

AQS 200

ROOT CAUSE INVESTIGATION

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Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

LECTURE 3 – PROBLEM SOLVING



Developed as part of NSF ATE Grant #1304474

Problem Solving

Definition of a problem:

Problem: *A question proposed for solution*

Webster's Revised Unabridged Dictionary

A problem *is a state of difficulty that needs to be resolved*

Wordnet

Problem Solving

How to solve a problem

1. Identify the cause (or causes) of the problem.
2. Find ways to eliminate these cause and prevent them from recurring.

Typically different levels of causes

symptoms

first level

higher level

ROOT CAUSE

Problem Solving

Always late for morning classes.

Symptoms

Not actual causes
– instead signs of existing problems

PROBLEM

First Level

Causes that lead directly to the problem

HIGHER LEVEL

Causes that lead to first level causes

ROOT CAUSE

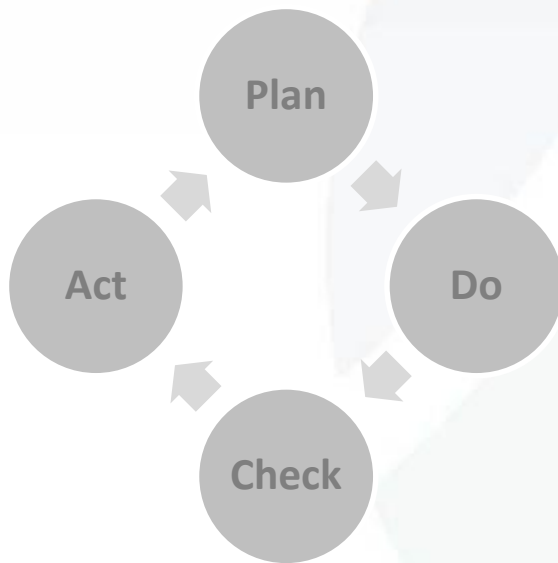
Highest level
“True “ cause of the problem

Problem Solving

Problem Solving is a Process:

Problem Solving - Process

Deming Wheel



1. Recognize the problem

2. Define the problem

3. Understand the problem

4. Identify the root cause of the problem

5. Eliminate the root cause

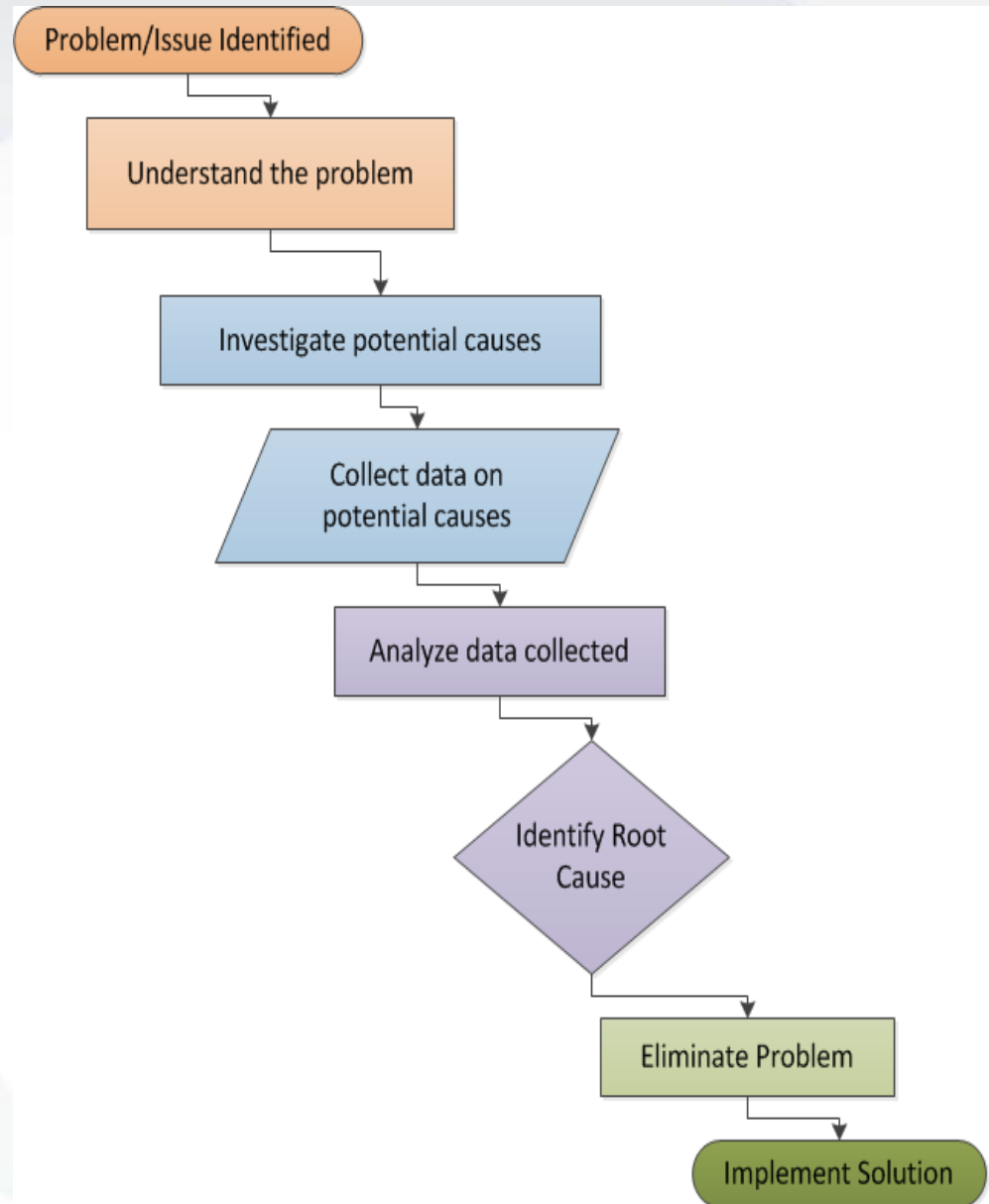
6. Monitor the symptoms of the problem to verify root cause elimination (or reduction)

