Root Cause Analysis

Prevent Today's Problem from Recurring Tomorrow

Get to the ROOT of it!

Training prepared by: Cindi Kingery (JPL), Jay Krueger (JPL), Kien Nguyen (JPL)
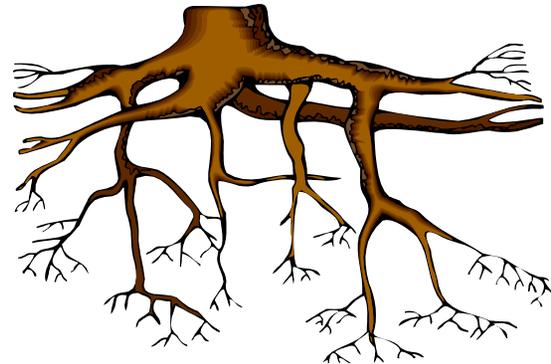
Training Agenda

- **Purpose**

- **Root Cause Analysis (RCA)**
  - **Undesired Outcome**
  - **Collection Step**
  - **Analysis Step**
  - **Solutions Step**

- **Summary**
  - **FAQ's**

- **Case Study**

Why?

- Organizations frequently do not or do not go far enough to expose root cause(s).

- Often the underlying organizational factors of a problem (e.g. training, process, infrastructure, etc.) are not addressed.

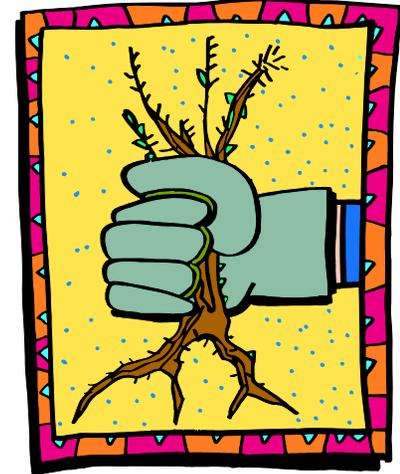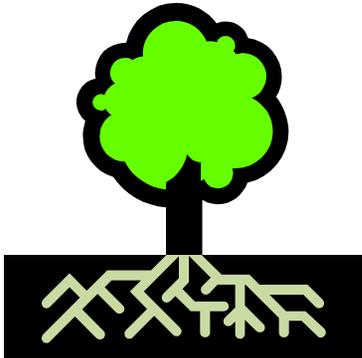- Root Cause Analysis is imperative to a good supply chain.
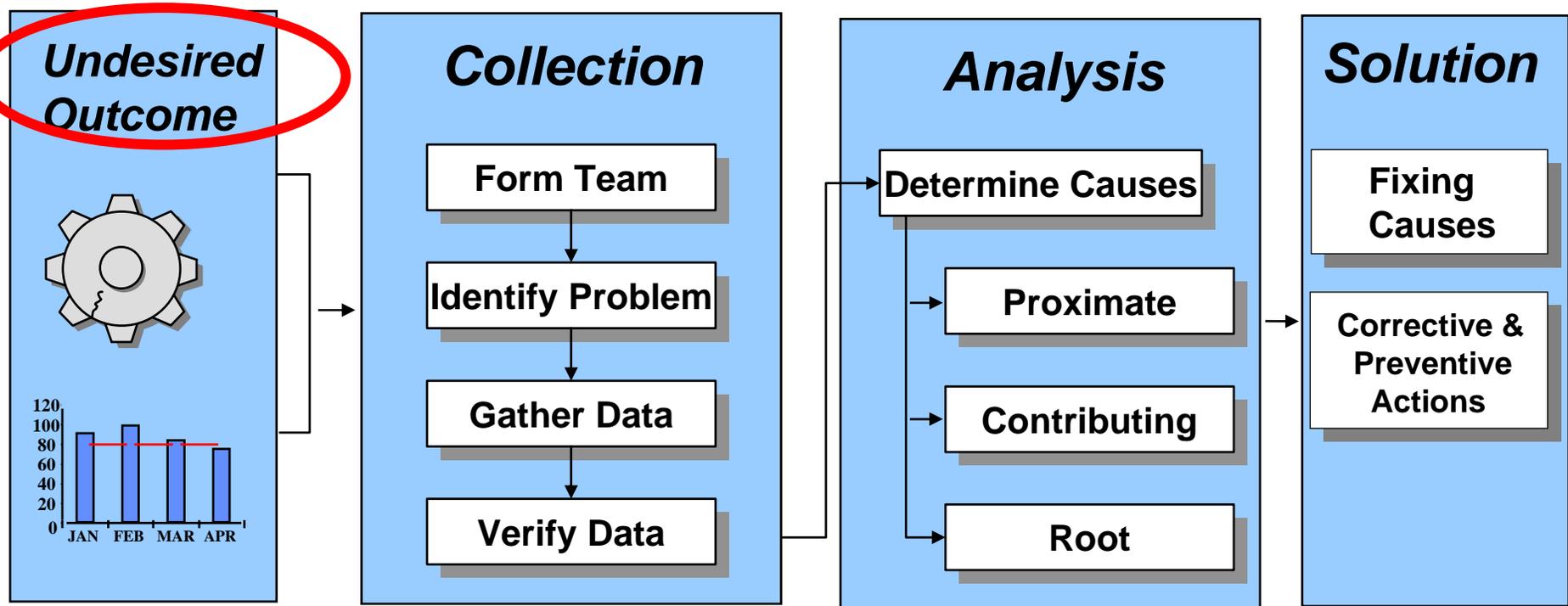
What is the purpose of this training?

- To continually **improve** performance

- To broaden our focus from fixing to **preventing**

- To equip you with an additional effective **tool** to discover the causes of undesired outcomes so that meaningful corrective and preventive actions can be applied

What is "Root Cause Analysis"?

• Finding the real cause of the problem and resolving it, rather than continuing to deal with its symptoms

Root Cause Analysis process

Undesired Outcome

120
100
80
60
40
20
0
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Collection

| Form Team |
| Identify Problem |
| Gather Data |
| Verify Data |

Analysis

| Determine Causes |
| Proximate |
| Contributing |
| Root |

Solution

| Fixing Causes |
| Corrective & Preventive Actions |

"Undesired Outcome"

The term for "<u>what</u> <u>happened</u>."

Examples:

- The machine broke down.
- The circuit board was burnt during test.
- The assembly failed acceptance test.
- "Reset CPU" command was rejected.
- The parts were rejected at final inspection.
- The software exhibited a fatal shutdown.
- Tire blew out.
- The part fell off the pallet.
- The two cars collided.

Undesired Outcome = Event Question

An Event Question should be :
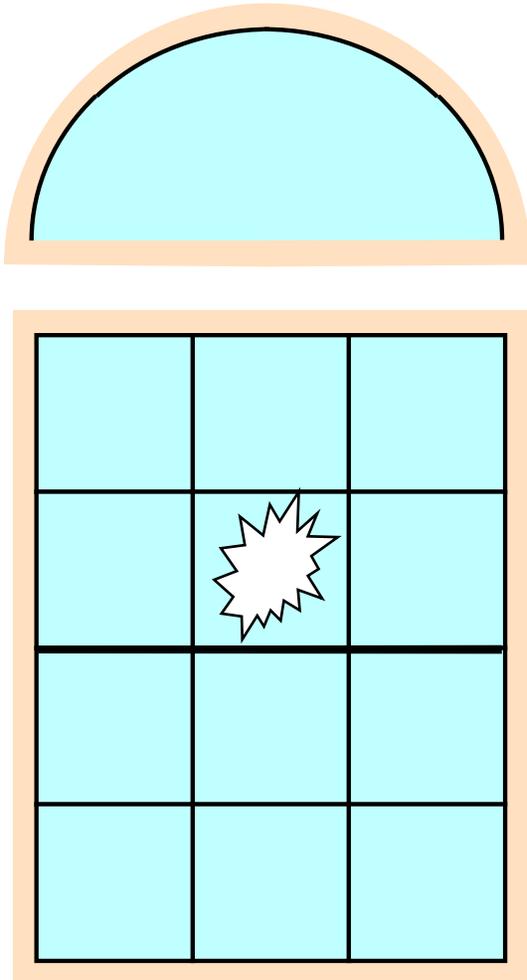
- Short

- Simple

- Concise

- Focused on One Problem

An Event Question <u>does</u> <u>not</u>:

