

# NERC

NORTH AMERICAN ELECTRIC  
RELIABILITY CORPORATION

# Root Cause Analysis

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Hands on Relay School

March 15, 2019

**RELIABILITY | ACCOUNTABILITY**





# Stuff Happens

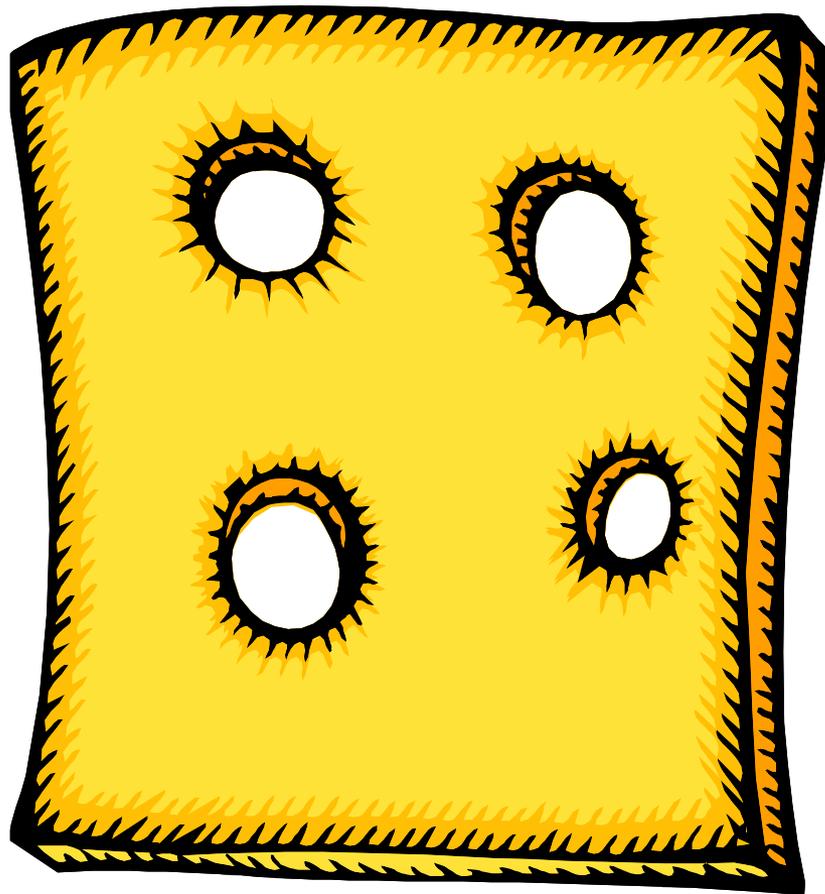




**Boeing 737 MAX 8**

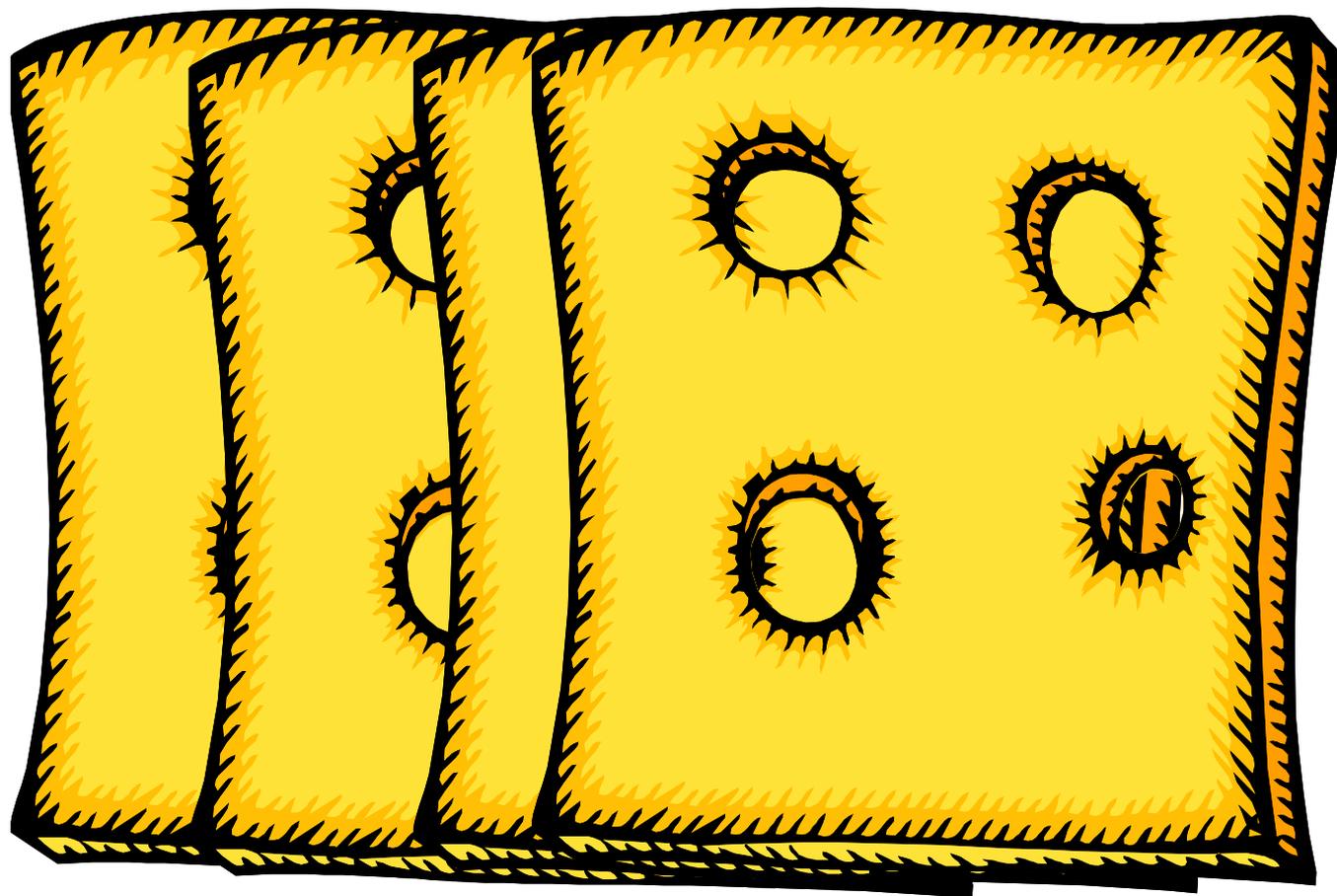


***Even the best defenses are fallible and  
can have holes.....***



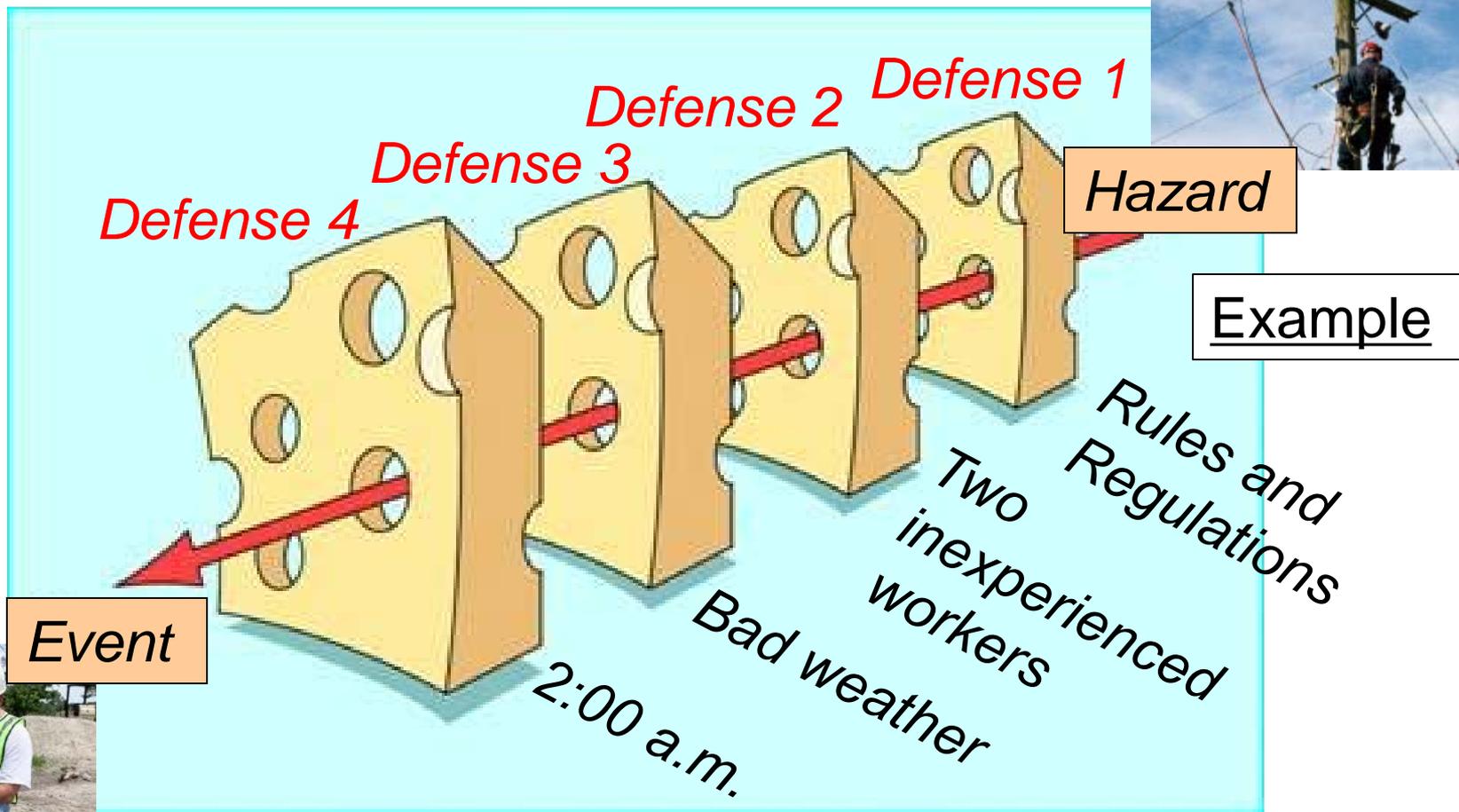
# Defense in Depth

***Multiple defenses decrease the likelihood of an event.....***



# Defenses

***But it is possible that under the wrong set of circumstances, an event could occur....***



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.

