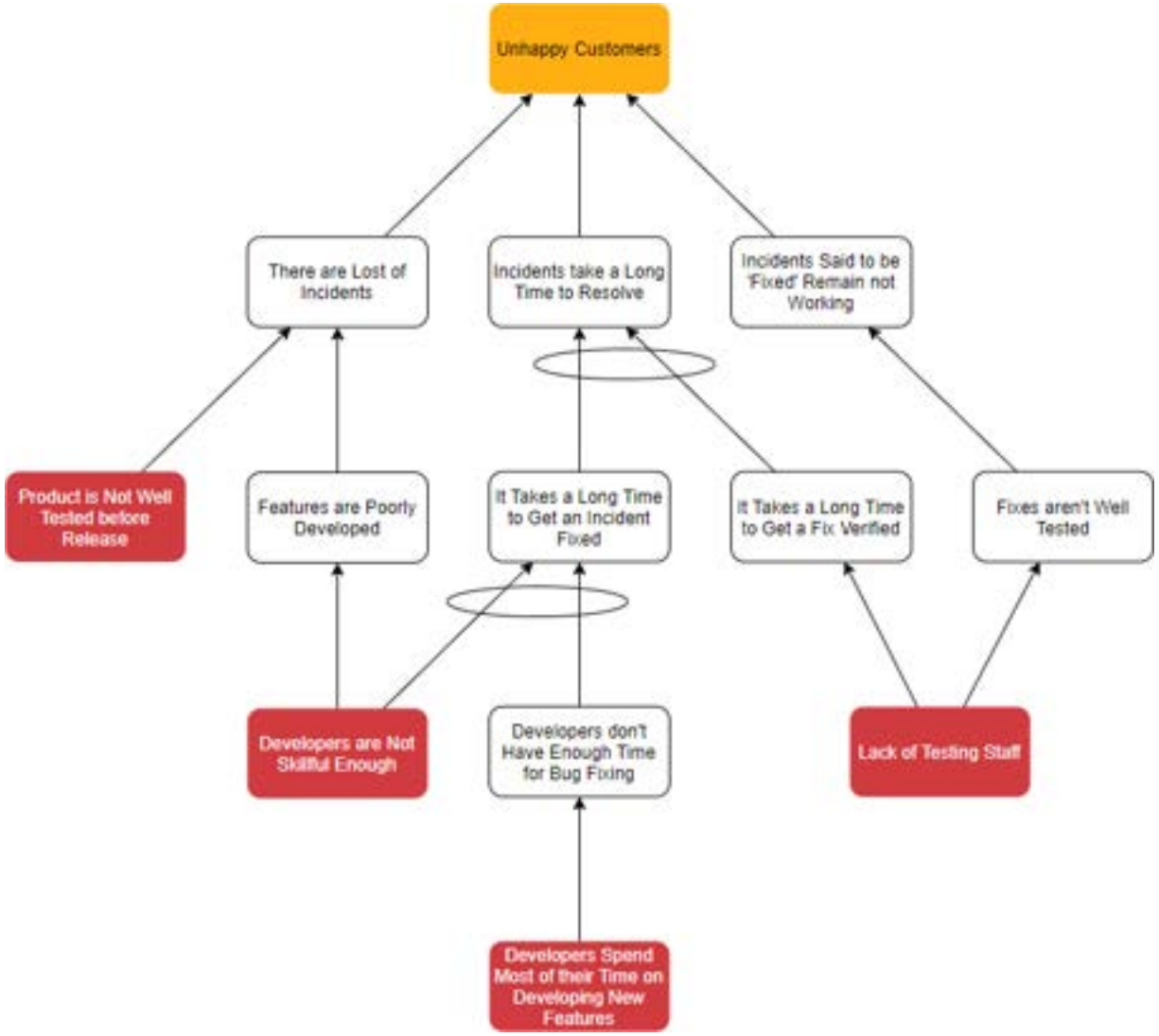
PROCESS – FAULT TREE ANALYSIS

4. If your analysis involves the quantitative part, evaluate the probability of occurrence for each of the components and calculate the statistical probabilities for the whole tree.

5. Double-check your overall fault tree analysis diagram and implement modifications to the process, if necessary.

6. Collect data, evaluate your results in full details by using risk management, qualitative and quantitative analysis to improve your system.

METHODS - CURRENT REALITY TREE



METHOD – CURRENT REALITY TREE

1. Identifies the symptoms or undesirable effects (UDEs) present in our reality. UDEs cover a fairly large span and originate from different sources and have different weights.

2. To be effective, must identify the minimum necessary things that need to change by identifying the few things causing the majority of the current problems.

3. The fewer elements we find that cause the problems the more powerful and focused our improvement process will be.

METHOD – CURRENT REALITY TREE

4. We call problems “UDEs” to remind us that these are not things that exist in isolation but are the negative effects of some cause. They are symptoms and they result from a cause.

