Guide to Root Cause Analysis

Version 1.0
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Revision History

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1. Introduction

Root Cause Analysis (RCA) has become among the most effective, reliable methods in modern quality-oriented industry in identifying the likeliest causes of accidents and recurring effects or phenomena of an unwanted nature. It is a tool which can help professionals from various backgrounds identify causes to a given failure and home in on the most probable cause(s) based on factual information to devise a resolution that will greatly reduce the effect, or that may completely eliminate it, with high confidence.

In a growing firm that involves product development, manufacturing, quality activities, and other services, unwanted situations which consume resources and tend to happen in a repeated fashion are more of a norm than the exception. Necessity dictates that it is beneficial to figure out what really is causing the situation to occur and remove it so the situation does not occur again. RCA is the tool to finding a realistic cause for the problem effectively and efficiently.

The key is describing the problem, per se, clearly rather than just the underlying, observable effect. Then using a process-based analysis, you can drive to an effective resolution which you can implement and institute.

The focus of this paper is to formalize our root-cause investigation activities in a structure that is more compatible with industry standards by:

1. Explaining the method.
2. Describing the cause-and-effect tool.

It is not my intent for this paper to be a comprehensive RCA manual. Rather, a brief, straight-to-the-point guide to identifying causes of systematic failures for training and working experience. Nevertheless, the paper is structured such that a step-by-step execution guide is facilitated. Most importantly, the objective is to provide you with the knowledge and understanding of the RCA Method and encourage you to use it in your future continuous improvement work.

2. The Cause and Effect (a.k.a fishbone) Diagram

This tool lets a group start with an "effect" – a problem, or in some cases a desired effect or result – and create a structured list of possible causes for it. It is a great tool for gathering group ideas and inputs, being basically a structured brainstorming method. By establishing categories of potential causes, it helps ensure that a group thinks of many possibilities rather than just focusing on a few typical areas (e.g. people, bad material).

Just like any process with input (X) and output (Y) variations, we can apply the same principle of X and Y to the fishbone model: the "effect" or problem is the Y, and the possible root causes that appear on the "bones" are the Xs. See Figure 1.
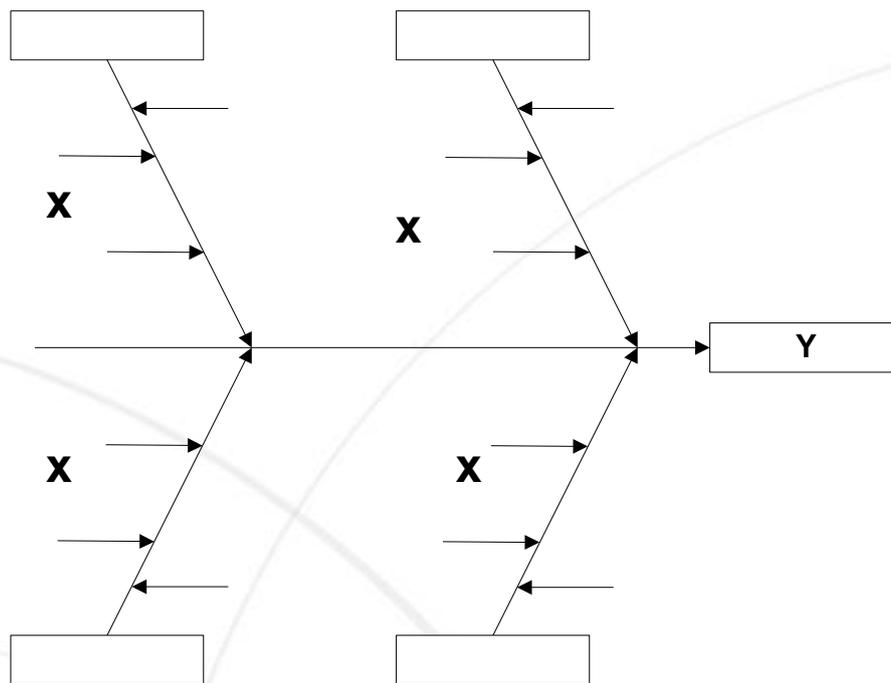
FIGURE 1. A FISHBONE SKELETON

As we move deeper into root cause analysis, we'll likely be examining all of these potential causes of variation so as to target the so-called "vital few" Xs, or causes, that contribute most to the problem.