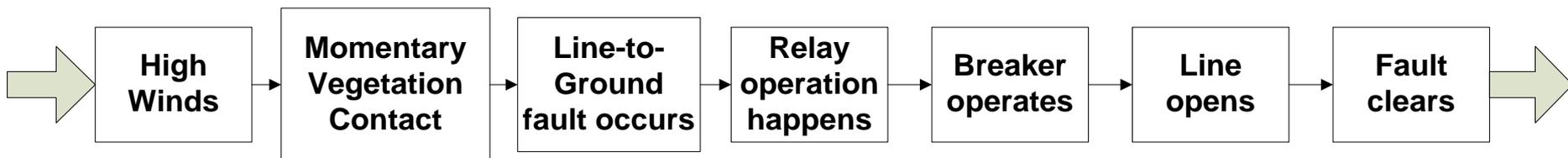
- An identified reason for the presence of a defect or problem.
- The most basic reason, which if eliminated, would prevent recurrence.

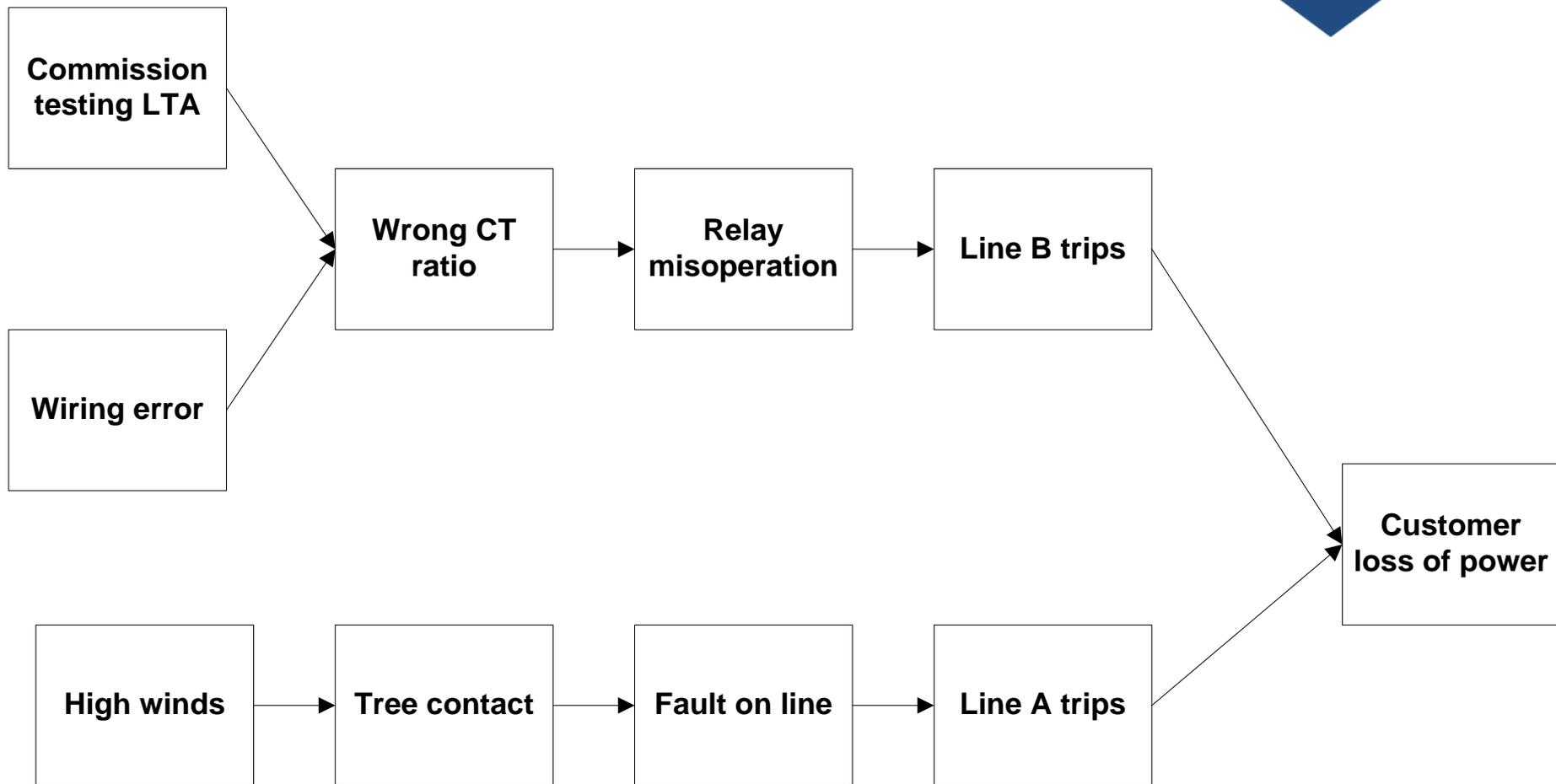
*Should  
typically ask  
WHY ???*

*7 or more  
times*

WHY ???  
WHY ???

- Cause and Effect are the same thing
- Causes and effects are part of an infinite continuum of causes





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*

METHOD	WHEN TO USE	ADVANTAGES	DISADVANTAGES	REMARKS
<b>Task Analysis</b>	Use whenever the problem appears to be the result of steps taken in a task (just about all the time)	Shows the steps which should have been taken.	Requires personnel and (possibly) equipment time to be performed correctly and completely	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).
<b>Events and Causal Factor Analysis</b>	Use for multi-faceted problems with long or complex causal factor chain	Provides visual display of analysis process. Identifies probable contributors to condition.	Time-consuming and requires familiarity with process to be effective.	Requires a broad perspective of the event to identify unrelated problems. Helps to identify where deviations occurred from acceptable methods.
<b>Change Analysis</b>	Use when cause is obscure. Especially useful in evaluating equipment failures	Simple 6-step process	Limited value because of the danger of accepting wrong "obvious" answer.	A singular problem technique that can be used in support of a larger investigation. All root causes may not be identified.
<b>Barrier Analysis</b>	Used to identify barrier and equipment failures, and procedural or administrative problems.	Provides systematic approach.	Requires familiarity with process to be effective.	This process is based on the MORT Hazard/Target concept

# Selection of methods (cont'd)

METHOD	WHEN TO USE	ADVANTAGES	DISADVANTAGES	REMARKS
<b>MORT/Mini-MORT</b>	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.	Can be used with limited prior training. Provides a list of questions for specific control and management factors.	May only identify area of cause, not specific causes.	If this process fails to identify problem areas, seek additional help or use cause-and-effect analysis.
<b>Human Performance Evaluations (HPE)</b>	Use whenever people have been identified as being involved in the problem cause.	Thorough analysis	None if process is closely followed.	Requires HPE training.
<b>Kepner-Tregoe</b>	Use for major concerns where all aspects need thorough analysis	Highly structured approach focuses on all aspects of the occurrence and problem resolution.	More comprehensive than may be needed	Requires Kepner-Tregoe training.
<b>Fault Tree Analysis</b>	Normally used for equipment-related problems	Provides a visual display of causal relationships,	Does not work well when human actions are inserted as a cause	Uses Boolean algebra symbology to show how the causes may combine for an effect
<b>Cause and Effect Charting (e.g., Reality Charting®)</b>	Useful for any type of problem. Visual display showing cause sequence.	Provides a direct approach to reach causes of primary effect(s). May be used with barrier/change analysis. Focus is on best solution generation.	May not provide entire background to understand a complex problem. Requires experience/knowledge to ask all the right questions.	Requires knowledge of the Apollo Root Cause Analysis techniques. Apollo RealityCharting® software may be used as a tool to aid problem resolution.”

**Brief Description of Event:**

At 0645 a initiating fault on the 500 kV B-G #1 line resulted in:

- The 500kV B-G #1 line locking out at both ends
- The 500 kV C-B #1 and #2 lines being open ended
- Tripping of Generation C Units 1, 2, 3 and 4 on overspeed

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.