Problem Solving

Textbook

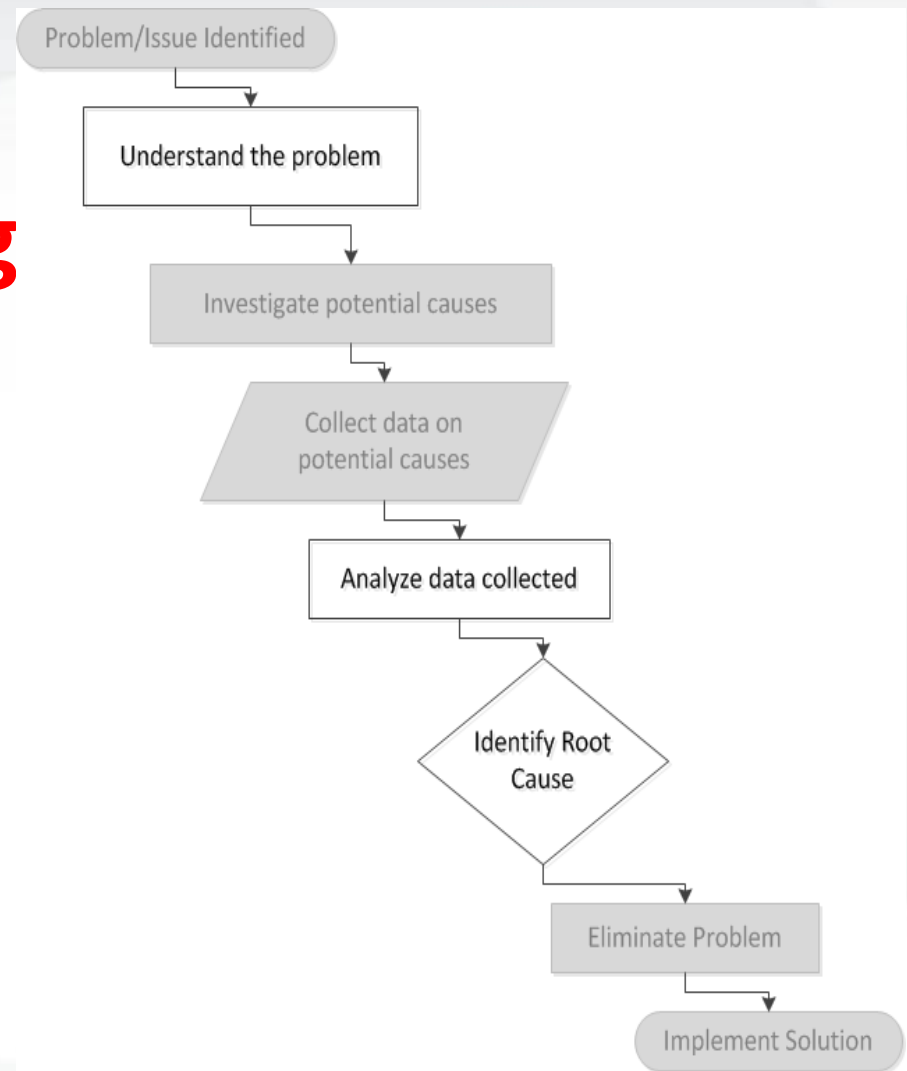
Next several weeks walk through each step