It is essential to understand that an effective RCA activity is as good as the C&E Diagram. Therefore, it is important to understand some of the characteristics of a "good" C&E diagram.

- Statement in Effect Box is the Conclusion Statement (fat rabbit from the lowest level Pareto) of defect identification activity (e.g. TQM 7-Step)
- The word 'Why' is not the effect box (statement of effect, not a question).
- Has a minimum of 4 branches.
- Each 'Why chain' goes 5 Whys where possible.
- There is a clear logical connection between each level in a 'Why chain'.
- Selected root causes are identified on the diagram (typically by circling the statements).
- Selected root cause(s) are verifiable (using data).
- Selected root cause(s) are directly controllable by the team.

The RCA method relies on previous activity of failure identification and confirmation. This includes data gathering and Pareto charting. The Pareto's fat rabbit is used for the effect statement as the greatest impact.

STEP 1: PREPARE
The first step is to prepare for the Root Cause Analysis. Draw the structure of the C&E Diagram (see Figure 2 as an example) on a large board:

- Write a title.
- Draw the Effect Box, trunk, and main branch boxes.
- Write the conclusion from a defect's investigation in the Effect Box.

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Title

Broken
tires are
25% of
Roomba
returns
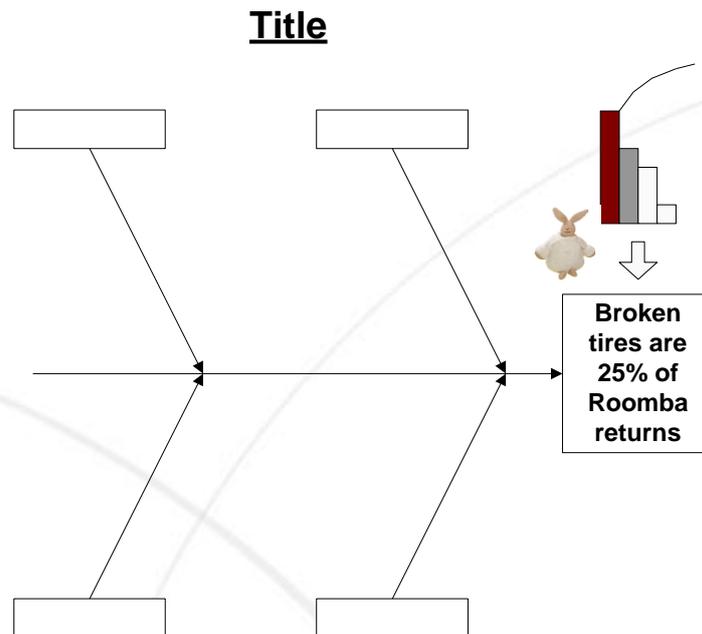
FIGURE 2. C&E DIAGRAM PREPARED

You must get into the right mindset. The conclusion from an investigation of a broken process does not explicitly or implicitly state the root cause or imply a solution. Furthermore, the customer input is understood and accepted without denial. Remember, the customer is NOT the root cause; data will be used to get to the root cause.

STEP 2: LIST

The second step is to list all possible causes and scrub down to start marking up the diagram. The purpose is to identify any cause the team can think about then categorize them and place them appropriately where they belong under the main branch headings of the fishbone.

- Begin by answering the question 'What could be causing the effect?' See Table 1 for a list of categories.
- You can use various techniques such as free-wheel brainstorming or process flow diagrams to collect as many causes as possible. The team must avoid critiquing each other or analysis of ideas. At this stage it is a matter of quantity, not quality.

The Ms	The Ps
Machines	Plant
Methods	Process
Manpower	People
Milieu (environment)	Place
Materials	Provisions
Measurement	Policies

TABLE 1. STANDARD C&E DIAGRAM HEADINGS

- Compile all causes and categorize them according to branch headings listed in Table 1.
- Write each cause on a Post-it and place under the appropriate branch heading.
  - o   Use semantics to scrub each label: language of report, no opinions.

