Stuff Happens
Boeing 737 MAX 8
Even the best defenses are fallible and can have holes.....
Multiple defenses decrease the likelihood of an event.....
But it is possible that under the wrong set of circumstances, an event could occur....
Why conduct a Root Cause Analysis

RCA is a tool designed to help identify not only what and how an event occurred, but also why it happened. Only when investigators are able to determine why an event or failure occurred will they be able to specify workable corrective measures that prevent future events of the type observed.

The basic reason for investigating and reporting the causes of occurrences is to enable the identification of corrective actions adequate to prevent recurrence and thereby protect the health and safety of the public, the workers, and the environment.
What is a Root Cause?

• An identified reason for the presence of a defect or problem.
• The most basic reason, which if eliminated, would prevent recurrence.

Should typically ask WHY ???

7 or more times
Cause and Effect - principles

– Cause and Effect are the same thing

– Causes and effects are part of an infinite continuum of causes
Cause and Effect - principles

- Commission testing LTA
- Wiring error
- Wrong CT ratio
- Relay misoperation
- Line B trips
- Customer loss of power
- High winds
- Tree contact
- Fault on line
- Line A trips
1. Root causes are specific underlying causes.
2. Root causes are those that can reasonably be identified.
3. Root causes are those management has control to fix.
4. Root causes are those for which effective recommendations for preventing recurrences can be generated.
Root causes are underlying causes.
The goal should be to identify specific underlying causes. The more specific you can be about why an event occurred, the easier it will be to arrive at recommendations that will prevent recurrence.
Root causes are those that can reasonably be identified.

Event analysis must be cost beneficial. It is not practical to keep valuable manpower occupied indefinitely searching for the root causes of occurrences. Structured RCA helps analysts get the most out of the time they have invested in the analysis.
Root causes are those over which management has control.

Analysts should avoid using general cause classifications such as operator error, equipment failure or external factor. Such causes are not specific enough to allow management to make effective changes. Management needs to know exactly why a failure occurred before action can be taken to prevent recurrence.

We must also identify a root cause that management can influence. Identifying “severe weather” as the root cause of parts not being delivered on time to customers is not appropriate. Severe weather is not controlled by management.
Root causes are those for which effective recommendations can be generated.

Recommendations should directly address the root causes identified during the event analysis. If the analysts arrive at vague recommendations such as, “Improve adherence to written policies and procedures,” then they probably have not found a basic and specific enough cause and need to expend more effort in the analysis process.
Five phases:

I. Data Collection
II. Assessment
III. Corrective Actions
IV. Inform
V. Follow-up

Ref: DOE-NE-STD-1004-92
<table>
<thead>
<tr>
<th>METHOD</th>
<th>WHEN TO USE</th>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task Analysis</td>
<td>Use whenever the problem appears to be the result of steps taken in a task (just about all the time)</td>
<td>Shows the steps which should have been taken.</td>
<td>Requires personnel and (possibly) equipment time to be performed correctly and completely</td>
<td>Should be conducted as both a Cognitive Task Analysis (what was the person thinking while conducting the task) and a Contextual Task Analysis (what was going on while the task was being done).</td>
</tr>
<tr>
<td>Events and Causal Factor Analysis</td>
<td>Use for multi-faceted problems with long or complex causal factor chain</td>
<td>Provides visual display of analysis process. Identifies probable contributors to condition.</td>
<td>Time-consuming and requires familiarity with process to be effective.</td>
<td>Requires a broad perspective of the event to identify unrelated problems. Helps to identify where deviations occurred from acceptable methods.</td>
</tr>
<tr>
<td>Change Analysis</td>
<td>Use when cause is obscure. Especially useful in evaluating equipment failures</td>
<td>Simple 6-step process</td>
<td>Limited value because of the danger of accepting wrong “obvious” answer.</td>
<td>A singular problem technique that can be used in support of a larger investigation. All root causes may not be identified.</td>
</tr>
<tr>
<td>Barrier Analysis</td>
<td>Used to identify barrier and equipment failures, and procedural or administrative problems.</td>
<td>Provides systematic approach.</td>
<td>Requires familiarity with process to be effective.</td>
<td>This process is based on the MORT Hazard/Target concept</td>
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<td>MORT/Mini-MORT</td>
<td>Used when there is a shortage of experts to ask the right questions and whenever the problem is a recurring one. Helpful in solving programmatic problems.</td>
<td>Can be used with limited prior training. Provides a list of questions for specific control and management factors.</td>
<td>May only identify area of cause, not specific causes.</td>
<td>If this process fails to identify problem areas, seek additional help or use cause-and-effect analysis.</td>
</tr>
<tr>
<td>Human Performance Evaluations (HPE)</td>
<td>Use whenever people have been identified as being involved in the problem cause.</td>
<td>Thorough analysis</td>
<td>None if process is closely followed.</td>
<td>Requires HPE training.</td>
</tr>
<tr>
<td>Kepner-Tregoe</td>
<td>Use for major concerns where all aspects need thorough analysis</td>
<td>Highly structured approach focuses on all aspects of the occurrence and problem resolution.</td>
<td>More comprehensive than may be needed</td>
<td>Requires Kepner-Tregoe training.</td>
</tr>
<tr>
<td>Fault Tree Analysis</td>
<td>Normally used for equipment-related problems</td>
<td>Provides a visual display of causal relationships,</td>
<td>Does not work well when human actions are inserted as a cause</td>
<td>Uses Boolean algebra symbology to show how the causes may combine for an effect</td>
</tr>
<tr>
<td>Cause and Effect Charting (e.g., Reality Charting®)</td>
<td>Useful for any type of problem. Visual display showing cause sequence.</td>
<td>Provides a direct approach to reach causes of primary effect(s). May be used with barrier/change analysis. Focus is on best solution generation.</td>
<td>May not provide entire background to understand a complex problem. Requires experience/knowledge to ask all the right questions.</td>
<td>Requires knowledge of the Apollo Root Cause Analysis techniques. Apollo RealityCharting® software may be used as a tool to aid problem resolution.”</td>
</tr>
</tbody>
</table>
**Something happens**