Tools associated with each phase



Problem Solving

Critical Thinking



Critical Thinking

- What is critical thinking?
 - the ability to think clearly and rationally about what to do or what to believe.
 - *includes the ability to engage in reflective and independent thinking.*

Critical Thinking

Skills enable the following :

- Understand the logical connections between ideas
- Identify, construct and evaluate arguments
- Detect inconsistencies and common mistakes in reasoning
- Solve problems systematically
- Identify the relevance and importance of ideas
- Reflect on the justification of one's own beliefs and values

Not just accumulating information

- deduce consequences
- make use of information to solve problems
- seek relevant sources of information

Critical Thinking

Relative to Root Cause Analysis

- *acquire knowledge*
- *improve our theories*
- *strengthen arguments*

*Misconception that not “creative”
requires logic/rationality
“out-of-the-box” by challenging consensus
evaluates new ideas for relevance to task at hand*

Critical Thinking

Is a metacognitive skill (*thinking about thinking*)

- be aware of the good principles of reasoning
- be reflective about our own reasoning.
- conscious effort to avoid biases, and maintain objectivity

There are three important components:

- Theory
- Practice
- Attitude

Critical Thinking

There are three important components:

- **Theory**
 - Follow correct rules of reasoning (logic, scientific reasoning, etc.)
 - What not to do (basic knowledge of mistakes people make)
- **Practice**
 - Apply theories to daily life (debate/discussions with others)
 - Reflect (think more deeply); make connections between ideas
- **Attitude**
 - Motivation for understanding
 - Common Obstacles
 - Prefer to be given answer rather than figure it out
 - Rely on “gut” feelings
 - Don’t review previous mistakes
 - Don’t like to be criticized

Critical Thinking

For problem solving

- Reflect on reason for “belief”
- Engage in debate
- Break old habits
- Work with complexities and abstract concepts

Improve Thinking Skills

- Truth-seeking
- Open-mindedness
- Analyticity
- Systematicity
- Confidence in Reasoning
- Inquisitiveness
- Maturity of Judgment

Improve Thinking Skills

- ***Truth-seeking***
 - try to understand how things really are
 - interested in finding out the fact(s)
- **Open-mindedness**
 - receptive to new ideas
 - even though intuitively do not agree
 - give them a fair hearing
- **Analyticity**
 - understand the reasons behind things
 - evaluate the pros and cons versus acting impulsively

Improve Thinking Skills

- **Systematicity**
 - break down a complex problem into parts
 - Systematic process
- **Confidence in Reasoning**
 - Confidence in judgment vs asking others
 - Reasons for confidence
 - Self evaluation of ideas
- **Inquisitiveness**
 - Look to investigate / question
- **Maturity of Judgment**
 - jump to conclusions
 - different perspectives or account for others experiences

Critical Thinking

The Cognitive Reflection Test developed by Shane Frederick

measure a person's tendency to override an initial "gut" response that is incorrect, and to engage in further reflection to find a correct answer.

The Cognitive Reflection Test

Question 1

A bat and a ball cost \$1.10 in total. The bat costs \$1.00 more than the ball. How much does the ball cost?

The Cognitive Reflection Test

Question 2

If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets?

The Cognitive Reflection Test

Question 3

In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake?