- o   Use ladder of abstraction: low to high.
- One main branch at a time, arrange labels (headings) on the C&E Diagram
  - o   Use logic: 'Why does this happen?'
  - o   Go down 5 whys where possible. See Figure 3 as an example.
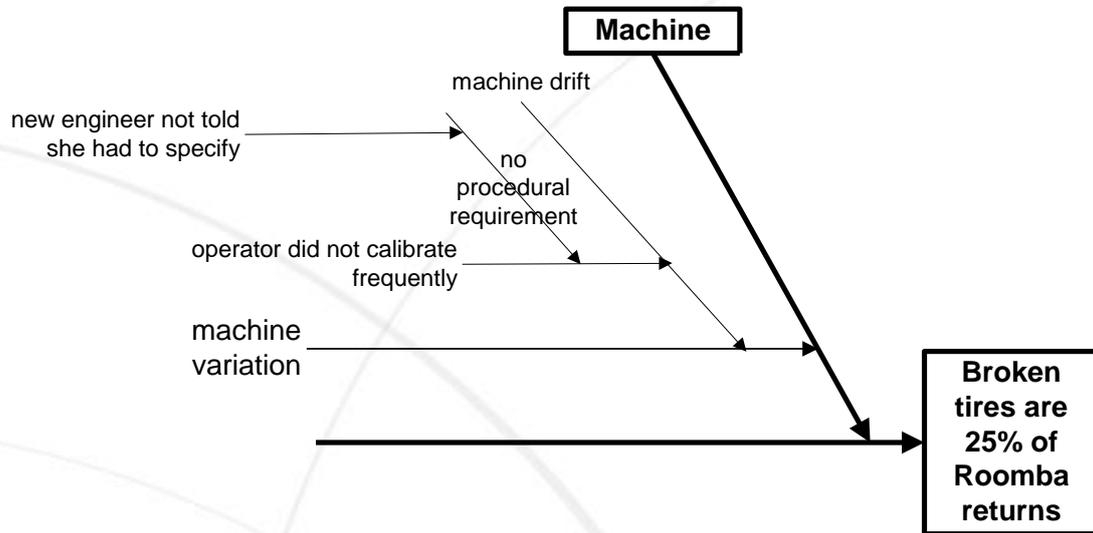
FIGURE 3. BREAKING DOWN CAUSES

STEP 3: USE

The third step is to use existing data to eliminate unlikely causes. By ruling out causes that do not apply or have no substantial relation to the cause only potential causes remain, which will facilitate honing in on the likeliest cause. See Figure 4.

- Delete any causes that are either not valid or extremely unlikely
  - o   Check Pareto diagrams, run charts, control charts, checklists, or customer data.
  - o   Use knowledge, experience, and common sense – must be verified
  - o   Mark deleted Post-its with a large X
- Eliminate any causes that, for a valid reason, will not be pursued at this time
  - o   Outside the scope of team, not controlled by team, impractical
  - o   Mark these Post-its with a large DIAMOND
- Identify remaining labels as 'Potential" causes
  - o   Circle the remaining potential root-causes
  - o   Check to ensure that all the lowest-level Post-its have been marked
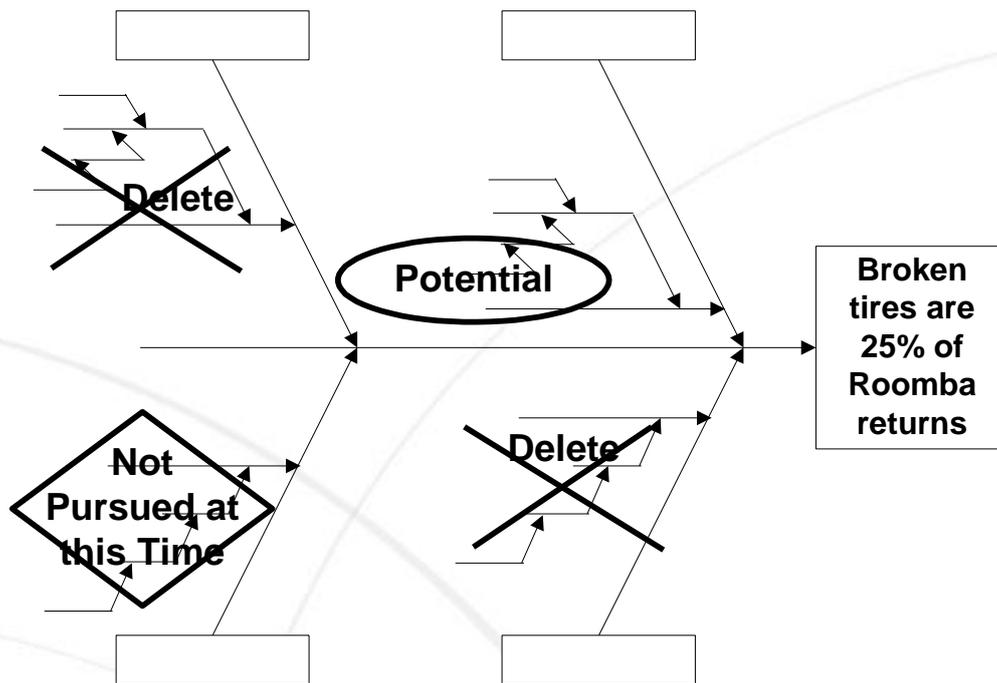
FIGURE 4. STEP3 ELIMINATION