- Tell what caused the event

- State what to do next

Event Question

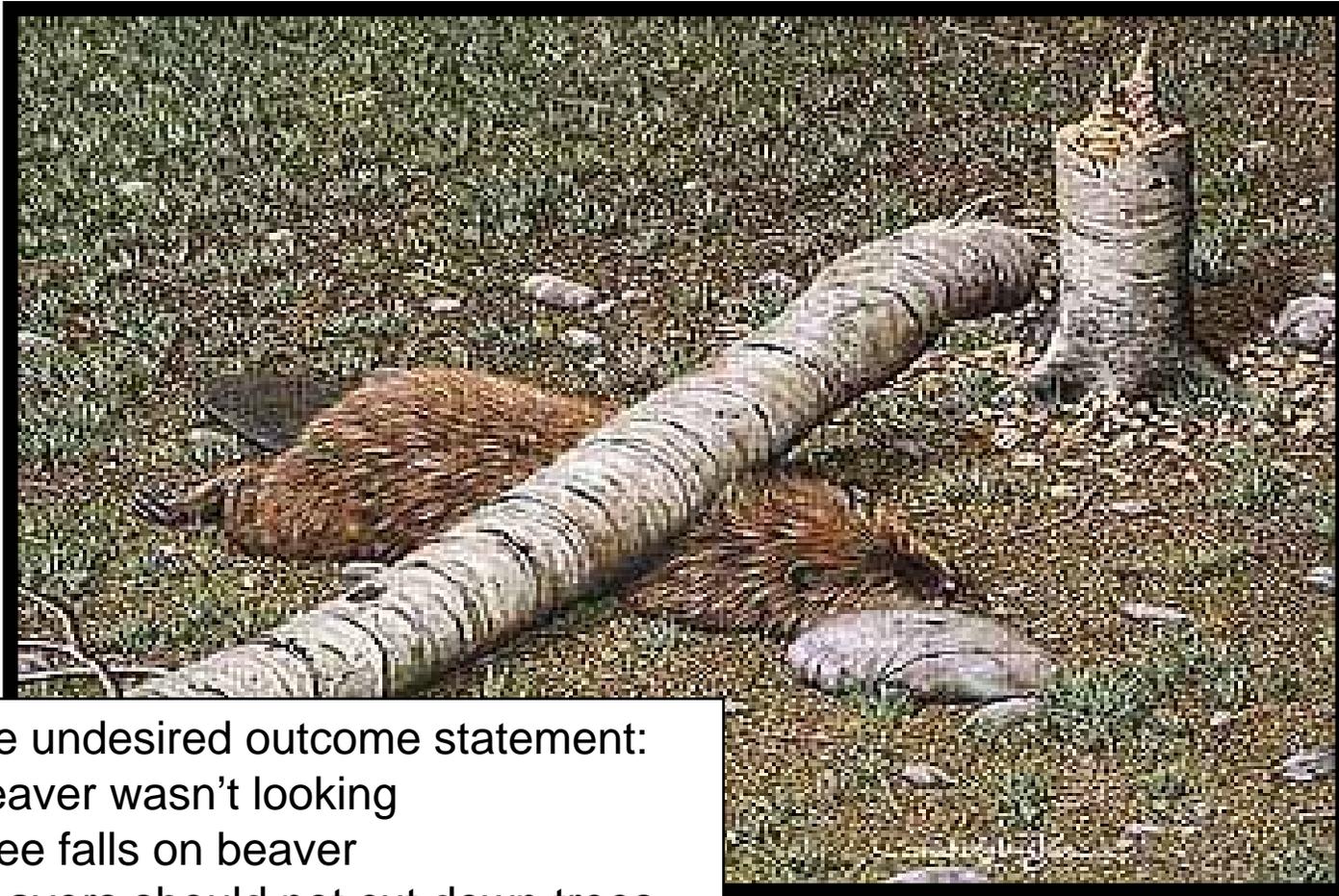The Event Question:

Why did the window break ?

Not:
Who threw that baseball?

"Oh No!"

Exercise #1

Select the undesired outcome statement:
1. Beaver wasn't looking
2. Tree falls on beaver
3. Beavers should not cut down trees until they have been certified
4. Wind blows tree onto hapless beaver

Note: No beaver was harmed during the creation of this presentation

Root Cause Analysis process

Undesired Outcome

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Solution

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- Corrective & Preventive Actions
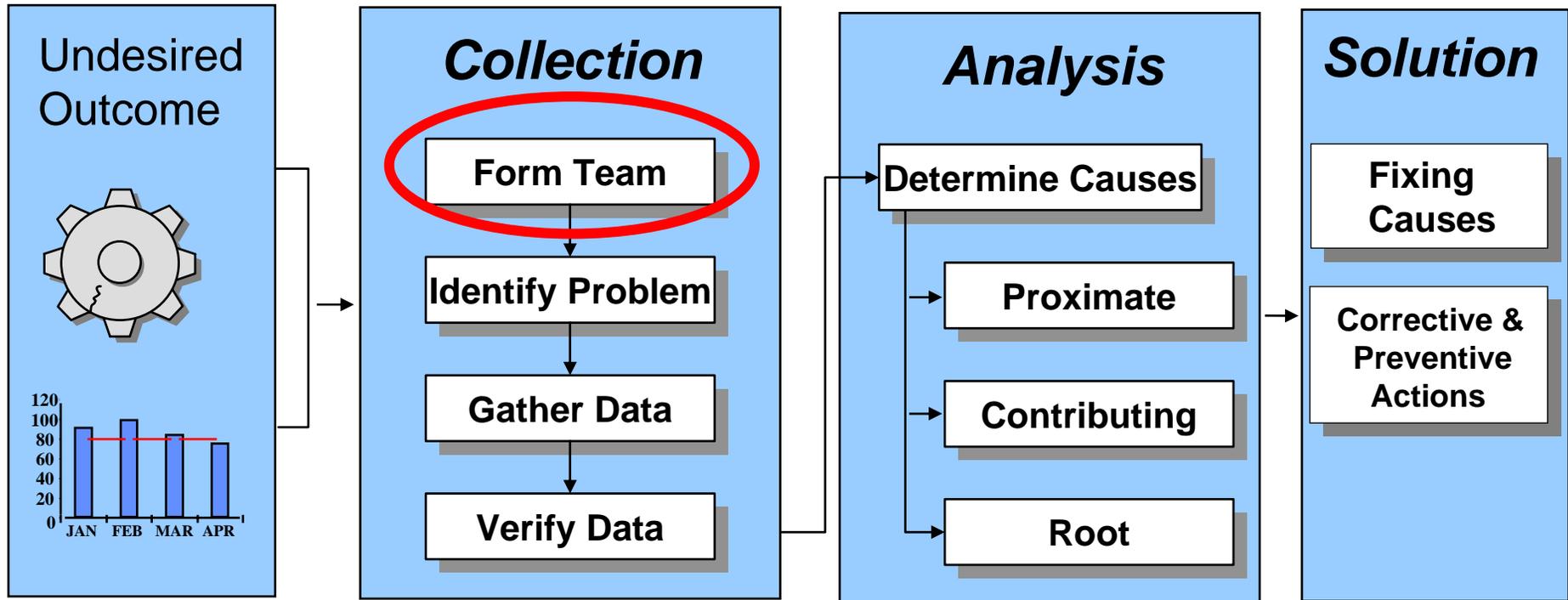
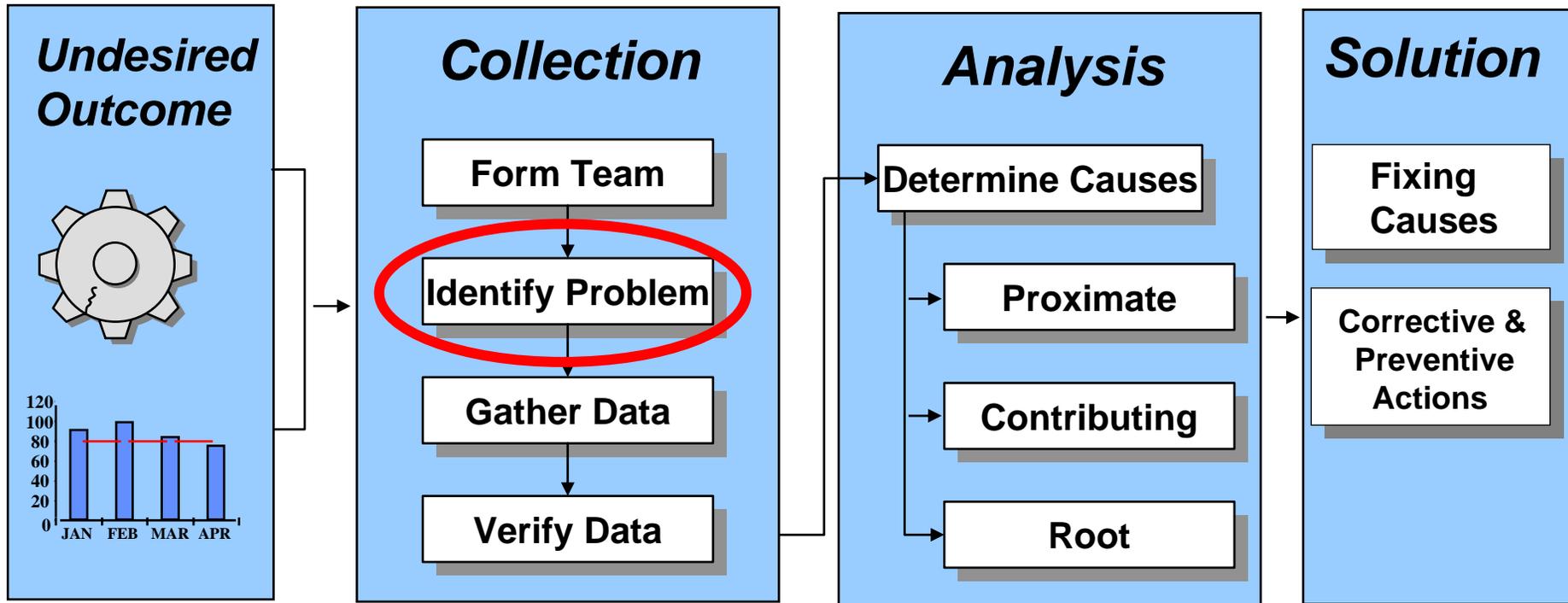# *Team Members*

Team should include

- Those capable of identifying the problems and causes

- Those having *vested ownership* of the problem to be solved

- Others who can provide resources & knowledge to help in the root cause process

Root Cause Analysis process

Undesired Outcome

Collection

Form Team

Identify Problem

Gather Data

Verify Data

Analysis

Determine Causes

Proximate

Contributing

Root

Solution

Fixing Causes

Corrective & Preventive Actions

Collection Step– Identify the Problem

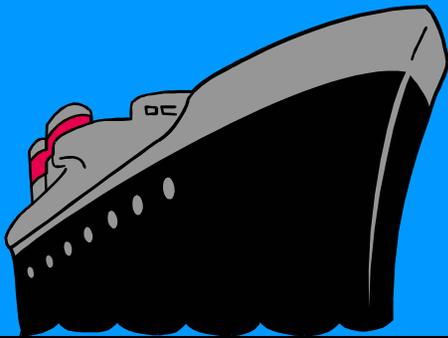Understand the problem (is there more than one?)

Why did the ship hit iceberg?

Why did the people perish?

Why did the ship sink?