Identify contributing causes of the event to the extent known.

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.

Identify any Protection System misoperations to the extent known. Identify any GADS, DADS, TADS, or Protection System misoperations reports that will be submitted.

Potential Relay Misoperation of CB #5 and CB #6 breakers at Station C.

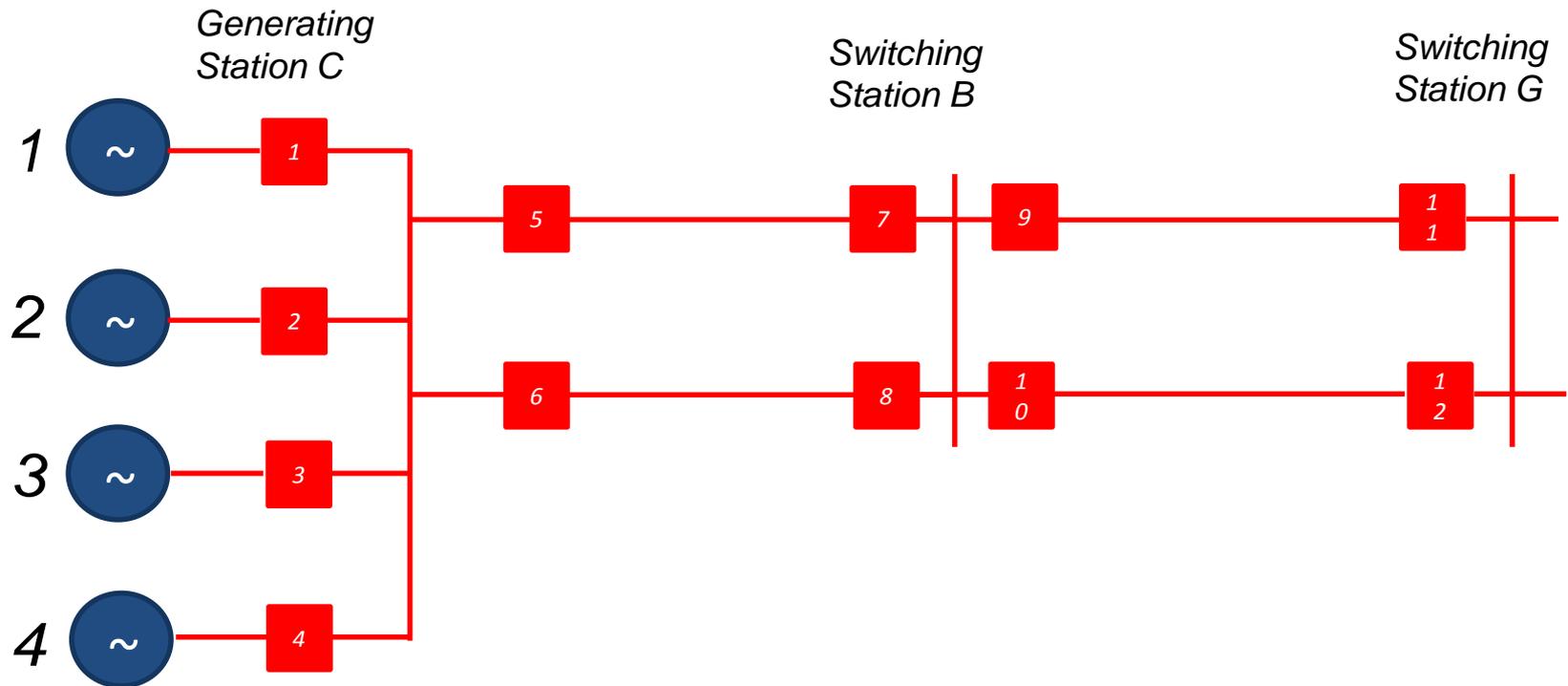
GADS and TADS will be reported. Any misoperations identified will be reported.

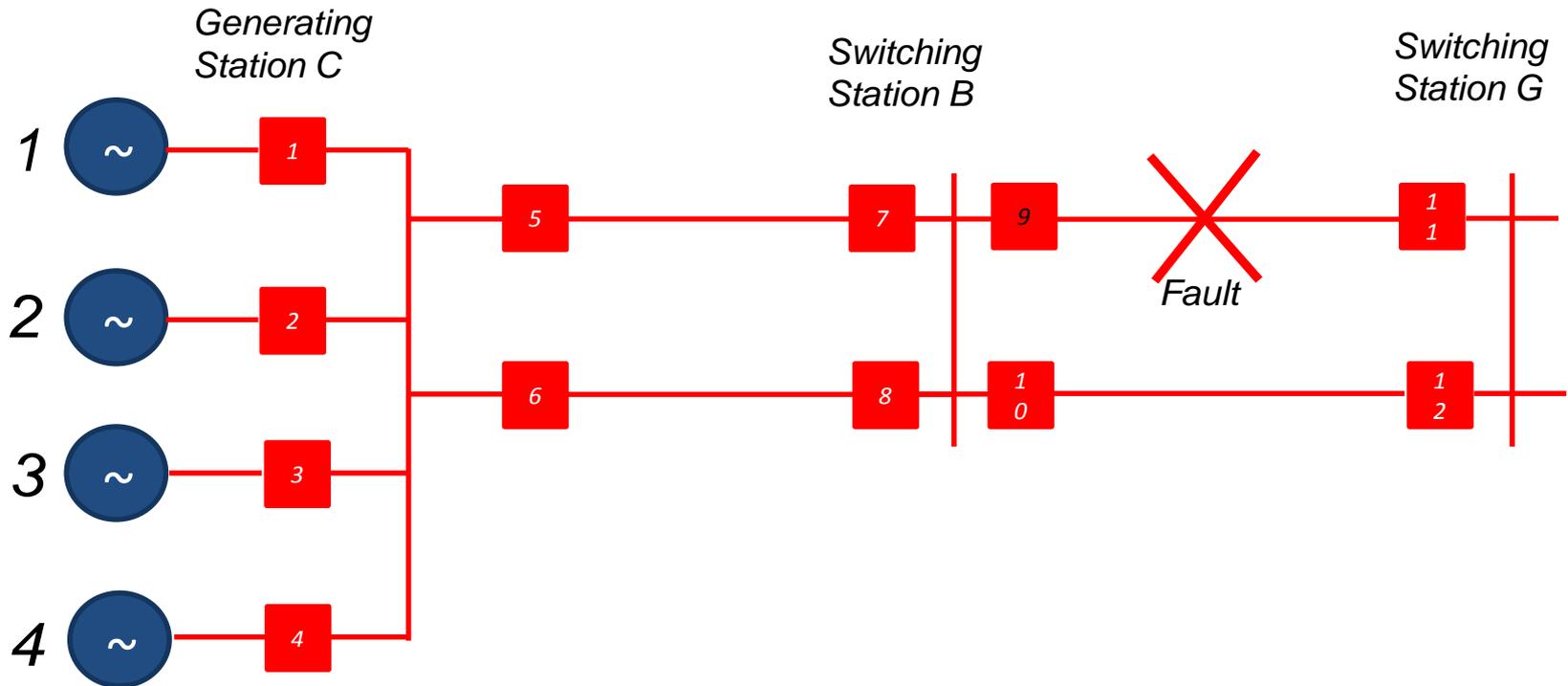
**Narrative**

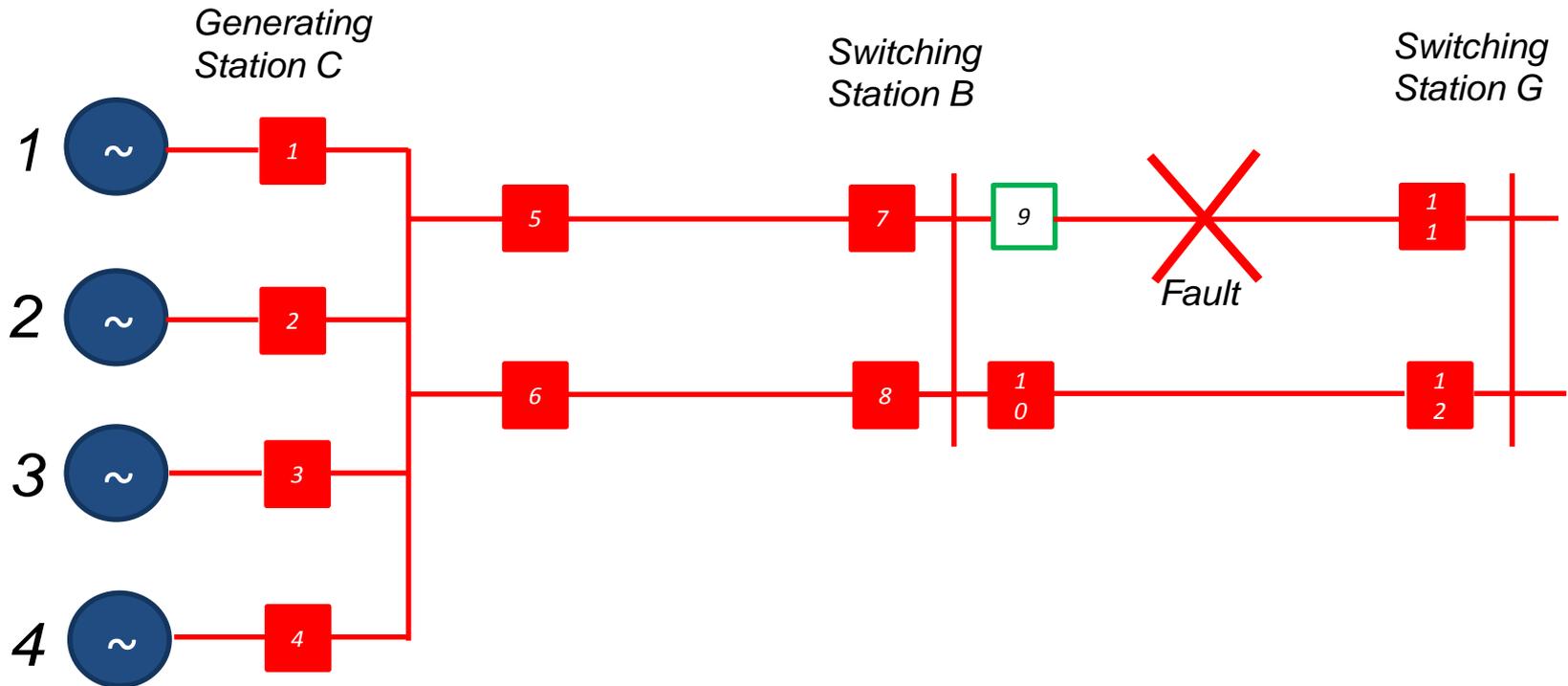
A single line to ground fault on 500kV line BG resulted in the line locking out after an unsuccessful reclose attempt at the station B end. Coincident with the initial trip, Station C breaker #5 tripped. Coincident with the reclose at Station B, the Station C #6 breaker tripped. Upon losing both lines from Generating Station C, all four units tripped on overspeed.