<table>
<thead>
<tr>
<th>Brief Description of Event:</th>
<th>An initiating fault on the 500 kV B-G #1 line resulted in potential misoperation relay openings of CB #5 and CB #6 breakers at Station C. Station C CB #5 and #6 relays have been taken out of service and are being tested to confirm whether or not they mis-operated.</th>
</tr>
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<tr>
<td>At 0645 a initiating fault on the 500 kV B-G #1 line resulted in:</td>
<td>Identify contributing causes of the event to the extent known.</td>
</tr>
<tr>
<td>- The 500kV B-G #1 line locking out at both ends</td>
<td>An initiating fault on the 500 kV B-G #1 line resulted in potential misoperation relay openings of CB #5 and CB #6 breakers at Station C. Station C CB #5 and #6 relays have been taken out of service and are being tested to confirm whether or not they mis-operated.</td>
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<tr>
<td>- The 500 kV C-B #1 and #2 lines being open ended</td>
<td>Identify any Protection System misoperations to the extent known.</td>
</tr>
<tr>
<td>- Tripping of Generation C Units 1, 2, 3 and 4 on overspeed</td>
<td>Potential Relay Misoperation of CB #5 and CB #6 breakers at Station C.</td>
</tr>
<tr>
<td>Note: The B-G #1 line was patrolled to investigate and determine the cause of the initiating fault and no cause found. The line was successfully returned to service.</td>
<td>Identify any GADS, DADS, TADS, or Protection System misoperations reports that will be submitted.</td>
</tr>
<tr>
<td></td>
<td>GADS and TADS will be reported. Any misoperations identified will be reported.</td>
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<td><strong>Narrative</strong></td>
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<td>A single line to ground fault on 500kV line BG resulted in the line locking out after an unsuccessful reclose attempt at the station B end. Coincident with the initial trip, Station C breaker #5 tripped. Coincident with the reclose at Station B, the Station C #6 breaker tripped. Upon losing both lines from Generating Station C, all four units tripped on overspeed.</td>
<td>Single lines showing Stations C, B and G.</td>
</tr>
<tr>
<td>1. If a one-line diagram is included, please provide an explanation.</td>
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</table>
Misoperation Event

Generating Station C

1

2

3

4

Switching Station B

5

6

7

8

9

10

11

12

Switching Station G

1

2
Generating Station C

Switching Station B

Switching Station G

Misoperation Event

Fault
Generating Station C

Switching Station B

Switching Station G

Misoperation Event

Fault
Generating Station C

Switching Station B

Switching Station G

Fault
Misoperation Event

Generating Station C

Switching Station B

Switching Station G

Reclose Fault

1

2

3

4
Generating Station C

Switching Station B

Switching Station G

Fault
So what happened?