Root Cause Analysis process

Undesired Outcome

Collection
- Form Team
- Identify Problem
- Gather Data
- Verify Data

Analysis
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- Contributing
- Root

Solution
- Fixing Causes
- Corrective & Preventive Actions
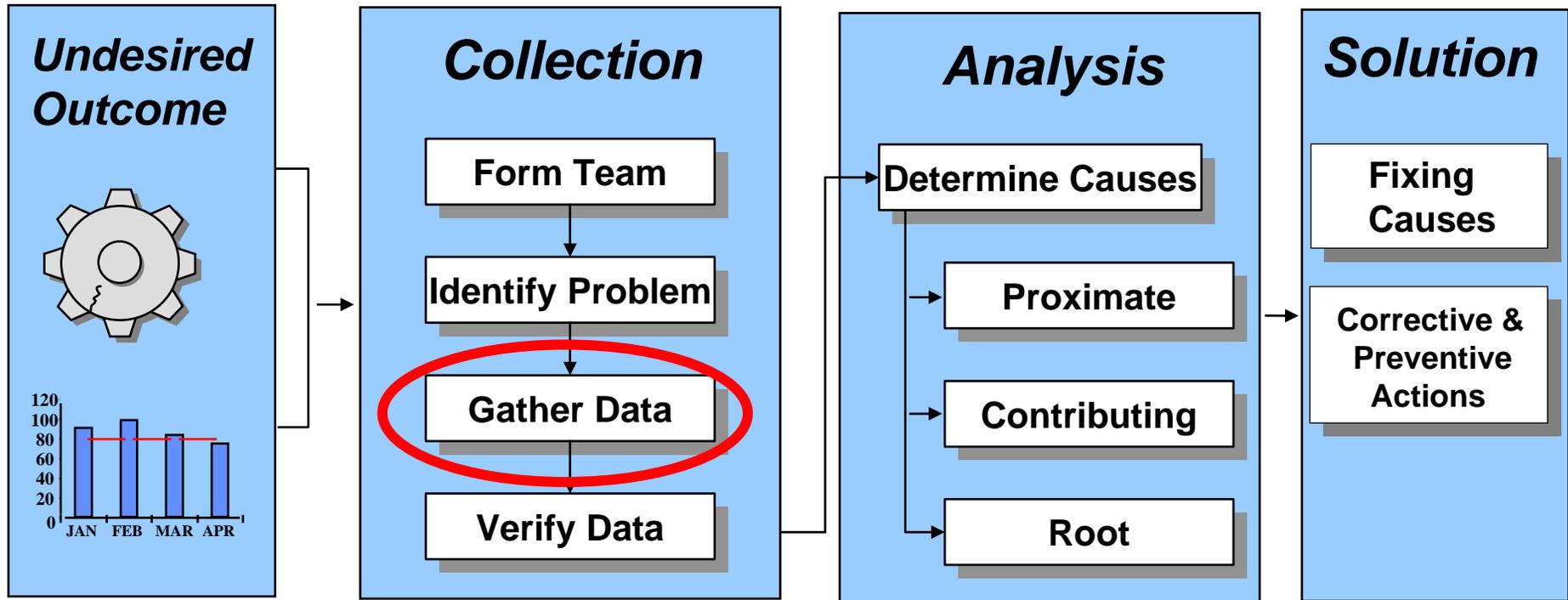
Collection Step– Gather Data

Data to Consider:

- Location (Where)
- Names (Who)
- Roles/Functions
- Time (When)
- Conditions (operating/environmental)
- Instructions (How)
- Equipment
- Physical Evidence
- Recent Process Changes
- Degree of Training

Data collection is done by team members

Collection Step– Gather Data

Methods:

Photographs

Interviews

Recording Objective Evidence

Collection Step– Gather Data

Don't forget to ask….what role did organizational factors play?

- Policies and Procedures
- Resource constraints
- Processes
- Infrastructure
- Systems
- Operating Instructions
- Training
- Management Processes
- Others…

Collection Step– Gather Data

- Event: Window Broken

- Event Question: Why did window break?

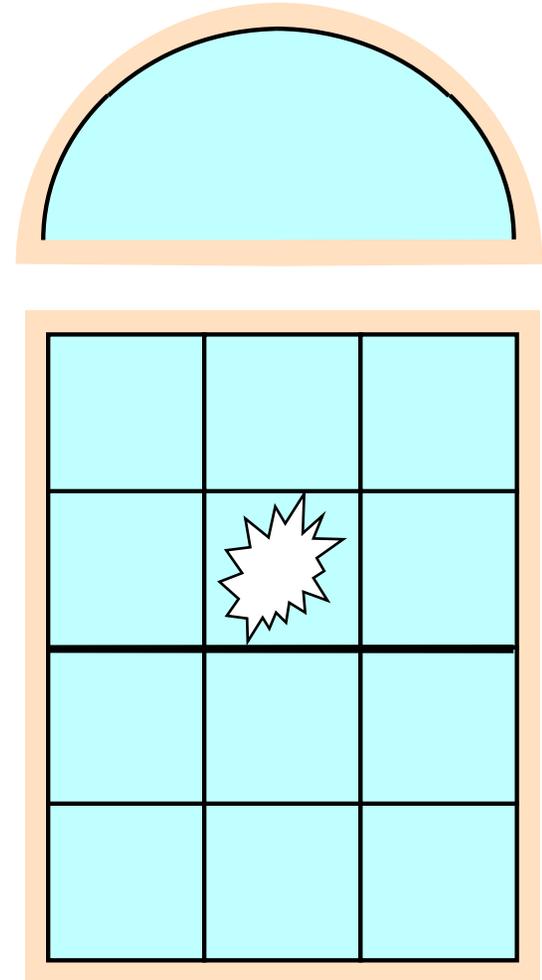- Data to Collect:

  _____

  _____

  _____

- Team:

  _____

  _____

  _____

Collection Step– Gather Data

- Event: Window Broken
- Event Question: Why did window break?
- Data to Collect:

  Visual evidence, interviews with children/neighbors, police report, insurance report

- Team:

  Mom, Dad, children, neighbors, police

Root Cause Analysis process

Undesired Outcome

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Fixing Causes
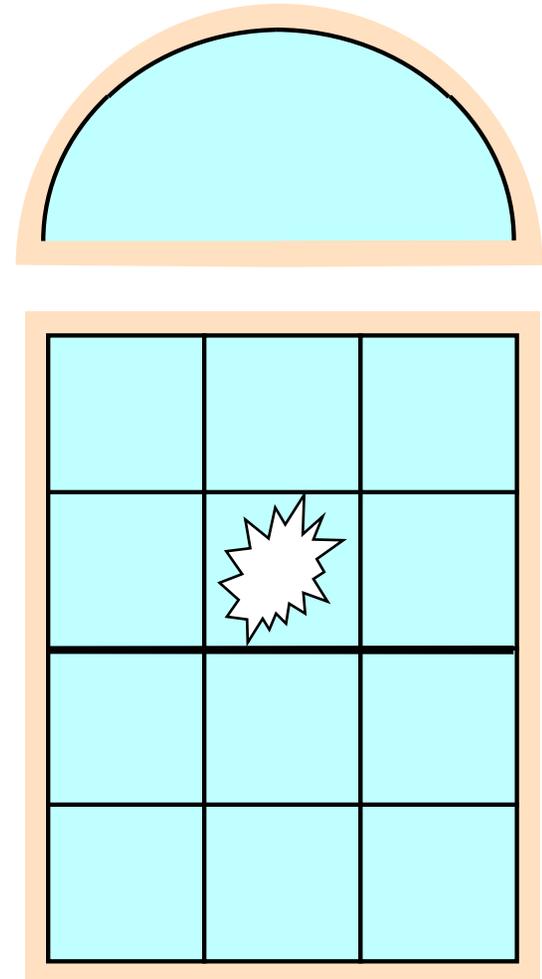
Corrective & Preventive Actions
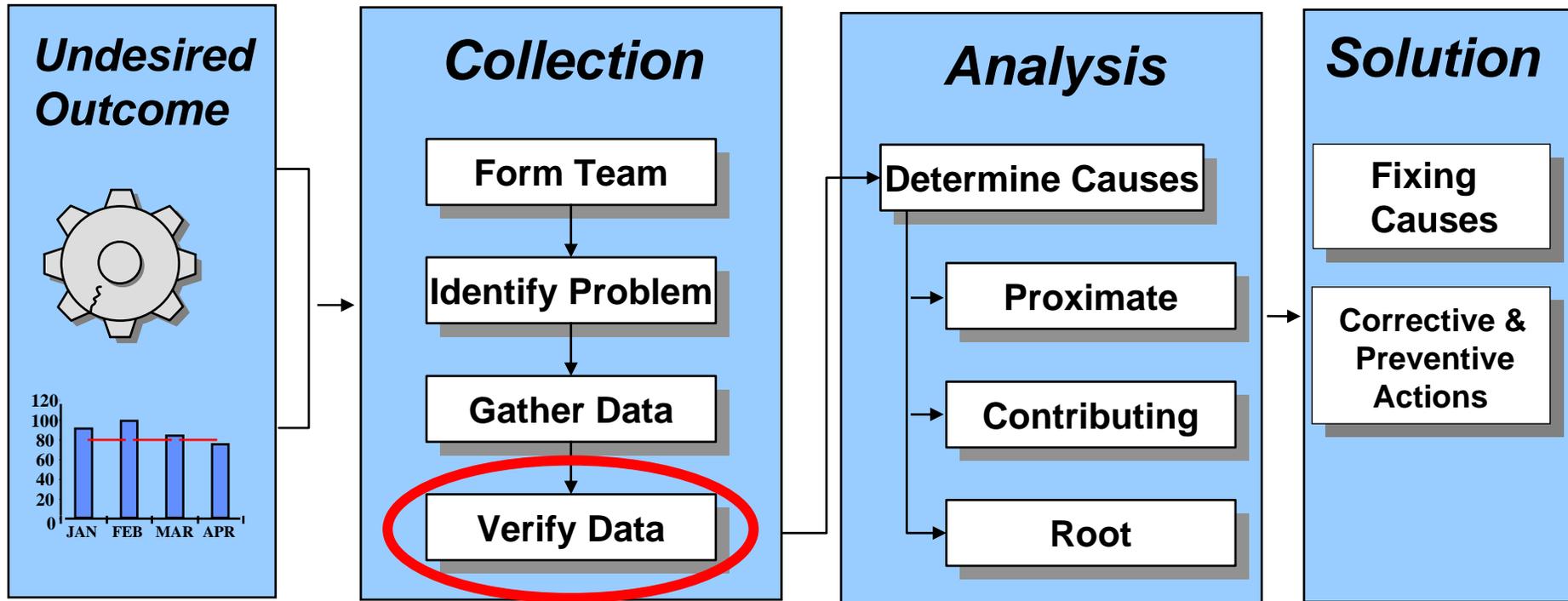
Collection Step - Verify the Accuracy of the Data!