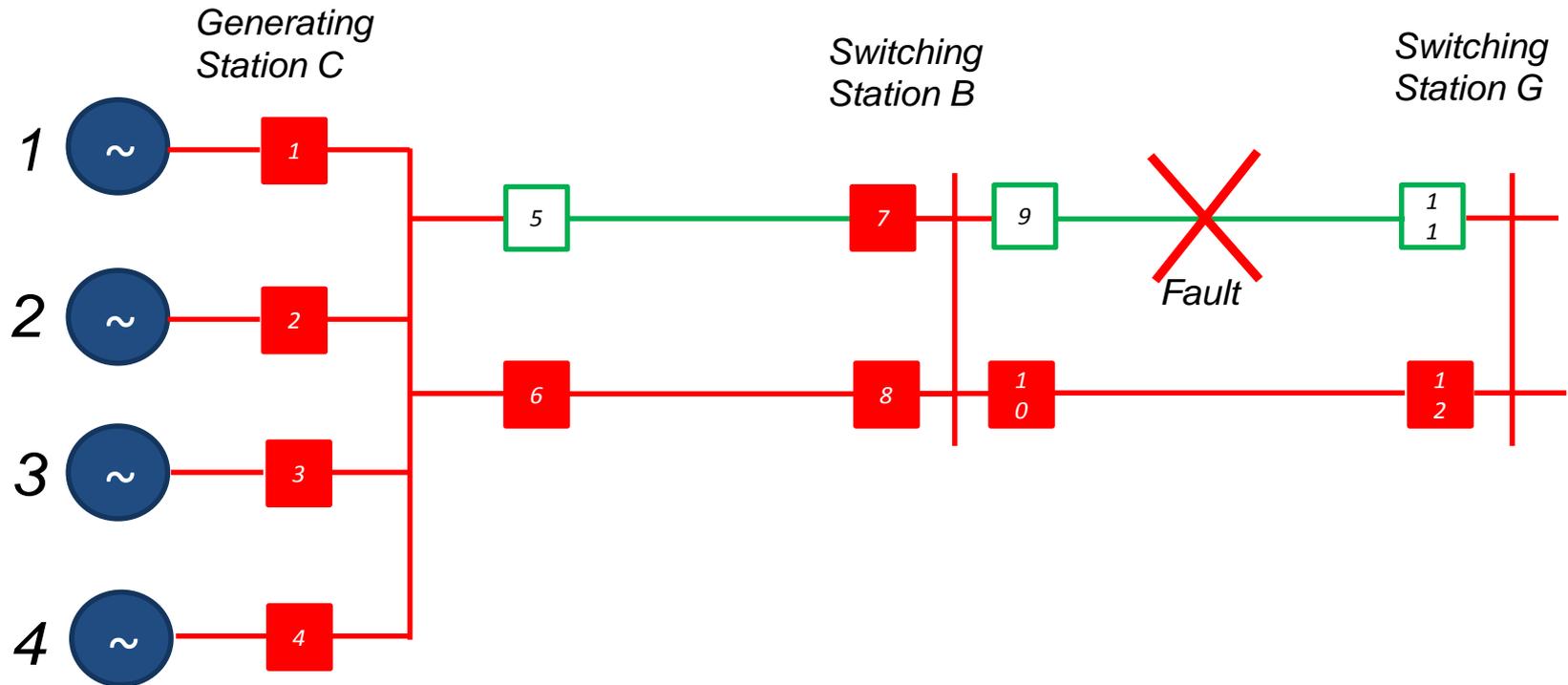
1. If a one-line diagram is included, please provide an explanation.

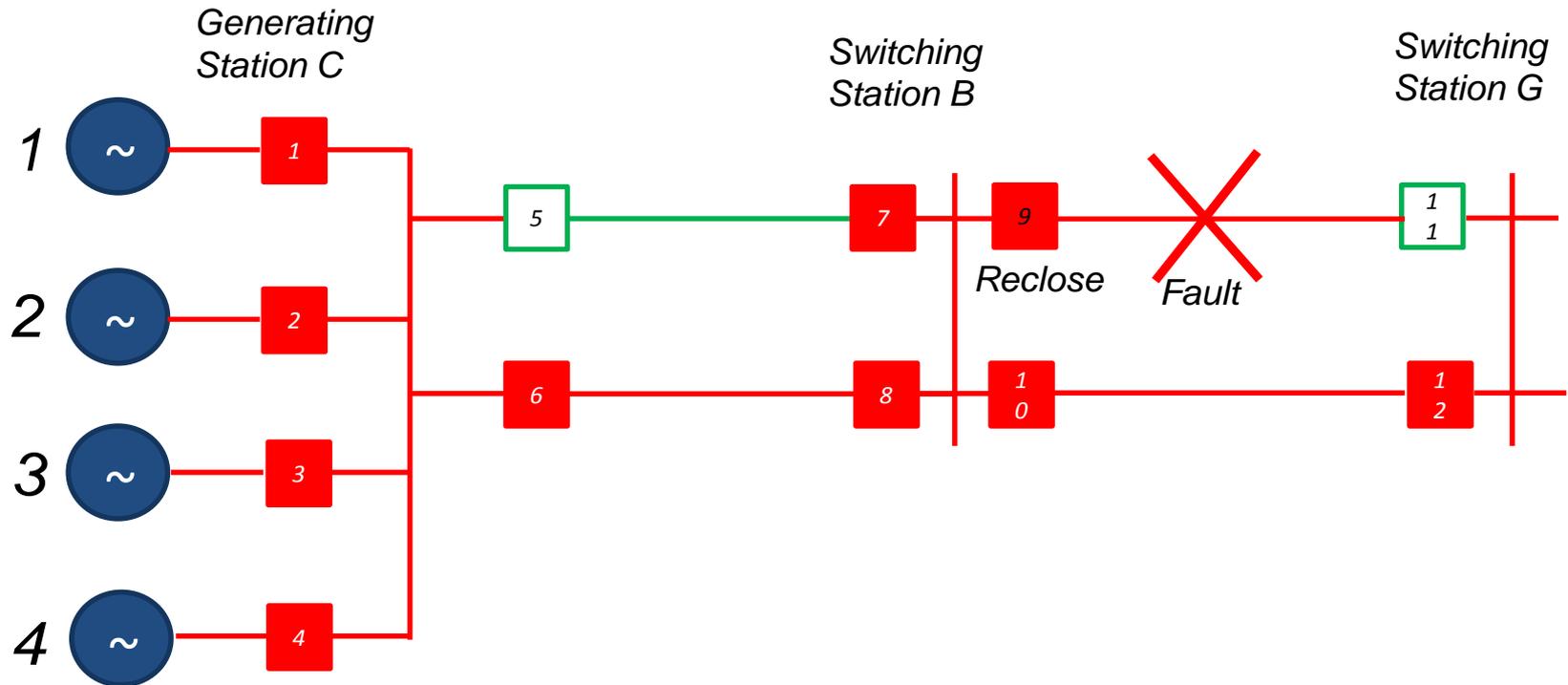
Single lines showing Stations C, B and G.