STEP 4: SELECT

The fourth step is to select the most probable root causes using new data. This step involves further experimentation or testing for data collection.

- Identify ways to confirm or eliminate the remaining potential root causes
  - o Gather new facts, make additional observations.
  - o Check assumptions and confirm questionable facts.
  - o Develop a plan and track it. Consider both data collection and analysis.
- Carry out the confirmation tests and determine the most probable root causes
  - o Use test results.
  - o Put a cross through the circled potential causes.
  - o User scatter diagram for testing the relationship between a potential cause and the effect.
  - o If the root cause has not been identified, re-evaluate the Xs and DIAMONDs.

STEP 5: HOME-IN
The fifth step is to home in on a root cause and testing the logic of the resolution.

- Select the most dominant root cause using tools such as:
    - ○ Selection Matrix (see Appendix A.1)
    - ○ Correlation Matrix (see Appendix A.2) for mfg process driven
- Put a cross through ruled-out potential causes
- If possible, verify the selection by running a test to reproduce the problem
- Complete the C&E Diagram
    - ○ Finalize the markings of Post-its / causes
    - ○ The diagram should have
        - ▪ A Title
        - ▪ A Conclusion statement
        - ▪ Notes that give reasons for markings
        - ▪ The names of contributors
        - ▪ Date
- Review the Diamond's causes with your sponsor for possible handover to another team.

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Appendix A

	Feasibility of Finding a Solution	Impact on Effect	Under Direct Control of Team	*	**Total Score**
Cause 1					
Cause 2					
Cause 3					

* Additional criteria as needed

Weighing system: 1, 3, 5

FIGURE A.1 SELECTION MATRIX

Effect

On the

Process

Known to have a direct effect on the process					highest ☆
Known to have an effect on the process when combined with other variables					
Known to have an indirect effect on the process					
Unknown effect on the process.					
Correlation ↑ Data →	No known method to collect data on the variable	Limited data are available on the variable	Data are available, but inconsistent	Data are available and consistent	Variable can be adjusted causing process to change