- Check the accuracy

- Use multiple sources

- Note conflicting information

Root Cause Analysis process

Undesired Outcome

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Solution
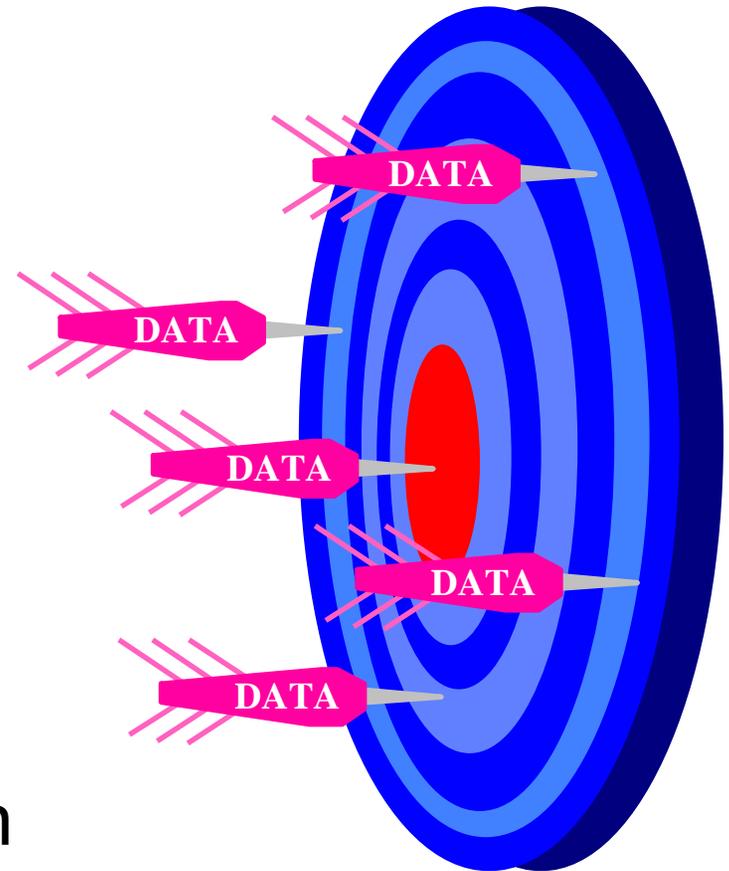
- Fixing Causes
- Corrective & Preventive Actions
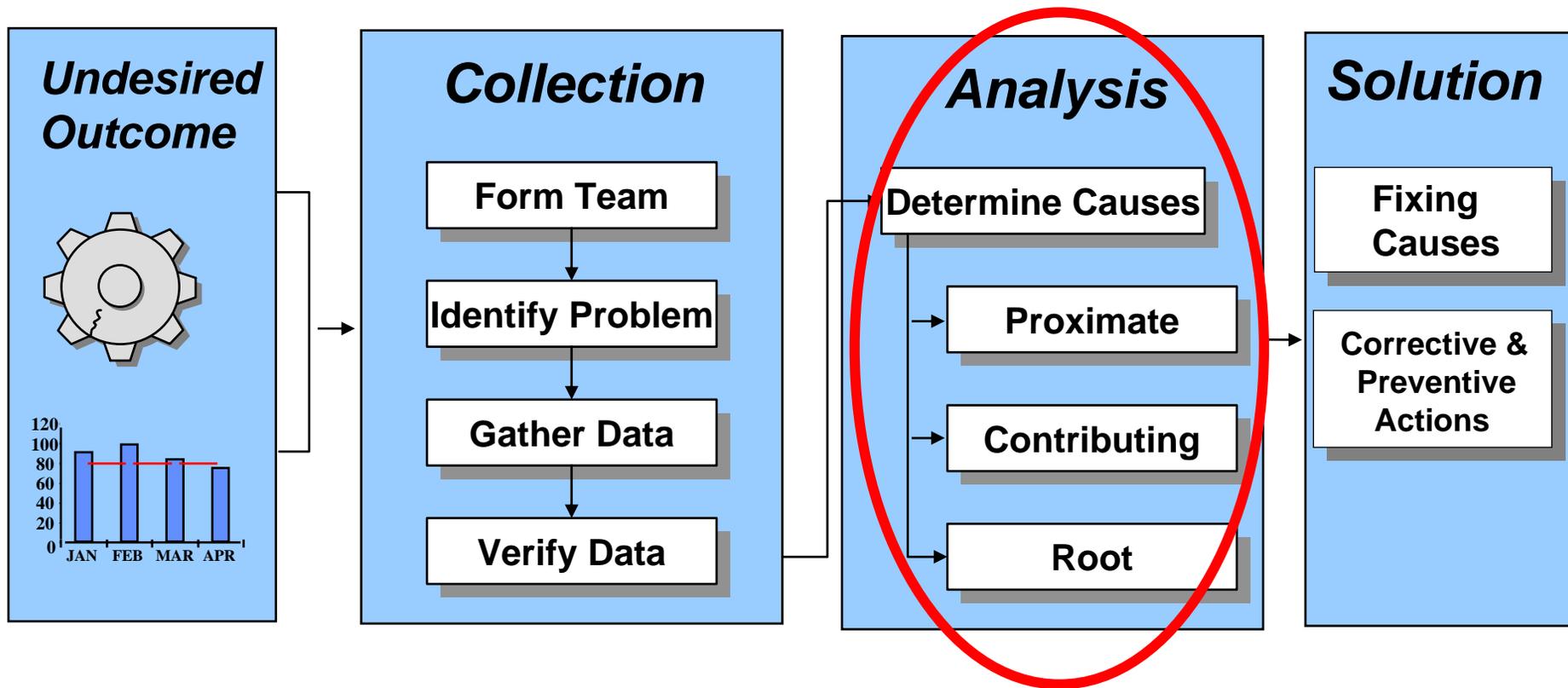
Analysis Step – Determine Causes

Root Cause Analysis simply asks the question…

Why?

….enough times to find the root cause

Definitions

- **Undesired Outcome**
  - That which went bump during the night

- **Proximate Cause**
  - The event(s) that occurred, including any condition(s) that triggered the undesired outcome

- **Contributing Cause**
  - The event(s) or condition(s) that may have contributed to the occurrence of an undesired outcome but, if eliminated or modified, would not by itself have prevented the occurrence.

- **Root Cause**
  - The event(s) or condition(s) that led to the proximate cause and subsequent undesired outcome and, if eliminated, or modified would have prevented the undesired outcome.

Definitions - Example

- UNDESIRED OUTCOME: Didn't get to work on time
  - Event Question: Why were you late?

  - Car wouldn't start
    Why wouldn't the car start?

  - Battery was dead (Proximate Cause)
    Why was the battery dead?

  - Dome light stayed on all night
    Why was the light on all night?

- ROOT CAUSE: Kids played in car and left door ajar

Key Concept:

The corrective action is different depending on where you stop (proximate cause or root cause) !

Analysis Step – Determine Causes

Timeline of causes leading to event

| Root Cause | ← | Contrib. Cause | ← | Proximate Cause | ← | Event Question |

Direction in which to uncover causes

Basic Reason(s) for Event

May Feed Proximate Cause(s)