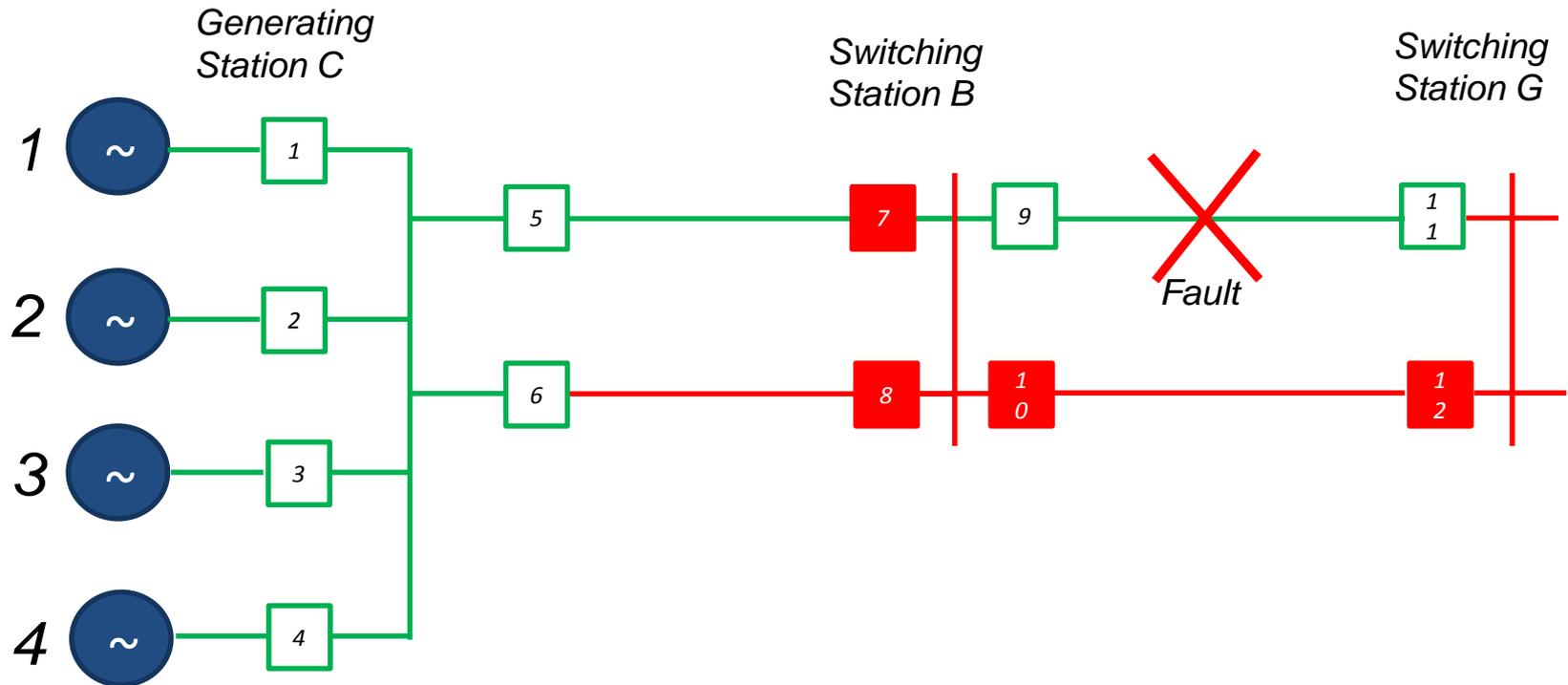












1. Initial fault occurred
2. CB5 tripped
3. CB6 tripped
4. Loss of 4 generators

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***.

## 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

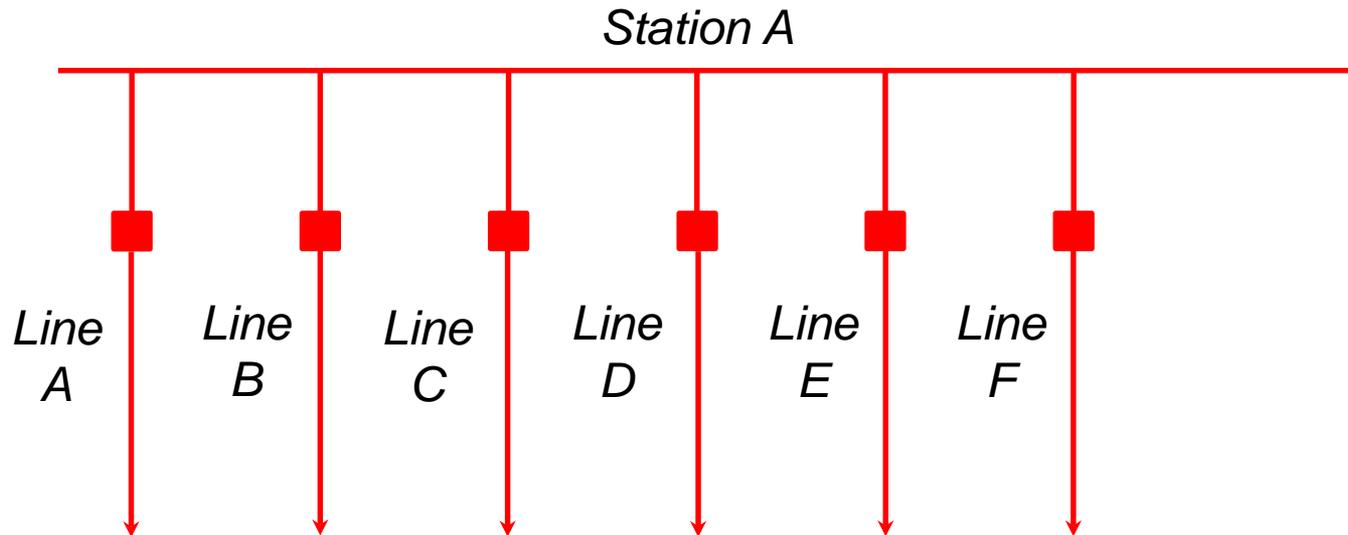
## 3. CB6 tripped

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

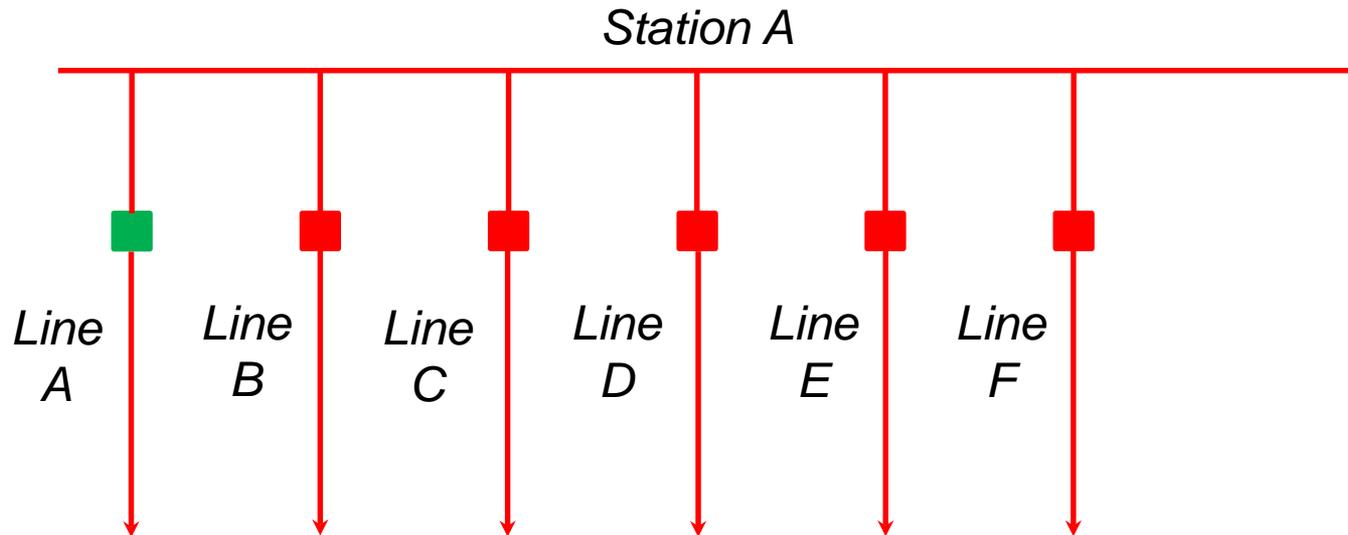
## 4. Loss of 4 generators

- Overspeed trip (loss of outlet path) – as designed

*For lines A,B & C –any two lines out of service initiates RAS to trip generation.*