The Cognitive Reflection Test

The answers are:

Question 1: \$0.05

Question 2: 5 mins

Question 3: 47 days

The Cognitive Reflection Test

The answers are:
Question 1: \$0.05
Question 2: 5 mins
Question 3: 47 days

Average scores for students at various US universities:

- Massachusetts Institute of Technology: 2.18
- Princeton: 1.63
- Harvard: 1.43
- Michigan State: 0.79

The Cognitive Reflection Test

- Each of the question has an "intuitive" answer which is actually wrong.
- To get all questions right
 - need to suppress immediate reactions
 - reflect carefully to come to the correct answers.
- supposed to reflect the capacity for deliberate and reflective reasoning and to avoid jumping to conclusions.

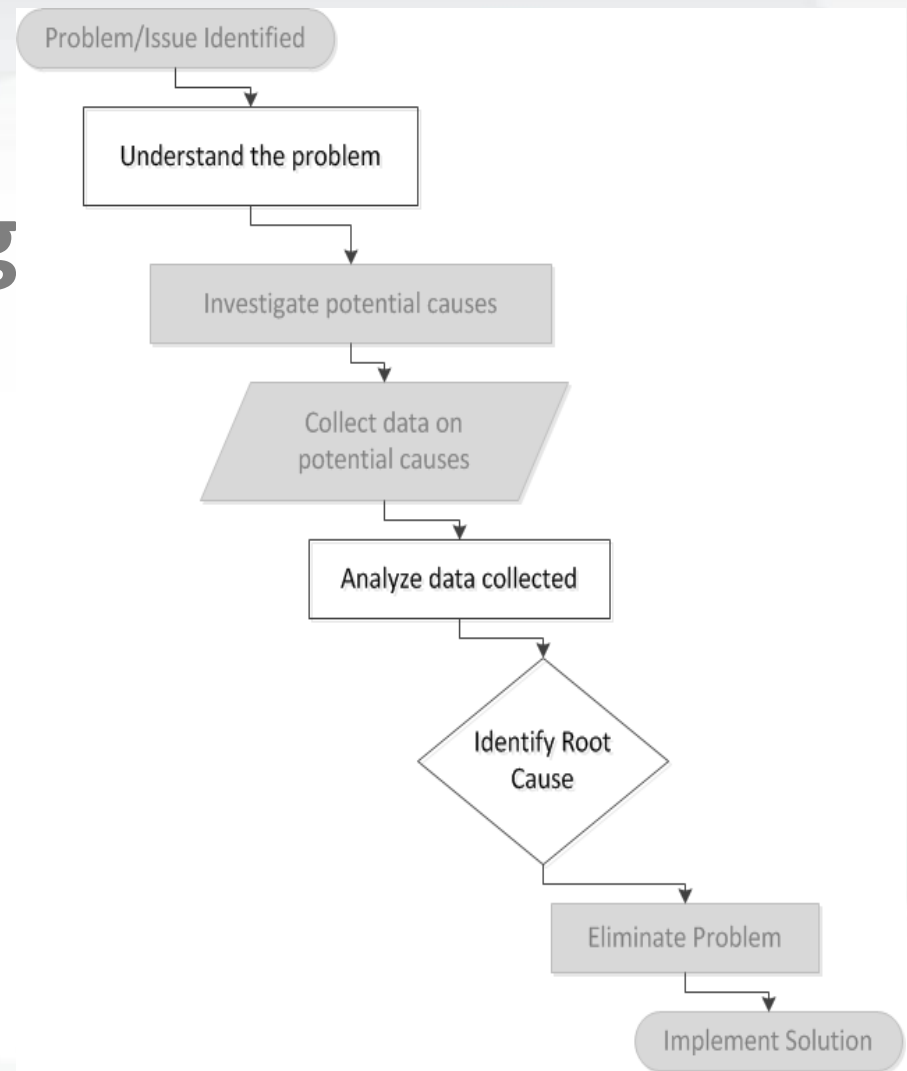
TAKEAWAY:

In some situations spending more time thinking about the question is better than coming up with quick answer

Problem Solving

Critical Thinking

Logic



Problem Solving – Logic

- The term "logic" came from the Greek word *logos*, which is sometimes translated as "sentence", "discourse", "reason", "rule", and "ratio".
- *Study of the principles of correct reasoning*
 - *principles governing the validity of arguments*
 - whether certain conclusions follow from some given assumptions

For example, consider the following three arguments

Problem Solving - Logic

#1 If Tom is a philosopher, then Tom is poor.