5. To identify the few things that need to be changed, we should rely on cause and effect relationships using a diagram called a CRT to show the relationships and links between the current undesirable effects.

6. The process used to identify how the UDE(s) are linked together results in a CRT.

BENEFITS – CURRENT REALITY TREE

1. Method to “drill down” past the surface symptoms into the deeper underlying issues. It starts with the symptoms and builds back to the core issues. It maps out a sequence of cause and effect from the core problem to the symptoms. Most of the symptoms will arise from one core problem or a core conflict. Remove the core problem and we may well be able to remove each of the symptoms as well. Work backwards from the apparent undesirable effects or symptoms to uncover or discover the underlying core cause.

BENEFITS – CURRENT REALITY TREE

2. The tool of choice in seeking to gain agreement on the magnitude of the problem that we are investigating and preliminary agreement on the core problem or core conflict that is driving the agreed upon symptoms or UDEs.

PROCESS – CURRENT REALITY TREE

1. The tree is read from the bottom to the top.

2. If “cause” then “effect”. Where there is an ellipse indicating a logical “and” we use “if cause” and if “other cause” then “effect”. If there are no negative feedback loops, or vicious cycles, some would say it isn’t a true CRT or we don’t fully understand the true reality of the situation.

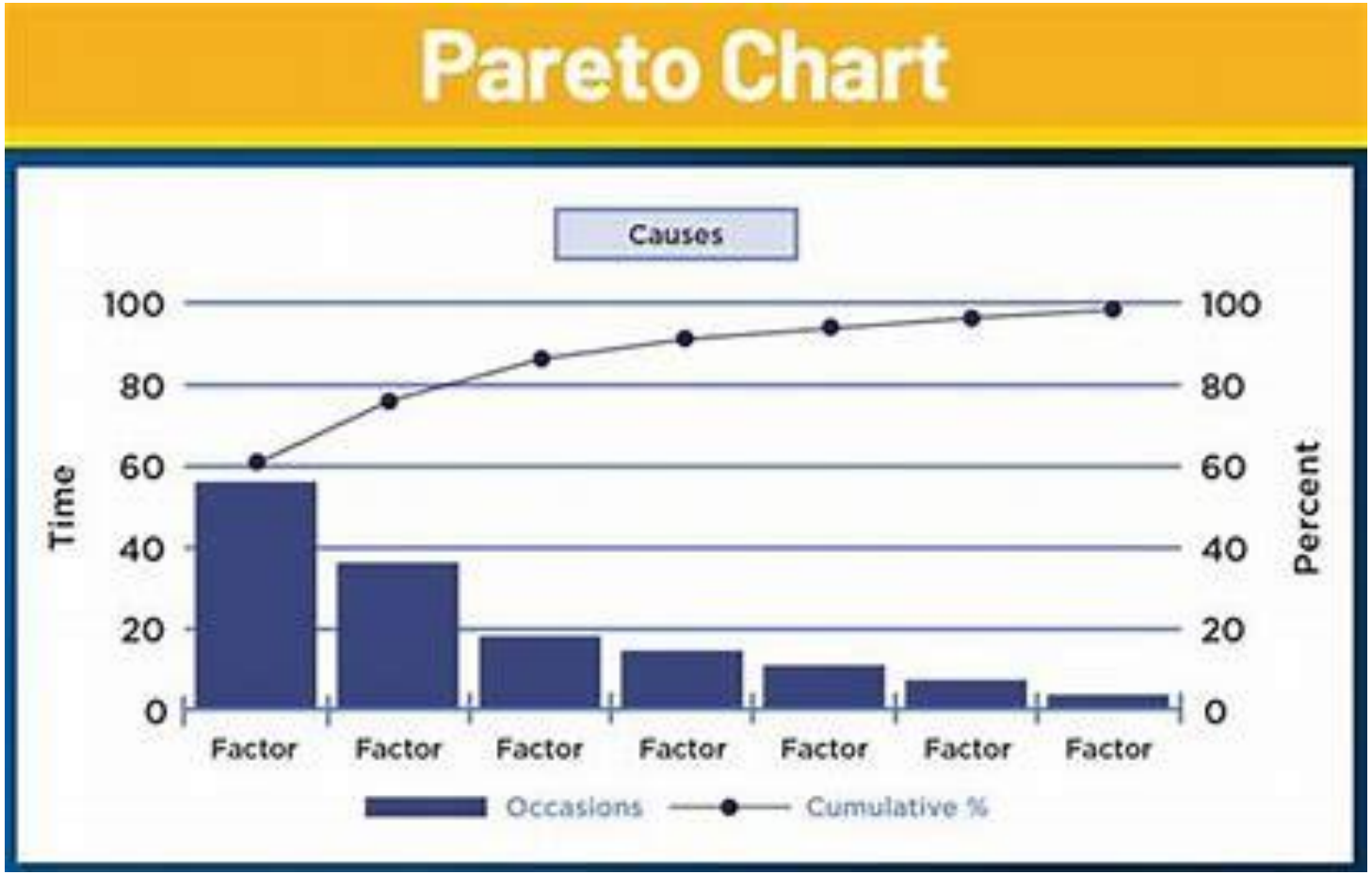
3. Most often the symptoms that arise from the underlying problem, in turn, cause the underlying problem to be worse than if it occurred in isolation.