Availability of data on the process

Worse	→	Best

FIGURE A.2 CORRELATION MATRIX

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Appendix B

PREPARE
for the root cause
analysis

LIST
all possible causes

USE
existing data to
eliminate unlikely
cause

SELECT
the most
propbable root
causes using new
data

HOME-IN
on a root cause

HEADER

HEADER

TRUNK

EFFECT

HEADER

HEADER
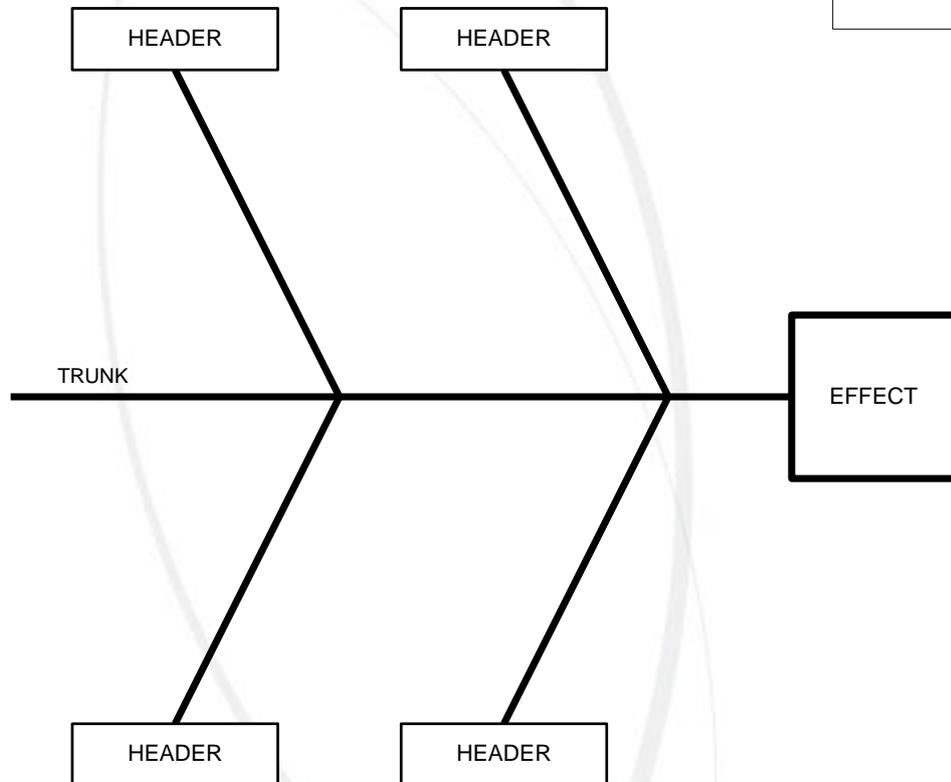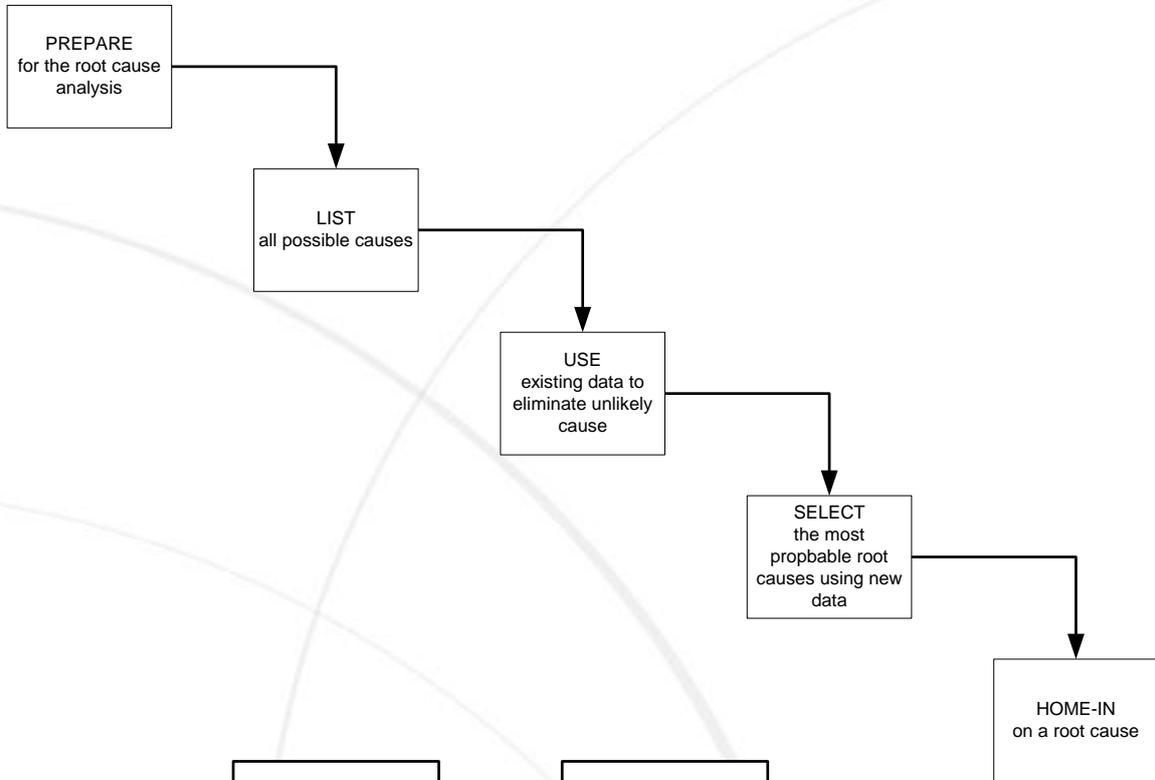
As a resul of step 2 in problem solving process, an effect of the problem is concluded. This conclusion does not state a root cause or imply a solution.

```
        ( STEP 1 )
            │
            ▼
   ┌─────────────────┐                    ┌──────────────────────────┐
   │  Get into the   │◄──────────────────►│ customer input is undertood│
   │  right mindset  │                    │ and accepted w/o denial   │
   └─────────────────┘                    └──────────────────────────┘
            │                                          │
            │                                          ▼
            │                             ┌──────────────────────────┐
            │                             │ agree that data will be   │
            │                             │ used to get to root cause │
            │                             └──────────────────────────┘
            │
            ▼
   ┌─────────────────┐                    ┌──────────────────────────┐
   │ Draw the C&E    │◄──────────────────►│  give the diagram a title │
   │   skeleton      │                    └──────────────────────────┘
   └─────────────────┘                               │