Triggers the Event
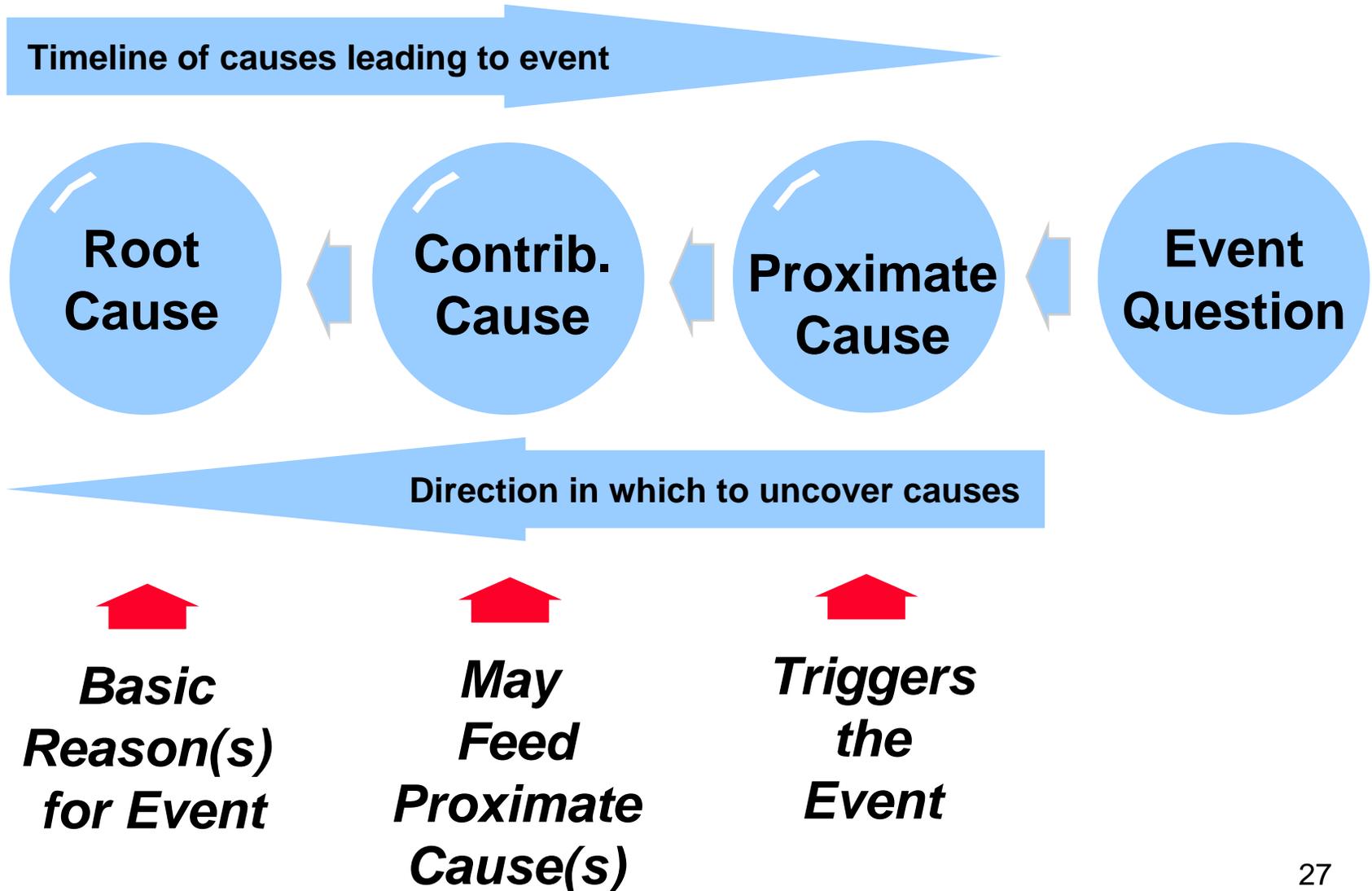
How Many Why's?

Not Effective   **Silly**
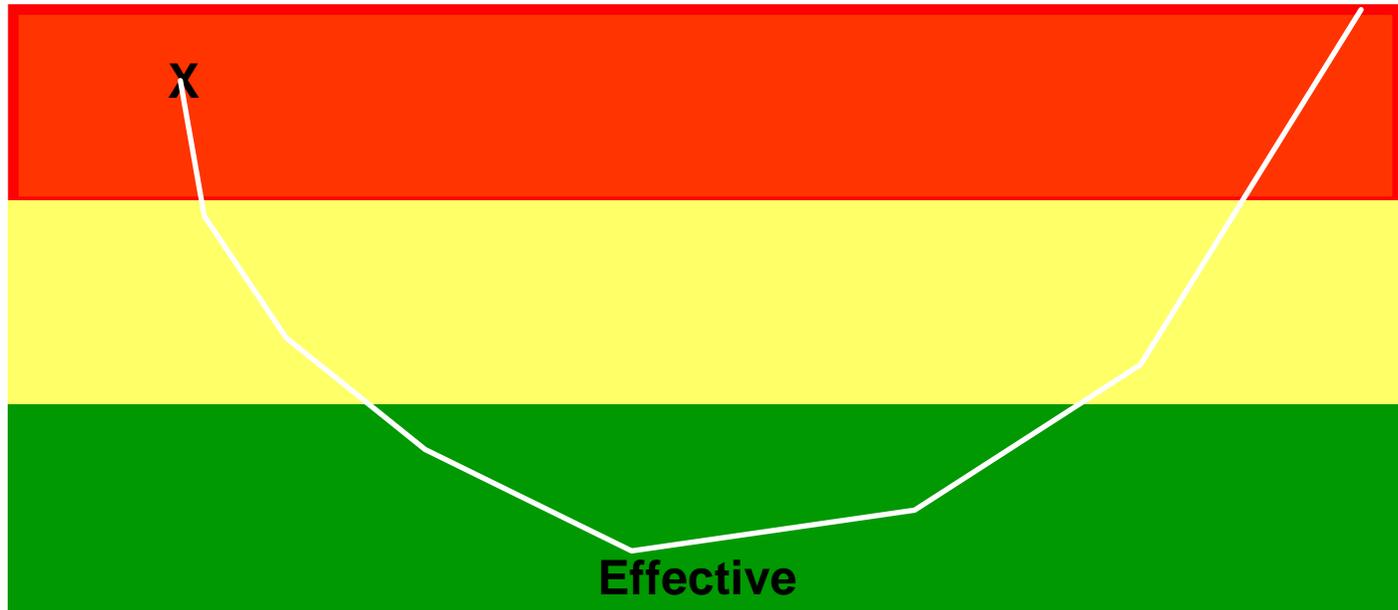
Number of Times "Why" is asked

- Simply ask "Why" a sufficient number of times to understand the cause(s) behind the problem
- Take actions to address causes

Exercise #3 – How many Why's?

↳ Received ticket for safety violation.

  ↳ Car exhaust too loud.

    ↳ Muffler knocked loose from tail pipe.

      ↳ Daughter hit pot hole.

        ↳ Pot holes in road.

          ↳ Winter-damaged roads.

At what point in this analysis have we gone far enough?

            Congress won't approve more $
            ↰ for better roads.

          ↰ Congress doesn't have extra $.

        ↰ Congress spent $$ on pork barrels.

      ↰ Too many lawyers in Congress.

  Solution? Drive car in Sweden where there are fewer lawyers

Exercise #4 – Doing robust analysis

- Undesired Outcome
  - Board failed functional test
    - Bad solder joint

- Root Cause
  - Soldering iron temperature was too low

- Corrective Action Taken
  - Changed test procedure to call out higher temperature

- What other questions would you have asked?

Different Approaches to Determining Cause

Fishbone Diagram

Process
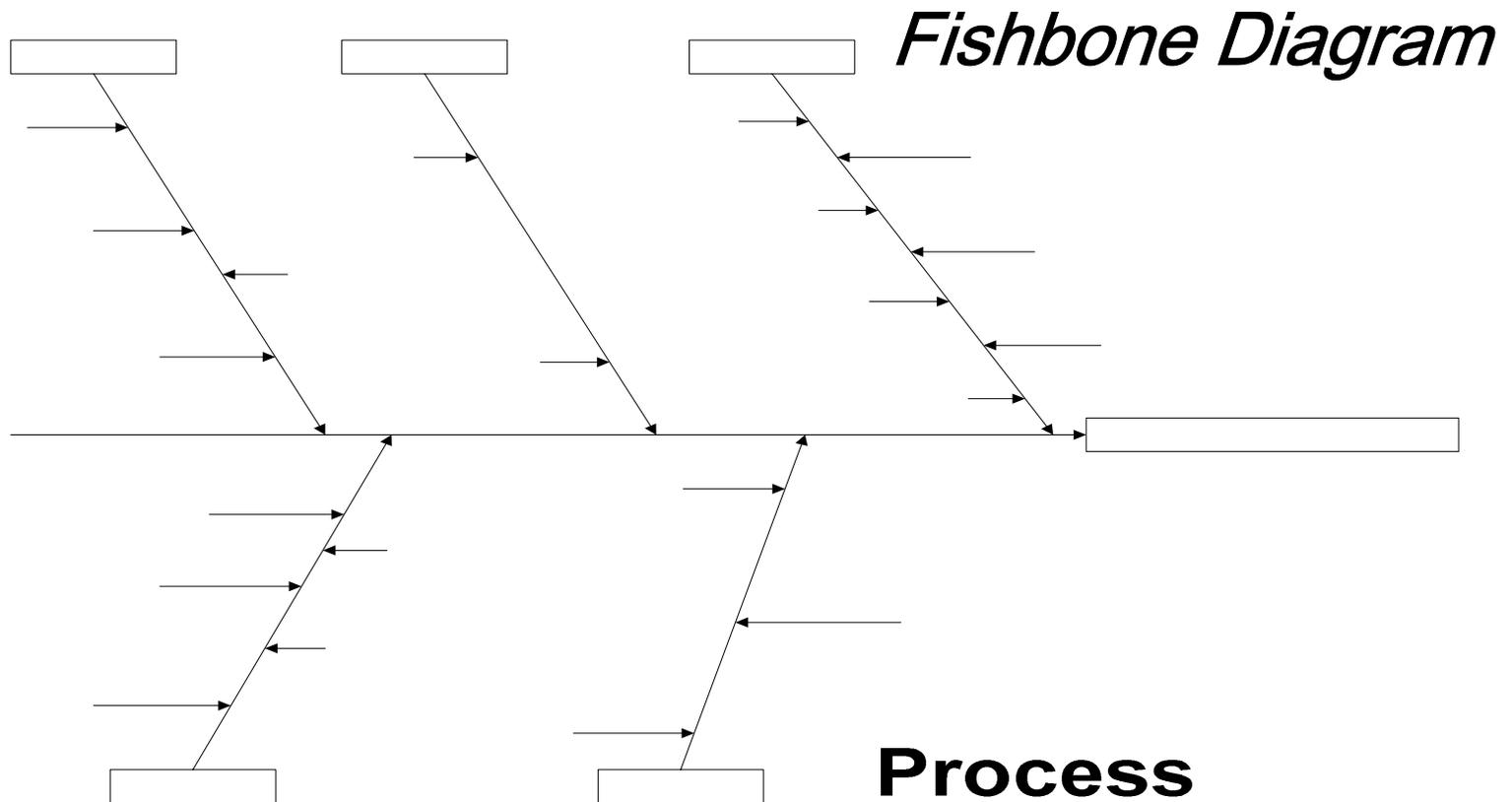
- Brainstorm all relevant factors and group into categories
- Depict the possible causes graphically
- Determine proximate, contributing, and root causes
- Take actions to address causes