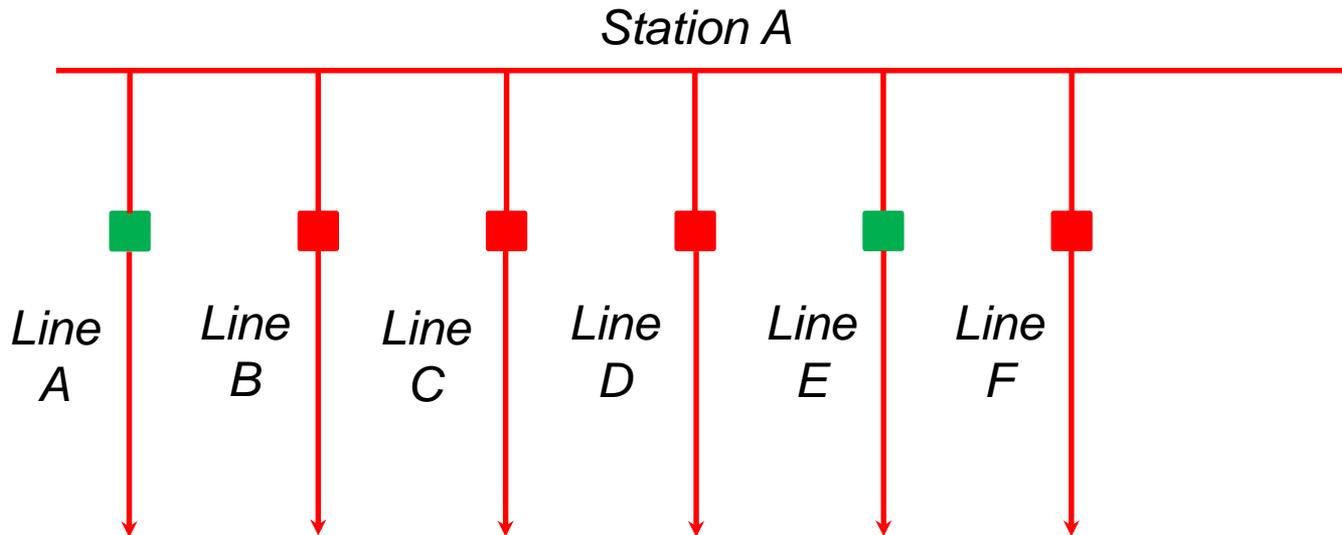


*For lines A,B & C –any two lines out of service initiates RAS to trip generation.*



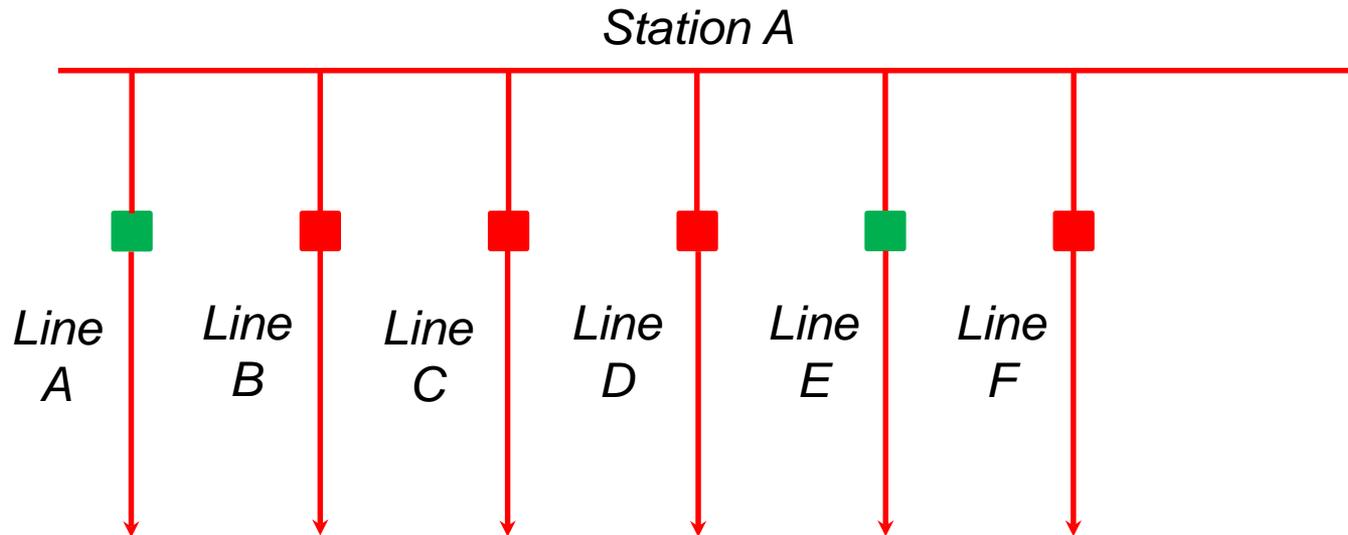
*Line A out of service prior to event*

*For lines A,B & C –any two lines out of service initiates RAS to trip generation.*



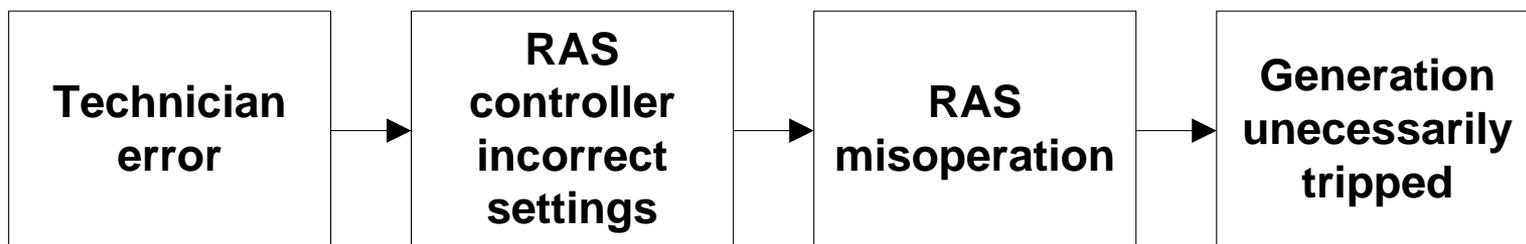
*Line A out of service prior to event  
Switched Line E out of service for maintenance*

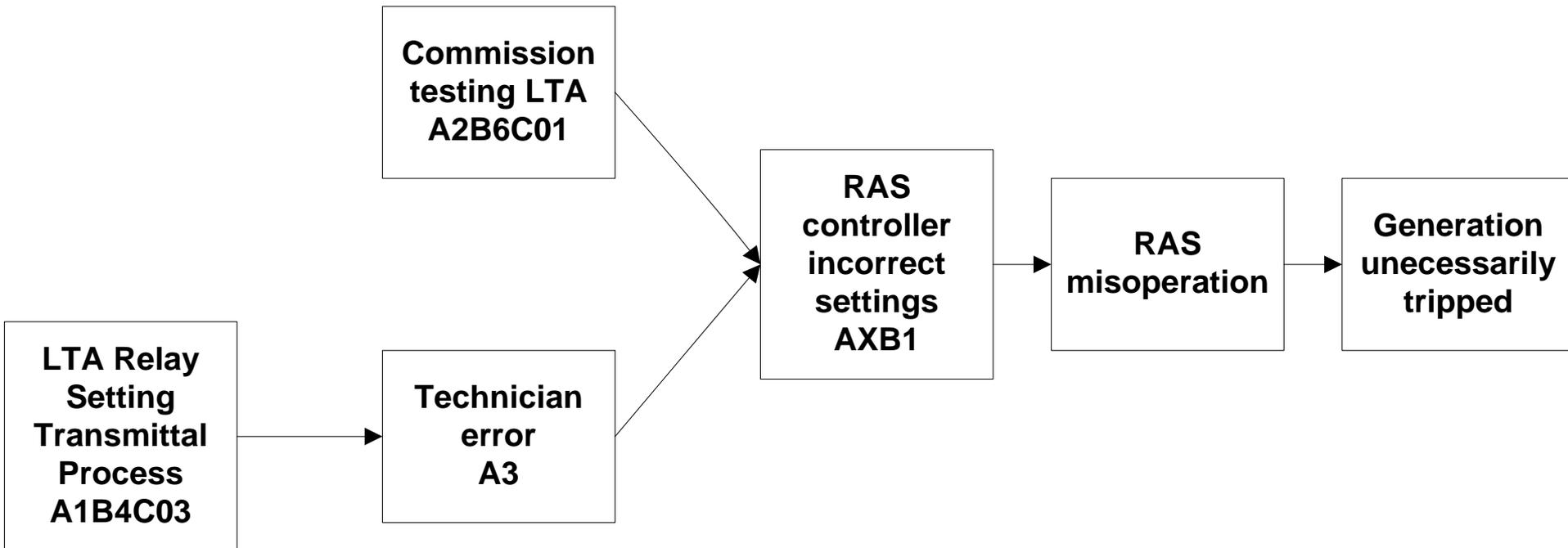
*For lines A,B & C –any two lines out of service initiates RAS to trip generation.*



*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





*RST procedure did not have a comparison of as-left settings versus as-issued/as-designed.*

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# NERC Cause Code Assignment Process