1. Initial fault occurred

2. CB5 tripped

3. CB6 tripped

4. Loss of 4 generators
After initial review of the events it was determined the **C end of the 500kV ‘#1’ and ‘#2’ line ground instantaneous relays mis-operated** for the fault on the 500kV Line #1 between B and G.

More extensive analysis revealed the cause of the SLYP/SLCN mis-operations was a **setting issue**.

A review of history shows the relay settings were correct when established, but over time, with system changes, **had not been kept correct for the changing system conditions**.
So what happened and why?

1. Initial fault occurred
   - Unknown, after patrol of line with nothing found????

2. CB5 tripped
   - Misoperation of Instantaneous Ground-overcurrent, due to incorrect settings
   - *Settings were not updated* as changes to system occurred

3. CB6 tripped
   - Misoperation of Instantaneous Ground-overcurrent, due to incorrect settings
   - *Settings were not updated* as changes to system occurred

4. Loss of 4 generators
   - Overspeed trip (loss of outlet path) – as designed
For lines A, B & C – any two lines out of service initiates RAS to trip generation.
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Line A out of service prior to event
For lines A, B & C – any two lines out of service initiates RAS to trip generation.

Line A out of service prior to event
Switched Line E out of service for maintenance
For lines A, B & C – any two lines out of service initiates RAS to trip generation.

Line A out of service prior to event
Switched Line E out of service for maintenance
RAS initiated generation trip
1. When Line E breaker was opened, RAS indicated Line C out of service

2. RAS unintended operation

3. Loss of 4 generators
So what happened?

1. Technician error
2. RAS controller incorrect settings
3. RAS misoperation
4. Generation unnecessarily tripped
So what happened?

RST procedure did not have a comparison of as-left settings versus as-issued/as-designed.
NERC Cause Code Assignment Process
An Event Investigation and Data Analysis Tool

January 2018
# NERC CCAP Cause Code Quick Reference

## Appendix A – Cause Code Quick Reference

<table>
<thead>
<tr>
<th>Category</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design/Engineering</td>
<td>A1</td>
<td></td>
</tr>
<tr>
<td>Equipment/Material</td>
<td>A2</td>
<td></td>
</tr>
<tr>
<td>Individual/Human Performance</td>
<td>A3</td>
<td></td>
</tr>
<tr>
<td>Management/Organization</td>
<td>A4</td>
<td></td>
</tr>
<tr>
<td>Communication</td>
<td>A5</td>
<td></td>
</tr>
<tr>
<td>Training</td>
<td>A6</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>A7</td>
<td></td>
</tr>
<tr>
<td>Overall Configuration</td>
<td>A8</td>
<td></td>
</tr>
</tbody>
</table>

### AN - No causes found

### AZ - Information to determine causes (LTA)

#### B1 UNABLE TO IDENTIFY SPECIFIC ROOT CAUSE
- Unresolved, root cause identified but will require more investigation.
- Check list of common problem areas.
- Check for new/unusual events.
- Consider additional information from other sources.
- Cross-reference required for other sources of information.

#### B2 REPORT STOPS AT FAULT/ERROR MODE
- Report stops at fault/error mode.
- Identify possible causes.
- Review system logs and event records.

#### B3 OTHER PARTIES INVOLVED IN EVENT
- Identify other parties involved.
- Review interactions with other parties.
- Cross-reference with other parties.

### Level A codes are undefined
### Level B codes are all CAPS
### Level C codes are less than adequate
How is Cause Coding used

890 Events have been cause coded, with 2360 identified contributing causes
How is Cause Coding used

Management/Organization

- A4B3C08 = Job scoping did not identify special circumstances &/or conditions
- A4B1C06 = Previous industry or in-house experience was not effectively used to prevent recurrence
- A4B5C04 = Risks/consequences associated with change not adequately reviewed/assessed
- A4B1C09 = Corrective actions for previously identified problem was not adequate to prevent recurrence
- A4B5C05 = System interactions not considered or identified
- A4B3C11 = Inadequate work package preparation
- A4B1C08 = Corrective actions to a known or repetitive problem was untimely
- A4B5C03 = Inadequate vendor support of change
Stuff Happens
Expectations: Desired approach to work (as imagined)
Normal Practices: Work as actually performed (allowed by mgmt!)

Hidden hazards, threats, unusual conditions, & system weaknesses

* Adapted from Muschara Error Management Consulting, LLC
Questions

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