Chambers purchased
w/o ETL involved

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Fault Tree Approach

Different Approaches to Determining Cause

Cause Chain

Event Question

Proximate Cause

Contributing Causes

Root Cause
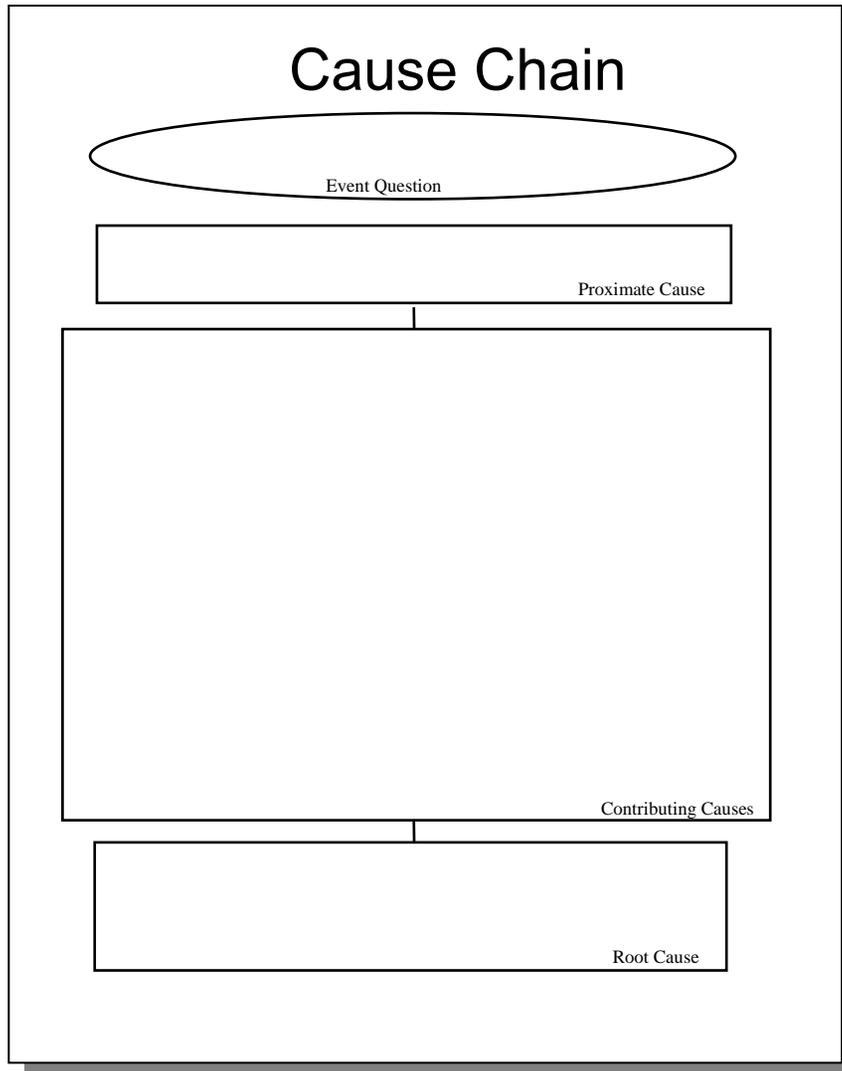
"Cause Chain" - introduced in this course

Another tool to better organize causes and distinguish between proximate, contributing and root.

Exercise #5:

Identify the proximate (P), contributing (C), and root (R) cause (s) for the following:

Event: During thermal vacuum testing, the high voltage amplifier (HVA) experienced a shutdown

Event question: Why did the HVA shutdown?

Investigation Revealed:

_____ Potting compound for key leads and terminals was only partially cured, reducing dielectric strength

_____ Potting was done in new facility that did not have verifiable temperature controls and no nitrogen backfill

_____ Grid and filament were found to be arcing to each other

_____ Sealing compound (used to seal the mold for curing), was present in the potting mix (silicon base in sealing compound prevents proper cure)

_____ Schedule pressures dictated the use of the new facility

_____ The teflon mold used for potting was distorted

Exercise #5:

Identify the proximate (P), contributing (C), and root (R) cause (s) for the following:

Event: During thermal vacuum testing, the high voltage amplifier (HPA) experienced a shutdown

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Investigation Revealed:

___C___ Potting compound for key leads and terminals was only partially cured, reducing dielectric strength

___C___ Potting was done in new facility that did not have verifiable temperature controls and no nitrogen backfill

___P___ Grid and filament were found to be arcing to each other

___C___ Sealing compound (used to seal the mold for curing), was present in the potting mix (silicon base in sealing compound prevents proper cure)

___R___ Schedule pressures dictated the use of the new facility

___C___ The teflon mold used for potting was distorted

Cause Chain

Why did the HVA shutdown?

Event Question

Grid and filament were arcing to each other

Proximate Cause

Potting compound for key leads and terminals was only partially cured, reducing dielectric strength

Sealing compound (used to seal the mold for curing), was present in the potting mix

Potting was done in new facility that did not have verifiable temperature controls and no nitrogen backfill

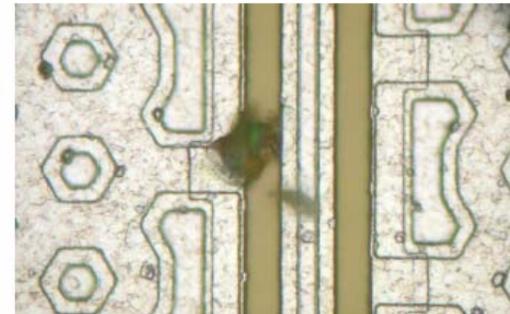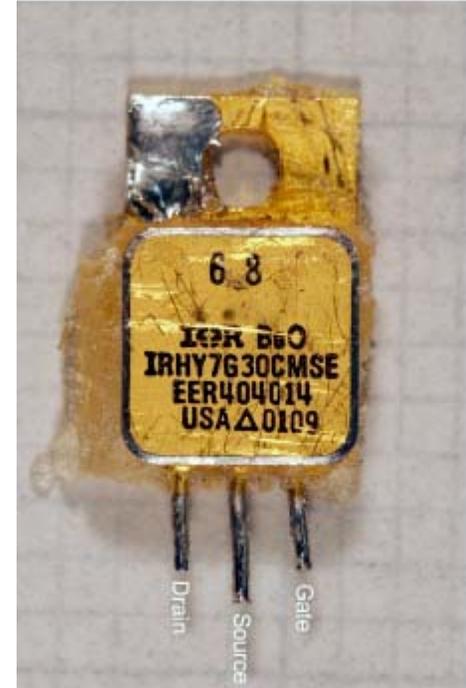The teflon mold used for potting was distorted, allowing sealing compound to mix with potting compound

Contributing Causes

schedule pressures dictated the use of the new facility

Root Cause

Exercise #5:

The Cause Chain

Is The Cause Chain Correct?

Test the chain by
trying it backwards.

Ask ...
"Does it follow that
(this cause)
leads to the
(previous cause)?"

Event

Cause

Cause   Cause

Cause
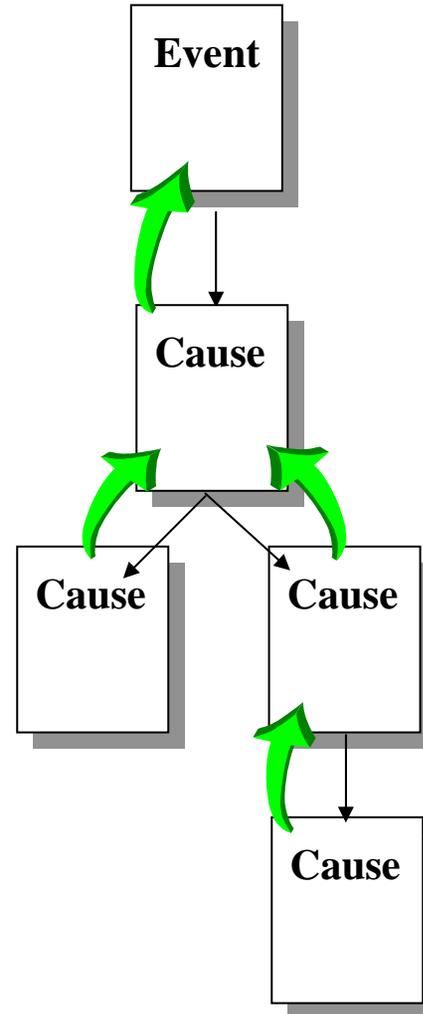
Exercise #6

- Event: During performance testing of the radar at 16kbps, errors were noted in the spacecraft telemetry display. The same test run at 4kbps was successful.