An Event Investigation and Data Analysis Tool

January 2018

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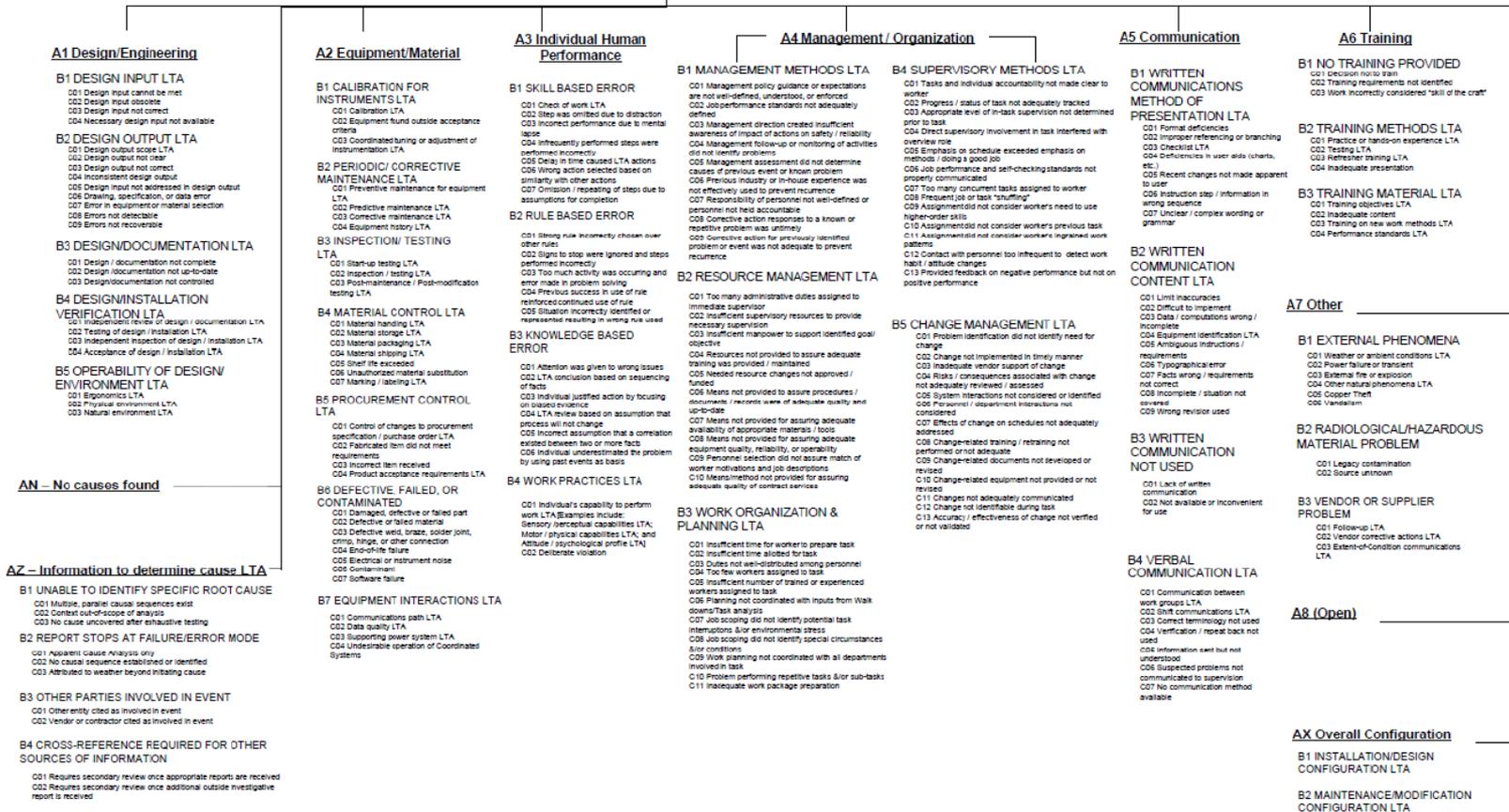
3353 Peachtree Road NE  
Suite 600, North Tower  
Atlanta, GA 30326  
404-446-2560 | [www.nerc.com](http://www.nerc.com)

Appendix A – Cause Code Quick Reference

## NERC CCAP Cause Code Quick Reference

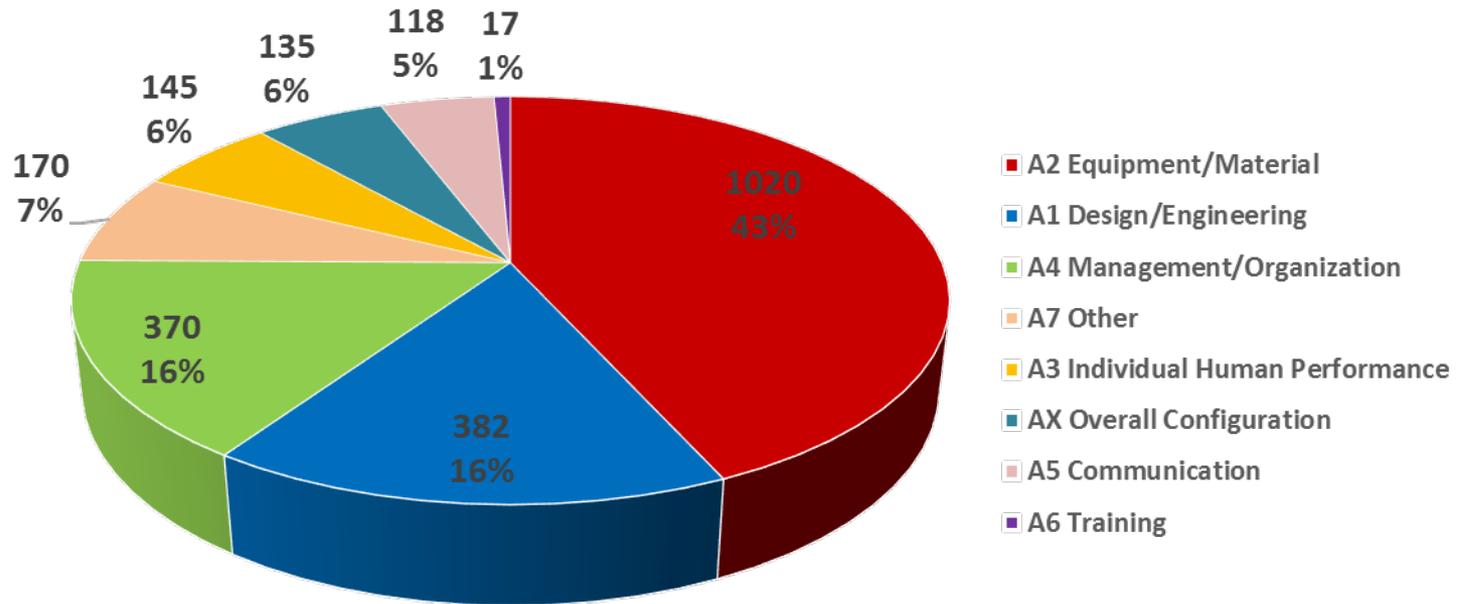
[nerc.lessonslearned@nerc.net](mailto:nerc.lessonslearned@nerc.net)

[www.nerc.com](http://www.nerc.com)



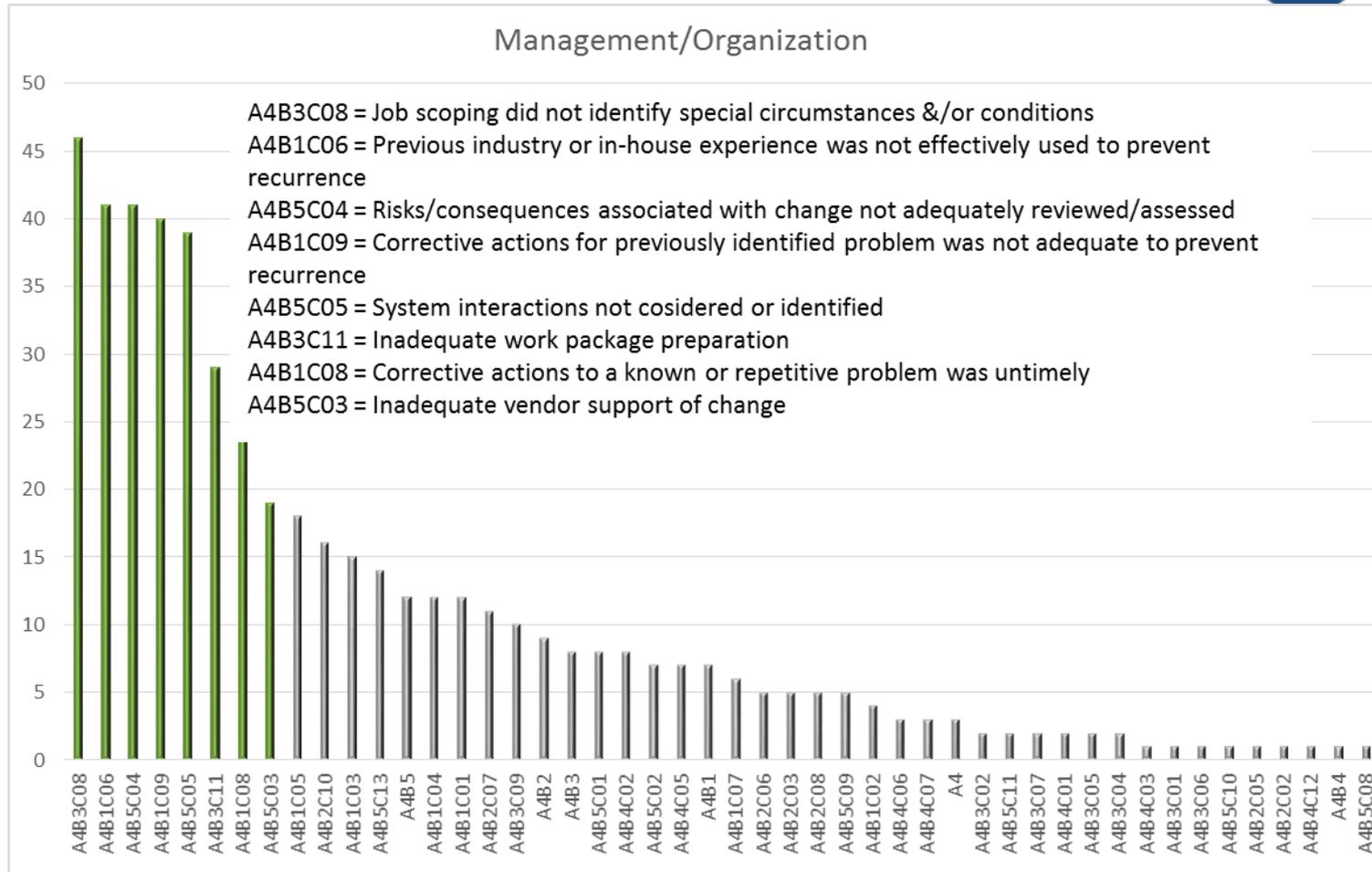
Level A nodes are underlined  
 Level B nodes are in ALL CAPS  
 Level C nodes are in "sentence case"  
 LTA = Less Than Adequate