PROCESS – CURRENT REALITY TREE

4. In the case of a core conflict, even when we are in total control of the situation we may let the conflict continue to exist because both of the entities “Neutral Effect A” and “Neutral Effect B” are required in order to satisfy something else.

5. The entities that give rise to all the problems are not perceived to be a problem by themselves.

METHODS - PARETO CHART



METHOD – PARETO CHART

Pareto charts can be highly effective, they are only useful for certain types of data, namely hypothetical data.

BENEFITS – PARETO CHART

1. Method to analyze data about potential root cause problems in processes or the frequency of problems.
2. Deals with many different problems and causes, but you want to focus on the most significant ones.
3. For analyzing wide-reaching causes by zeroing in on their individual components.
4. Easy to convey information to others about the data.

PROCESS – PARETO CHART

1. Decide on the categories that will be used to group your data items.

2. Decide on appropriate measurements for your data. This will be frequency, quantity, cost, time, and so on.

3. Next, decide on the length of time your Pareto chart aims to cover. Will it be a single work cycle, a full day, or week? Need to decide the period early on. It could be longer still, a month or even a year.

PROCESS – PARETO CHART

4. Gather the data, recording which category each item reflects. If you already have the data, then you should simply put it in order, assigning and arranging by category.

5. Calculate the subtotal of each category's measurements.

6. Devise an appropriate scale for your measurements. There should be a maximum value of the largest subtotal with marking the scale on the left side of your diagram.

PROCESS – PARETO CHART

7. Draw the bars and add appropriate labels for each category, placing the tallest on the far left, and descending to the smallest on the far right. Small measurement categories should be labeled as “other”.

8. Calculate each category’s percentage, that is, each category’s subtotal divided by the total for all of them. Then draw a right vertical axis labeled with these percentages, ensuring it matches the other scale.

PROCESS – PARETO CHART

9. Finally, calculate and draw your cumulative sums. This can be done by adding the subtotals for your first and second categories, placing a cross over the second bar to illustrate that sum. Combine this figure with the subtotal for the third category, placing another cross above the third bar to illustrate the new sum. Continue to do this for the other categories and join each cross with a line until they are all connected. The final cross should correspond to 100% on the right-hand scale.

RESULTS

- Training required?
- Process/policy/procedure changes?
- Personnel issue?
- Root cause addressed?

EXAMPLE

UPS transferring load

- 3 cases of blown fuses
- 1 case shifted to internal bypass

1. Found voltage regulator out of calibration
2. Circuit breaker needed lubrication

EXAMPLE

Utility power disruption
- Work on switchboard. SEPAM relay setting set too low to reduce arc flash rating.

1. Setting was not documented
2. Assumed low risk
3. Procedure reviewed 9 months beforehand
4. Procedure did not include checking relay setting
5. Procedure did not address energized work

EXAMPLE

Isolating a branch circuit

- Wrong UDP de-energized

1. Marking of breaker changes lacking
2. Procedure steps missing initials, dates. Some N/A.
3. Process using colored stickers ambiguous.
4. Risk level underestimated.

EXAMPLE

Arc flash from generator feeder cables

Significant damage to cables

1. Vendor RCA.
2. Determined crimping wasn’t adequate – too much white space between wires.

EXAMPLE

Capacitors in UPS power modules exploding

1. Manufacturing variation allows thermal runaway.
2. OEM developed a wire kit to sense bulging of the capacitors and turn off the module if sensed.
3. OEM stopped using that manufacturer.

EXAMPLE

Failure of new generator during IST testing

- Engine had to sent back to France. 39 hours of run time.

1. Vendor driven RCA.
2. Performed fractographic and metallographic exams, hardness testing, bolt elongation tensile testing and dimension analysis.
3. Reviewed cylinder lining, piston and pin, valve stem, connecting rod and counterweight bolts/sleeves.
4. Found counterweight bolts torque inadequate clamping force.

TAKE AWAYS

- RCA is a value-added process
- Process should be well defined
- Tracking action/activities

Questions

QUESTIONS?

Thank you!

Lee McClish

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https://datacenter.hello.global.ntt/en/us-data-centers

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