- Investigation Revealed:
    - Interface Control Drawing requirement stated that rate be command-able to "either 4 or 16 kbps"
    - Circuit was designed to operate at 4kbps
    - Designer interpreted "either" to be whichever one he wanted (would work with the system)

Cause Chain
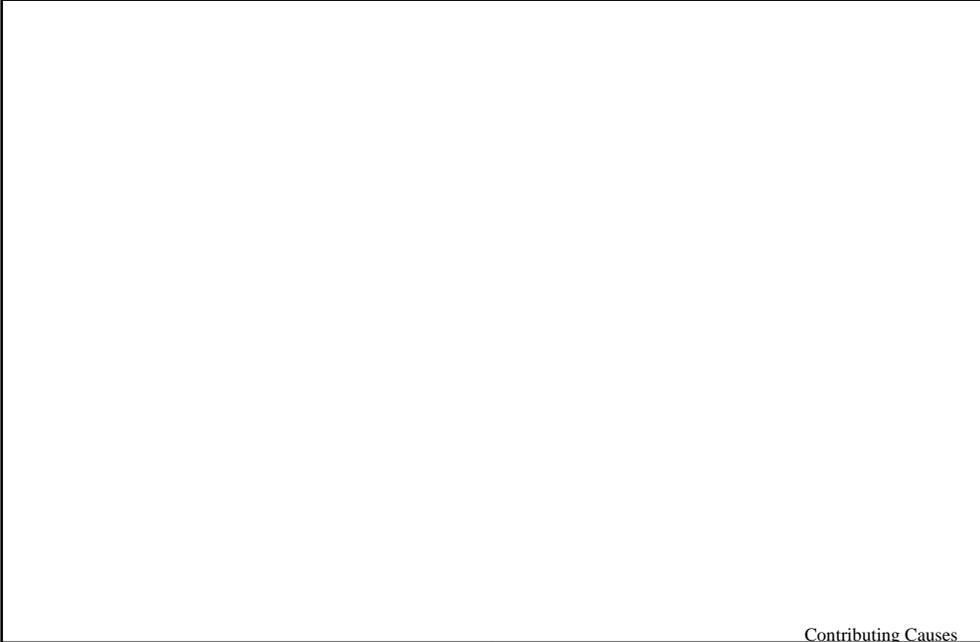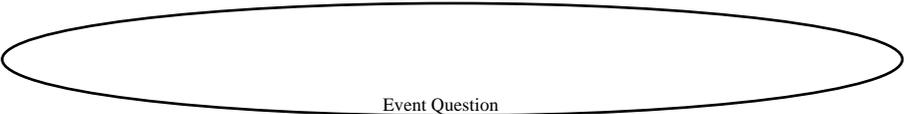
Complete a cause chain for Exercise #6

Event Question

Proximate Cause

Contributing Causes

Root Cause

Documenting RCA Results

• Regardless of the type of problem, the RCA process described herein can be used

• How you choose to analyze for root cause is up to you (fault trees, fishbone, etc), however:

> • The RCA documentation should accompany your problem report to show logic used in developing root cause.

Root Cause Analysis process

Undesired Outcome

Collection

- Form Team
- Identify Problem
- Gather Data
- Verify Data

Analysis

- Determine Causes
- Proximate
- Contributing
- Root

Solution

- Corrective & Preventive Actions
- Fixing Causes
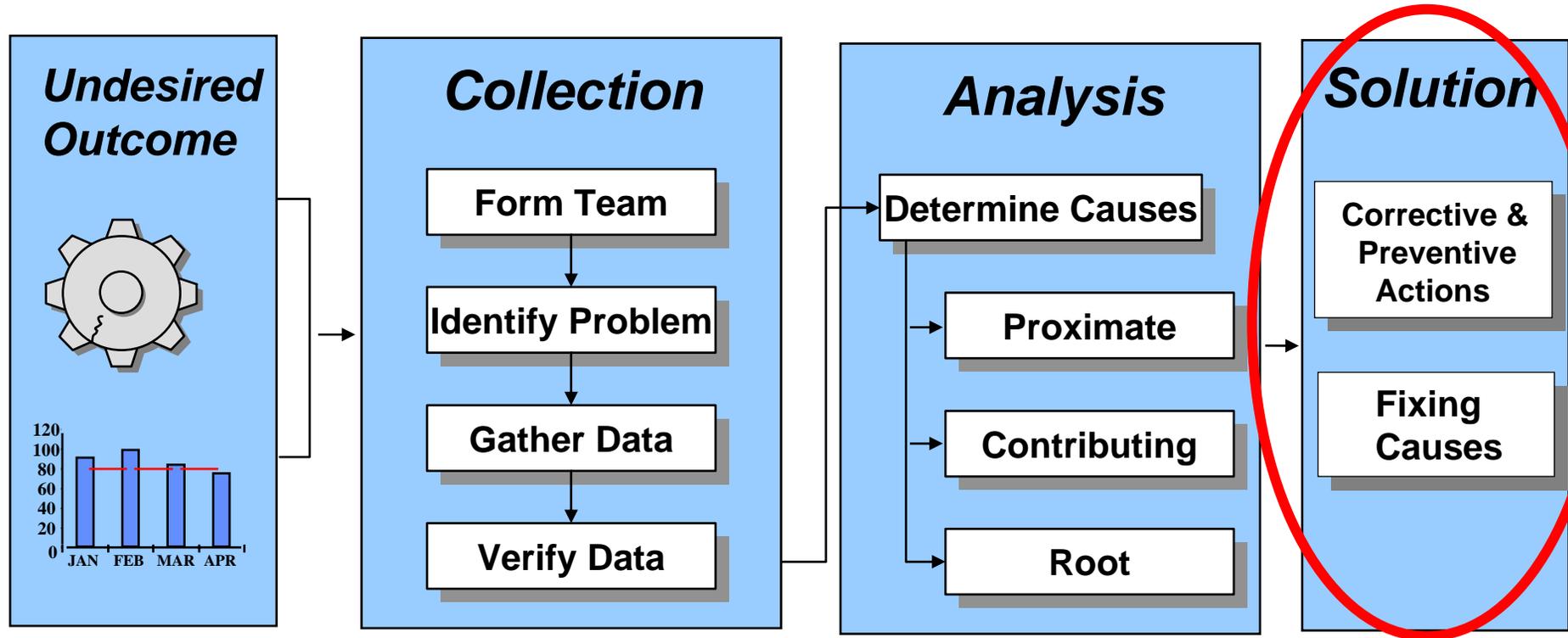
Solutions Step

- It's not enough that we know the cause(s), now we have to fix the cause(s)

- The fix for the cause(s) needs to be:
  - Appropriate for the magnitude and the risks of the problem
  - Bounded:
    - Clear understanding of what is being fixed
    - Is the scope across individual, group, section, project, etc. ?
    - *"Why's"* needs to be answered
  - Documented
  - Implemented in a timely manner
  - Effective: It prevents recurrence of the problem, over time
  - Evaluated for effectiveness

Root Cause Analysis Process Summary

Undesired Outcome

Collection

- Form Team
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- Proximate
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Solution

- Fixing Causes
- Corrective & Preventive Actions
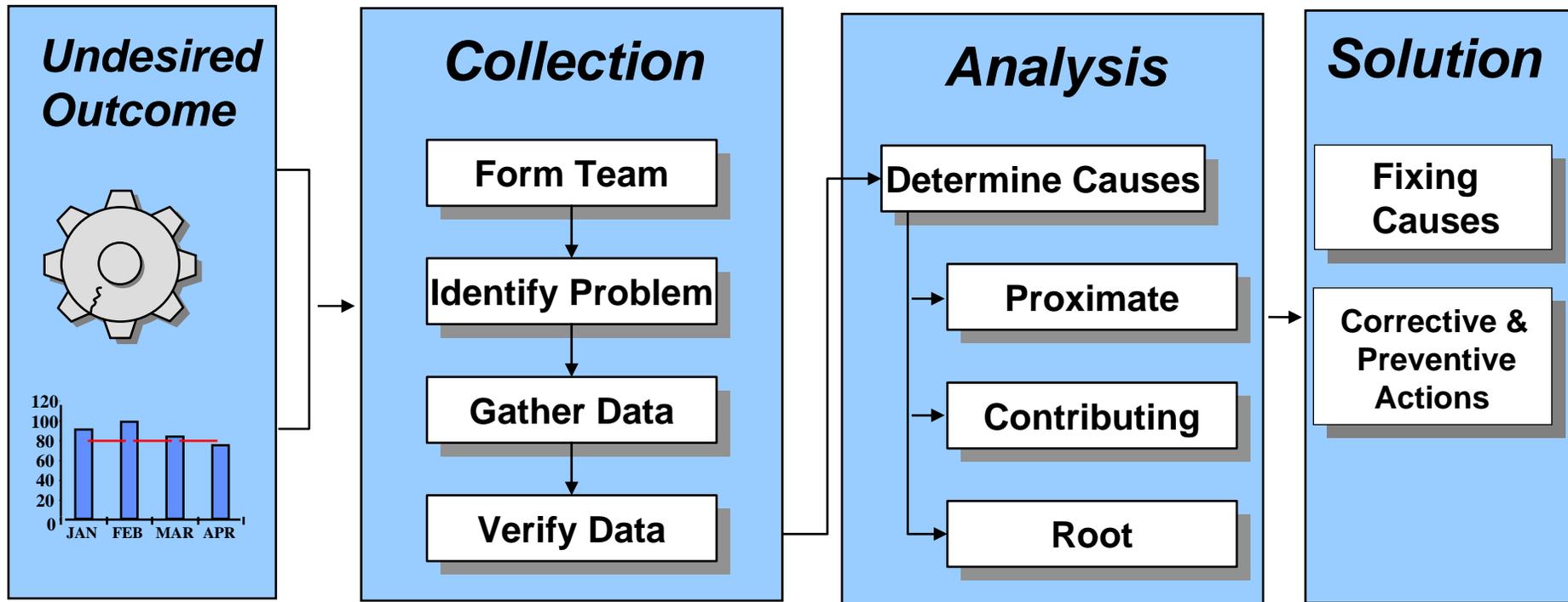
Frequently Asked Questions

- **Whose job is RCA?**
  - Answer: Everyone's

- **Do I HAVE to do Root Cause Analysis on every problem?**
  - Answer: No, however you should solve problems with the intent to prevent them from recurring and should be able to explain the proximate cause versus root cause of the problem

- **Do I HAVE to use the Cause Chain?**
  - Answer: No, the cause chain is just another tool, but it is a good way to organize your RCA logic

- **What should I do if I suspect that my problem has an institutional/company root cause that I cannot or should not fix?**
  - Bring the problem to you management, or a person responsible for corrective actions within your company. This will result in a Corrective Action Notice (CAN), in which upper management will be required to resolve, conduct additional review for RC and prevent. Make sure your documentation is complete and understandable.

Frequently Asked Questions, con't

- **How do I learn more about root cause analysis tools like the fishbone, etc?**
    - Answer: visit the web (google Root Cause Analysis) and read up on current thinking and training opportunities
    - Answer: visit www.goalqpc.com and purchase a "Memory Jogger" booklet
    - Answer: Periodically, the NASA Quality Suppliers intranet may have updates on RCA. Visit:
      https://secureworkgroups.grc.nasa.gov/qualitysuppliers

- **How can I do RCA better?**
    - Practice, practice, practice (apply the check-sheet)

Root Cause Analysis: Whose Job is it anyway?