            │                                          ▼
            ▼                             ┌──────────────────────────┐
      ( Next Step )                       │   draw the Effect box     │
                                          └──────────────────────────┘
                                                     │
                                                     ▼
                                          ┌──────────────────────────┐
                                          │  draw four branches (or 5)│
                                          └──────────────────────────┘
                                                     │
                                                     ▼
                                          ┌──────────────────────────┐
                                          │ place empty branch header │
                                          │ boxes. These are the causes│
                                          └──────────────────────────┘
                                                     │
                                                     ▼
                                          ┌──────────────────────────┐
                                          │ write the step 2 conclusion│
                                          │ statement of the PDCA in the│
                                          │        effect box          │
                                          └──────────────────────────┘
```
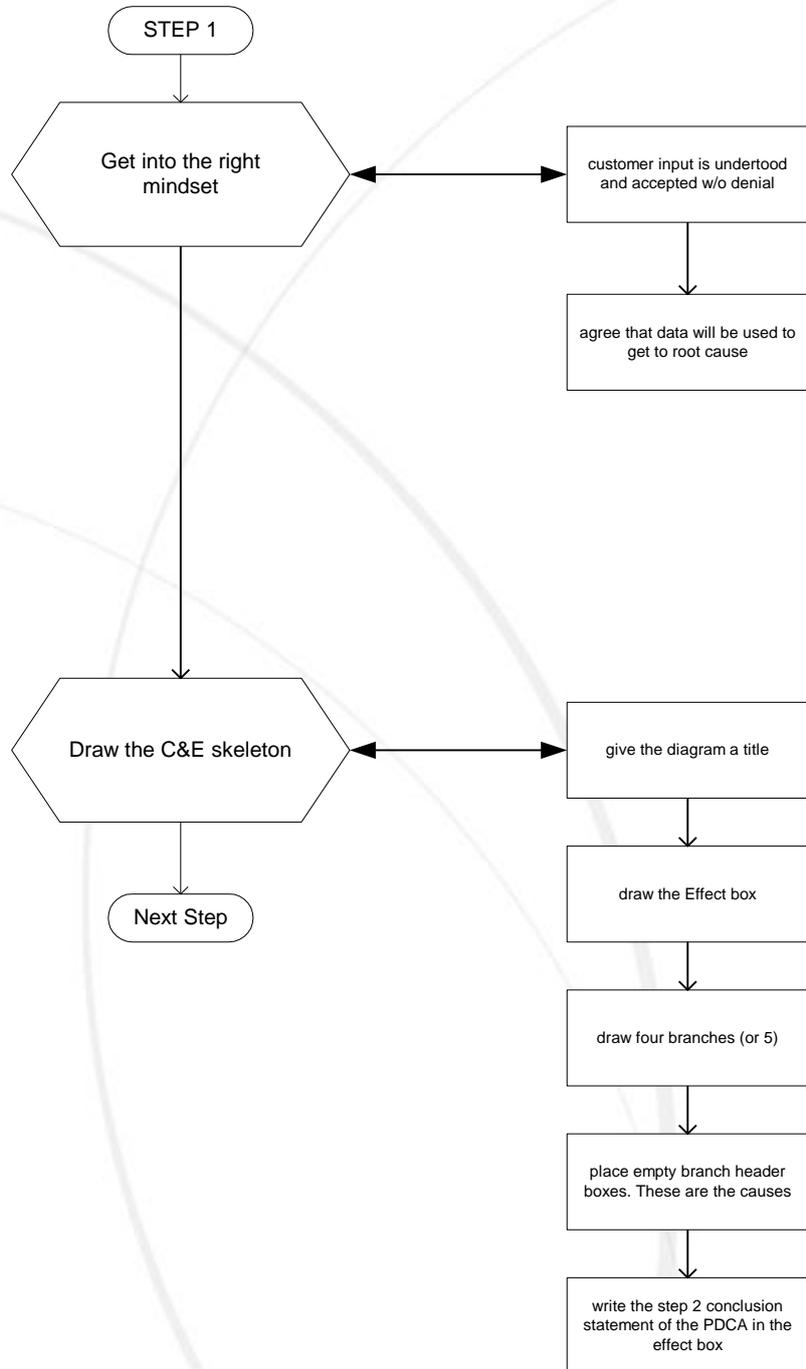
list all the possible causes for this effect. No critiquing. The
objective is to identify as many ideas as possible.