Tom is a philosopher.

Therefore, Tom is poor.

#2 If $K > 10$, then $K > 2$.

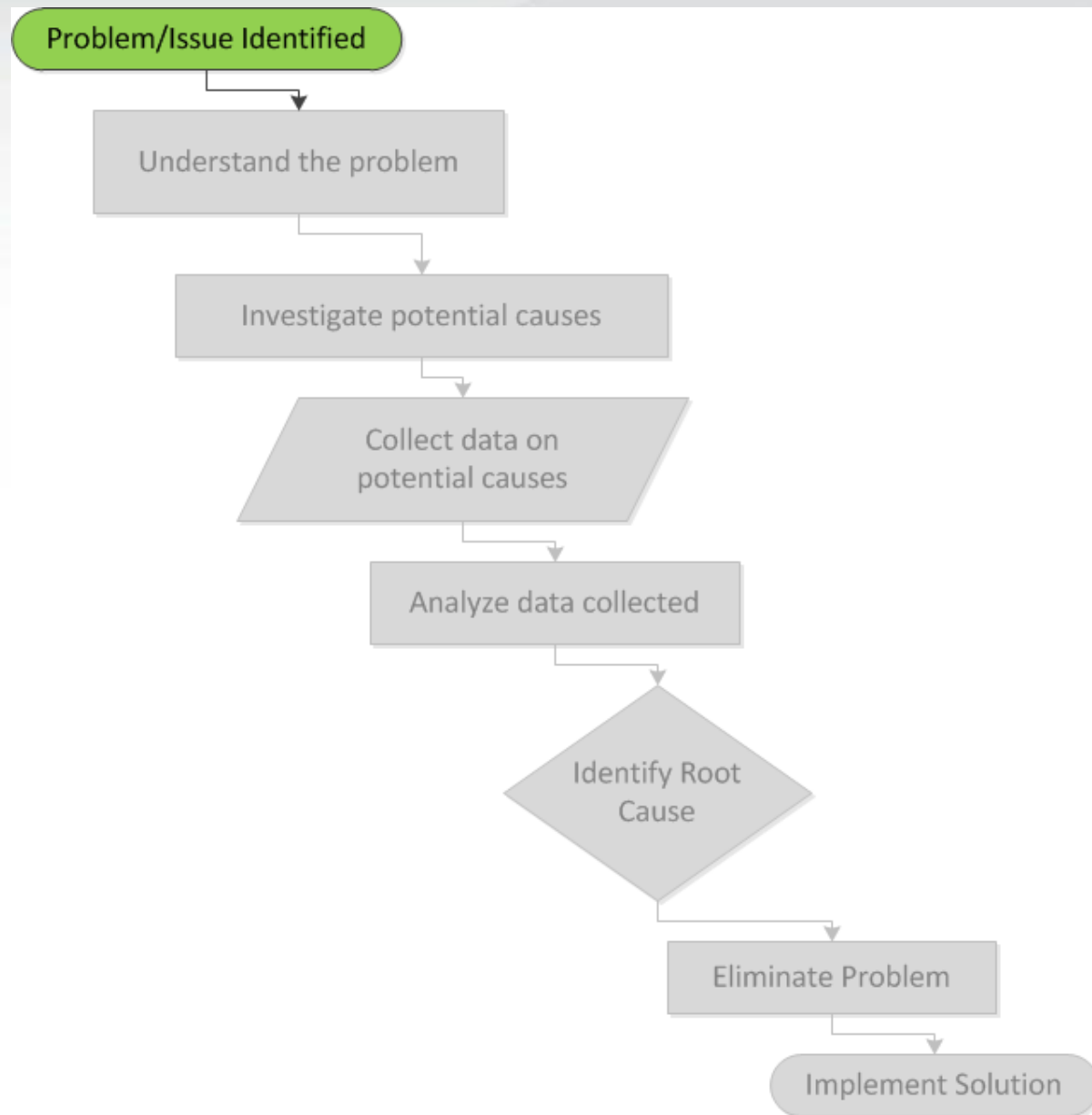
$K > 10$.

Therefore, $K > 2$.

#3 If Tarragona is in Europe, then Tarragona is not in China.