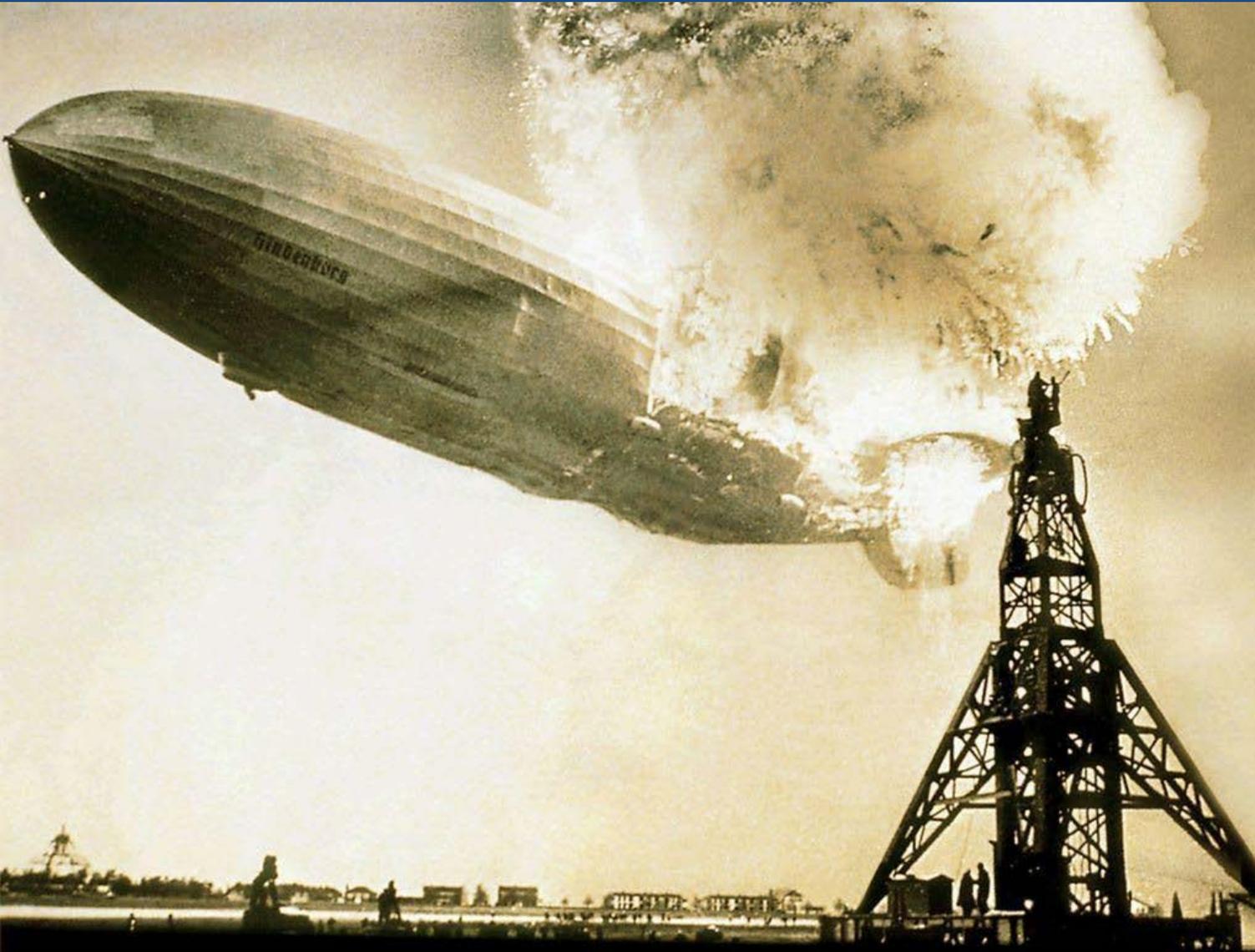
# How is Cause Coding used



890 Events have been cause coded, with 2360 identified contributing causes

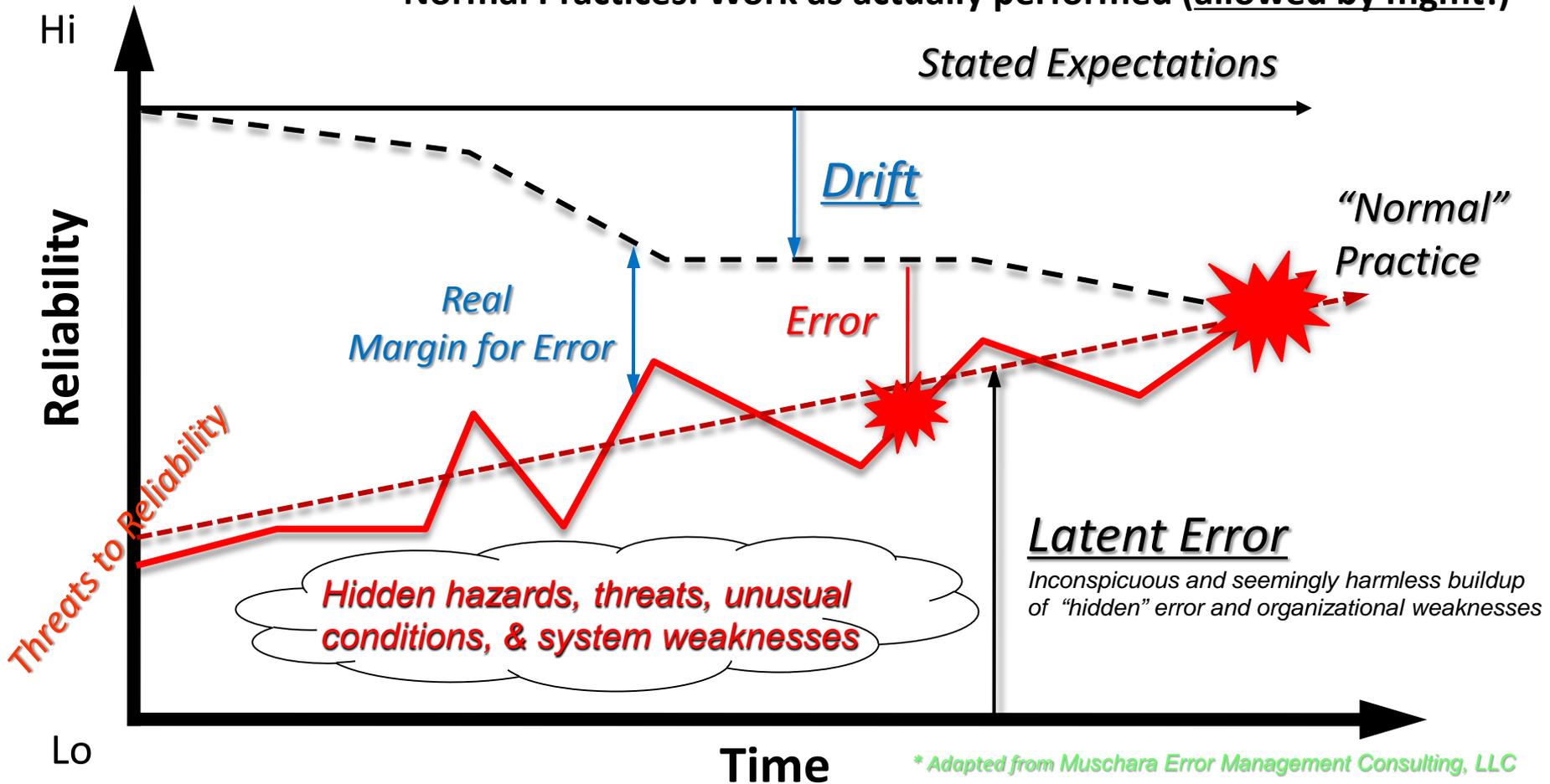
# How is Cause Coding used





Expectations: Desired approach to work (as imagined)

Normal Practices: Work as actually performed (allowed by mgmt!)





## Questions

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