on a flip chart

STEP 2

List causes ←→ answer the questoin: "What could be causing the effect?"

team brainstorming sessoin ──── Ms
                         ──── Ps

list causes not solutions

refer to process flow chart ←→ break flow down into greater, detailed flow

use the process flow chart to identify causes

"Why could this process step cause thje effect

Identify main branch ←→ analyze the identified causes

standard headings: Ms, Ps, RPD headings

heading names may be changed as applies to the problem

HEADER

cause 1

cause 2

cause 3

arrange the causes ←→ write cause on post-it

duplicate causes are permitted

place in most appropriate main branch

analyze each branch ←→ "Why" logic chain

1 branch at a time

go down 5 whys

Next Step

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existing data is used to eliminate unlikely causes. Unlike causes are also those that lie beyond the team members' authority.

```
  ( STEP 3 )
      |
      v
  <  delete  > <------------> [ review all data chart:      ]
      |                       [ pareto, run, control....    ]
      |                                  |
      |                                  v
      |                       [ not valid or                ]
      |                       [ unlikely causes             ]
      |                                  |
      |                                  v
      |                       [ mark post-it's: ] ------->   X
      v
  < eliminate > <-----------> [ valid causes but            ]
      |                       [ cannot be pursued           ]
      |                                  |
      |                                  v
      |                       [ mark post-it's: ] ------->   ◇
      v
  < potential > <-----------> [ remaining causes            ]
      |                       [ are potential               ]
      |                                  |
      |                                  v
  ( Next Step )              [ mark post-it's: ] ------->   ◯
```