Tarragona is in Europe.

Therefore, Tarragona is not in China



Proactive - Problem Prevention

- Effective problem prevention
 - Failure Mode Effect Analysis (FMEA)
 - Failure Mode Effect and Criticality Analysis (FMECA)

Originally FMEA has evolved into FMECA to highlight (rank) the various effects and their severity (criticality) to function/operation

Proactive - Problem Prevention

- Effective problem prevention
 - Failure Mode Effect Analysis
 - Failure Mode Effect and Criticality Analysis

| Phase | Question | Output |
|----------|---|---|
| Identify | What can go wrong? | Failure descriptions Causes Failure Modes Effects |
| Analyze | How likely is a failure? What are the consequences? | Failure rates → RPN (risk priority number) |
| Act | What can be done? How can we eliminate the causes? How can we reduce the severity | Design solutions Test plans Manufacturing changes Error proofing Etc. |

-based on Kmenta 2002

Problem Solving

FMEA Example

| Function | Potential Failure Mode | Potential Effect(s) of Failure | Severity | Potential Causes of Failure | Occurrence | Current Process Controls | Detection | Risk Priority Number (RPN) | Criticality | Recommended Actions | Responsibility | Target Completion Date | Action taken | Severity | Occurrence | Detection | RPN | Criticality |
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Risk priority number (RPN) = Severity * Occurrence * Detection

Criticality = Severity * Occurrence

Proactive - Problem Prevention

- Function of device/product/service
- Potential Failure mode: what can go wrong (failure)

Analysis started at high level to assess system (product). Can break down into greater detail for high risk area(s).

Proactive - Problem Prevention

- Function of device/product/service
- Potential Failure mode: what can go wrong (fail)
- Potential Failure effect: what happens on failure
 - How **severe** is the effect (1-10 or 1-5)
(minor to catastrophic)

Problem Solving

FMEA Example

| Function | Potential Failure Mode | Potential Effect(s) of Failure | Severity | Potential Causes of Failure | Occurrence | Current Process Controls | Detection | Risk Priority Number (RPN) | Criticality | Recommended Actions | Responsibility | Target Completion Date | Action taken | Severity | Occurrence | Detection | RPN | Criticality |
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Risk priority number (RPN) = Severity * Occurrence * Detection

Criticality = Severity * Occurrence

Proactive - Problem Prevention

- Function of device/product/service
- Potential Failure mode: what can go wrong (fail)
- Potential Failure effect: what happens on failure
- Potential Cause of failure: how does failure occur
 - How often does it **occur** (1-10 or 1-5)
(never/rarely to every batch/lot or use)

Problem Solving

FMEA Example

| Function | Potential Failure Mode | Potential Effect(s) of Failure | Severity | Potential Causes of Failure | Occurrence | Current Process Controls | Detection | Risk Priority Number (RPN) | Criticality | Recommended Actions | Responsibility | Target Completion Date | Action taken | Severity | Occurrence | Detection | RPN | Criticality |
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Risk priority number (RPN) = Severity * Occurrence * Detection

Criticality = Severity * Occurrence

Proactive - Problem Prevention

- Function of device/product/service
- Potential Failure mode: what can go wrong (fail)
- Potential Failure effect: what happens on failure
- Potential Cause of failure: how does failure occur
- Current Controls: how is failure recognized/corrected
 - How is it **detected** (1-10 or 1-5)
(easily to not detected)

Problem Solving

FMEA Example

| Function | Potential Failure Mode | Potential Effect(s) of Failure | Severity | Potential Causes of Failure | Occurrence | Current Process Controls | Detection | Risk Priority Number (RPN) | Criticality | Recommended Actions | Responsibility | Target Completion Date | Action taken | Severity | Occurrence | Detection | RPN | Criticality |
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Risk priority number (RPN) = Severity * Occurrence * Detection

Criticality = Severity * Occurrence

Proactive - Problem Prevention

- Function of device/product/service
- Potential Failure mode: what can go wrong (fail)
- Potential Failure effect: what happens on failure
- Potential Cause of failure: how does failure occur
- Current Controls: how is failure recognized/corrected
- Recommended actions:
 - How can failure severity/occurrence be reduced/eliminated
 - How can detection of failure be increased
- Responsibility: who's going to take action and when