Your Responsibilities

- Investigate problems to determine proximate cause

- Continue to ask "why?" until you have reached a reasonable, actionable level

- Ask questions during the investigation regarding training, procedures, facilities, methods, equipment, etc (use the check-sheet for help)

- Investigate the problem far enough to expose a process related root cause if there is one (you do not have to figure out what the root cause is within that process)

- If job-related cause(s) is identified, implement corrective and preventive action for that cause(s).

- Thoroughly document proximate, contributing and root causes on the problem/anomaly report

- If process-related root cause is confirmed or is strongly suspected

Process Responsibilities

- Identify the exact root cause within the process and determine the action required to correct the cause and prevent the cause from recurring

- Implement the corrective and preventive action.

- Thoroughly document your actions on a CAN or other report.

Case Studies
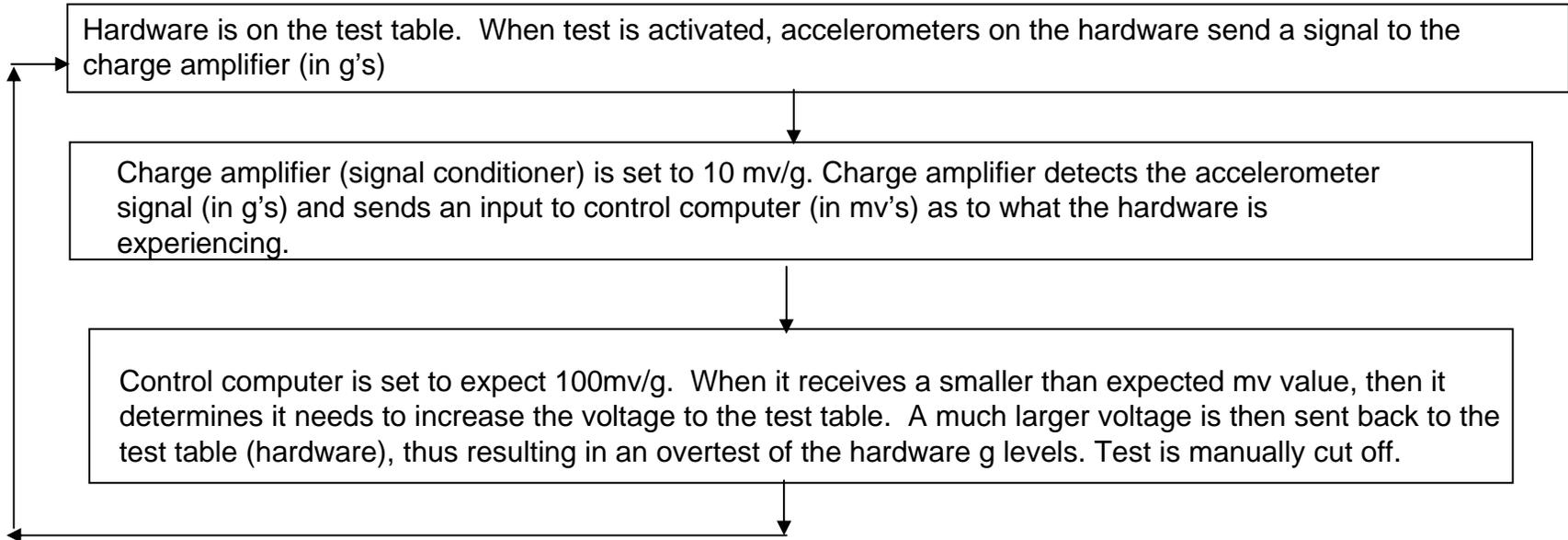
Case Study #1 – Test Lab

- During a laboratory vibration test, an assembly mass model of flight hardware was damaged
- The mass model consisted of two aluminum blocks mounted on a honeycomb structure. The honeycomb structure part of the mass model is considered "flight" hardware.
- The mass model was mounted on top of a series of transducers to map the force during the test.
- The first run was to consist of 30 seconds of data at the specified vibration level.
- The control computer was programmed to receive a signal from the control accelerometers with a sensitivity of 100 mv/g.
- The signal conditioner/charge amplifier that converts the charge from the accelerometer to a voltage that the control computer can use, was set to a sensitivity of 10 mv/g.
- This resulted in the vibration occurring at a level 10 times higher than called for. (The shaker should have delivered 1.3 grms, but instead delivered 13 grms)
- The test was manually shut down after approximately 2.5 seconds.
- The honeycomb structure of the mass model was damaged.

See next chart for more details

Case Study #1 – Test Lab

Test happened as follows:

Hardware is on the test table. When test is activated, accelerometers on the hardware send a signal to the charge amplifier (in g's)

Charge amplifier (signal conditioner) is set to 10 mv/g. Charge amplifier detects the accelerometer signal (in g's) and sends an input to control computer (in mv's) as to what the hardware is experiencing.

Control computer is set to expect 100mv/g. When it receives a smaller than expected mv value, then it determines it needs to increase the voltage to the test table. A much larger voltage is then sent back to the test table (hardware), thus resulting in an overtest of the hardware g levels. Test is manually cut off.

See next chart for more details

Case Study #1 – Test Lab

The investigation revealed the following information:

- There were two operators in the control room when the test was run. Both operators have about 10 years experience running these kinds of tests. There were no other personnel present during the test nor were there any requirements to have other personnel (including QA inspection) present during the test because the test was being run on a "mass model".
- The operators used the correct procedure for running the test and the values used had been properly specified by the cognizant engineer. A checklist was not used to verify the settings because the hardware was a mass model.
- The vibration test room is adjacent to a second vibration test room, however both rooms are run out of the same control room (see diagram below). Different computer screens in the control room are used for each room.
- The charge amplifiers for each vibration room are adjacent to each other in the control room. There are no labels on the charge amplifiers or computers. By reviewing the data on the charge amplifiers, the investigation revealed that the correct value for the test was entered, however it was entered into the wrong amplifier.
- The procedures noted the hardware was a "mass model" however the operators did not know that the honeycomb structure part of the model was considered flight hardware.
- There was a safety survey done prior to initiation of the test. The safety survey did not reveal that critical hardware (in this case flight hardware), was part of the mass model.
- There were no limits to prevent the hardware from being damaged should an over-test occur, because this was a mass model.
- No "bare table" test run was done because this was a mass model
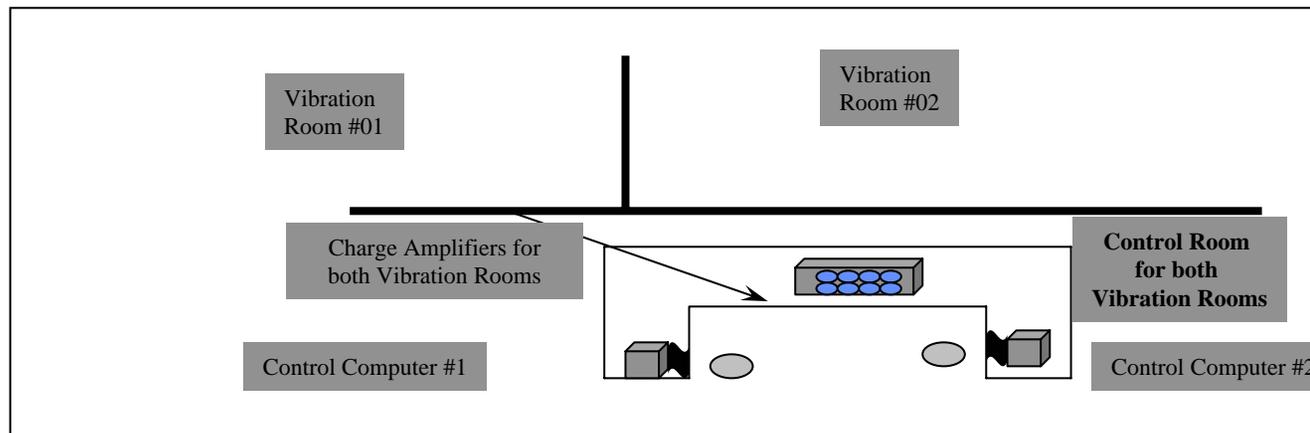
Test Lab Facility Diagram

Case Study #1

Activity:

1. Complete a cause chain on this problem identifying the event question, proximate cause, contributing cause(s) and root cause(s)

2. Determine whether a CAN should be generated and why/why not.

Appendices

Fixing the Causes: Changing the Process

- Understand the process by flowcharting it

- Clarify, re-order or restructure the process

- Drop non-value added steps from the process

- Make the process "goof proof"

- Periodic evaluation by manager, supervisor, or technical expert

- Form an on-going technical or business advisory group across Divisions where beneficial

- Set up metrics to drive the right actions in the process

- Others?
  - You bet !

Fixing the Causes: Documentation & Records

- Update or create documents where needed

  - Project documentation

  - Requirement documents

  - Procedures

  - Specifications

  - Handbooks and Guidelines

  - Forms/templates

- Submit updates to Process Document Owners

- Others?
  - You bet !

Fixing the Causes: Education & Training

- Infuse your solution into company training as appropriate:
  - Project Manager / Manager classes
  - Engineer classes
  - Supervisor classes
  - New Employee / Employee training classes
  - Safety Training classes
  - Other Human Resource classes

- Local training

- Mentoring

- Staff meeting, Team meeting, All-hands Employee meetins, etc.

- Provide recurrent training where needed

- Others?
  - You bet !

Fixing the Causes: Written Communication

- Awareness e-mails

- Directive e-mails

- Notice from System Safety to Mission Assurance Managers, Company President, Management

- Group wide, Section wide, and/or Division wide IOMs

- To Manager

- Others?
  - You bet !