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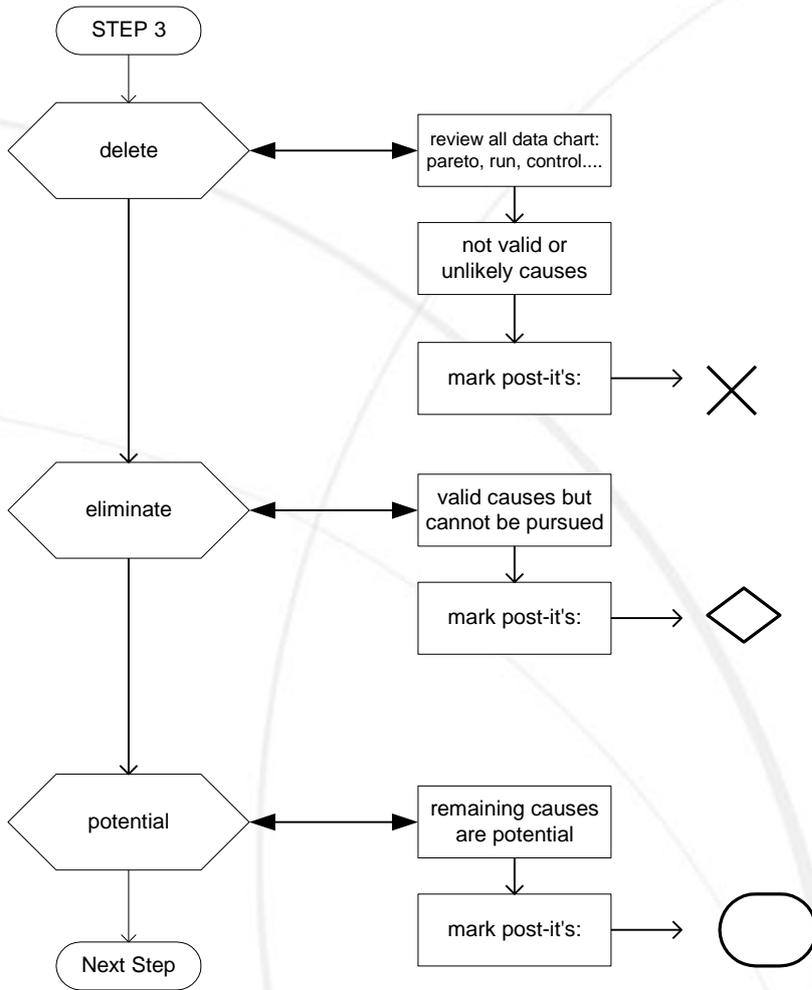
more data may be needed. Develp a plan to
collect data, then select the most probable
cuases.

```
        ( STEP 4 )

      ⬡ confirm          develop plan to
        potential  ⬌     collect new data
        causes           (facts)
                              │
                              ▼
                         check assumptions or
                         confirm questionable
                         facts
                              │
                              ▼
                         develop 4W+H         what │ where │ when │ who │ how
                         select plan          ─────┼───────┼──────┼─────┼─────


      ⬡ determine        use results to
        most       ⬌     eliminate
        probable              │
        causes                ▼
                         mark post-it's:  ⟶    ⊗
        ( Next Step )         │
                              ▼              use scatter
                         test relationship   plot
                         between potential
                         cause and effect
                              │
                              ▼
                         if no root cause,
                         re-evaluate
                         previously
                         eliminated causes
```

```
          ┌─────────────┐
          │   STEP 5    │
          └──────┬──────┘
                 │
                 ▼
        ╱─────────────────╲              ┌──────────────────┐
       ╱   root cause      ╲◄───────────►│  use selection or │
       ╲   selection       ╱             │ correlation matrix│
        ╲─────────────────╱              └────────┬─────────┘
                 │                                │
                 │                                ▼              ╭─────╮
                 │                       ┌──────────────────┐    │  ╳  │
                 │                       │ cross out ruled-out│   ╰─────╯
                 │                       │ potential causes   │
                 │                       └────────┬─────────┘
                 │                                │
                 │                                ▼
                 │                       ┌──────────────────┐
                 │                       │   reprproduce the │
                 │                       │      problem      │
                 │                       └──────────────────┘
                 ▼
        ╱─────────────────╲              ┌──────────────────┐
       ╱                   ╲◄───────────►│  complete C&E    │
       ╲   closing out     ╱             │     Diagram      │
        ╲─────────────────╱              └────────┬─────────┘
                 │                                │
                 ▼                                ▼
          ┌─────────────┐              ┌──────────────────┐
          │     End     │              │ review all Diamond│
          └─────────────┘              │   causes with     │
                                       │     sponsor       │
                                       └──────────────────┘
```

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