Problem Solving

FMEA Example

| Function | Potential Failure Mode | Potential Effect(s) of Failure | Severity | Potential Causes of Failure | Occurrence | Current Process Controls | Detection | Risk Priority Number (RPN) | Criticality | Recommended Actions | Responsibility | Target Completion Date | Action taken | Severity | Occurrence | Detection | RPN | Criticality |
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Risk priority number (RPN) = Severity * Occurrence * Detection

Criticality = Severity * Occurrence

FMEA Example - ATM

| Function | Potential Failure Mode | Potential Effects(s) of Failure | S | Potential Cause(s) of Failure | O | Current Process Controls | D | R | P | C | Recommended Action(s) | Responsibility and Target Completion Date | Action Results | | | | | |
|---|---------------------------------|--|---|---------------------------------------|---|--|----|-----|----|---|-----------------------|---|----------------|---|---|---|---|---|
| | | | | | | | | | | | | | Action Taken | S | O | D | R | C |
| Dispense amount of cash requested by customer | Does not dispense cash | Customer very dissatisfied | 8 | Out of cash | 5 | Internal low-cash alert | 5 | 200 | 40 | | | | | | | | | |
| | | Machine jams | | | 3 | Internal jam alert | 10 | 240 | 24 | | | | | | | | | |
| | | Incorrect entry to demand deposit system | | | 2 | None | 10 | 160 | 16 | | | | | | | | | |
| | Dispenses too much cash | Bank loses money | 6 | Bills stuck together | 2 | Loading procedure (riffle ends of stack) | 7 | 84 | 12 | | | | | | | | | |
| | | Discrepancy in cash balancing | | Denominations in wrong trays | 3 | Two-person visual verification | 4 | 72 | 18 | | | | | | | | | |
| | Takes too long to dispense cash | Customer somewhat annoyed | 3 | Heavy computer network traffic | 7 | None | 10 | 210 | 21 | | | | | | | | | |
| | | | | Power interruption during transaction | 2 | None | 10 | 60 | 6 | | | | | | | | | |
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Risk priority number (RPN) = Severity * Occurrence * Detection

Criticality = Severity * Occurrence

Proactive - Problem Prevention

- Function of device/product/service
- Potential Failure mode: what can go wrong (fail)
- Potential Failure effect: what happens on failure
- Potential Cause of failure: how does failure occur
- Current Controls: how is failure recognized/corrected
- Recommended actions: reduce severity/occurrence, increase detection
- Responsibility: who's going to take action and when
- **Actions taken: what was actually completed**
- **New values (reduction) RPN and/or Criticality**
 - Reduced value for Severity and/or occurrence based on actions taken
 - Increased detection (reduction in RPN value)

Problem Solving

FMEA Example

| Function | Potential Failure Mode | Potential Effect(s) of Failure | Severity | Potential Causes of Failure | Occurrence | Current Process Controls | Detection | Risk Priority Number (RPN) | Criticality | Recommended Actions | Responsibility | Target Completion Date | Action taken | Severity | Occurrence | Detection | RPN | Criticality |
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Risk priority number (RPN) = Severity * Occurrence * Detection

Criticality = Severity * Occurrence

Proactive - Problem Prevention

- Function of device/product/service
- Potential Failure mode: what can go wrong
- Potential Failure effect: what happens when it goes wrong
 - How severe is the effect (1-10 or 1-5)
(minor to catastrophic)
- Potential Cause of failure: how did the failure occur
 - How often does it occur (1-10 or 1-5)
(never/rarely to every batch/lot or use)
- Current Controls: how is it recognized/corrected
 - How is it detected (1-10 or 1-5)
(easily to not detected)
- Recommended actions: can effect be reduced, occurrence reduced/eliminated, detection increased
- Responsibility: who's going to take action and when

Problem Solving

FMECA Practice

| Function | Potential Failure Mode | Potential Effect(s) of Failure | Severity | Potential Causes of Failure | Occurrence | Current Process Controls | Detection | Risk Priority Number (RPN) | Criticality | Recommended Actions | Responsibility | Target Completion Date | Action taken | Severity | Occurrence | Detection | RPN | Criticality |
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Risk priority number (RPN) = Severity * Occurrence * Detection

Criticality = Severity * Occurrence

