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NORTH AMERICAN ELECTRIC
RELIABILITY CORPORATION

Cause Analysis

Methods and Tools

Ed Ruck

16-17 March 2021

RELIABILITY | ACCOUNTABILITY



- Please turn off electronics
- Participation
- Breaks
- Consideration for everyone

- Name
- Where you work
- What you do
- How long have you been doing it
- Any background in Cause Analysis
- Expectations for the course

- Cause Analysis Methods training
 - Reference for course: NERC “*Cause Analysis Methods for NERC, Regional Entities and Registered Entities*”.
 - Introduction to the fundamentals of systematic event causal analysis
 - Various techniques discussed
 - Purpose of the course is to enable attendees
 - to identify the appropriate use of causal analysis techniques for a given event,
 - apply selected techniques in analyzing the event.
 - Activities
 - discuss attributes of effective cause analyses,
 - conduct small group exercises using case studies of events to determine their root and/or apparent causes.
 - Applicability: NERC and Regional Entity personnel that conduct event analysis, audits, and investigations.
- Terminal Objective:
 - Given an event, select and apply appropriate causal analysis methods to determine the root and contributing causal factors that lead to events on the bulk power system, and develop corrective action recommendations.

- **EO1 – Define the following terms:**
 - Root cause
 - Apparent cause
 - Contributing cause
 - Common cause
 - Causal factor
 - Corrective action
- **EO2 – Discuss the attributes and appropriate application for each of the following causal analysis methodologies**
 - Change management analysis
 - Barrier analysis
 - Event and Causal Factor Analysis
 - Fault tree analysis
 - Management Oversight and Risk Tree (MORT)
 - Cause and Effect Analysis
 - Kepner-Tregoe (K-T) Problem Analysis
 - Cause and Effect Charting
 - Human Performance Evaluation
- **EO3 – Describe the steps to follow in RCA methodology for investigating an undesirable condition or problem**

- EO4 – Define and give examples of
 - Error mode
 - Error mechanism
 - Failure mode
 - Failure mechanism
- EO5 - Discuss the principles of human performance, error types, and factors that affect human error including organizational and programmatic contributors.
- EO6 - Analyze design, maintenance, operations and construction processes *and events* for human performance error contributors.
- EO7 – Given an event, select and apply the appropriate causal analysis methods for *stratifying* and analyzing data to reach *sound and logical conclusions, and associated corrective actions*.

**Rules of Procedure of the North American Electric Reliability Corporation
SECTION 800 — RELIABILITY ASSESSMENT AND PERFORMANCE ANALYSIS**

801. Objectives of the Reliability Assessment and Performance Analysis Program

The objectives of the NERC reliability assessment and performance analysis program are to:

- (1) conduct, and report the results of, an independent assessment of the overall reliability and adequacy of the interconnected North American bulk power systems, both as existing and as planned;
- (2) analyze off-normal events on the bulk power system;
- (3) identify the **root causes of events that may be precursors of potentially more serious events**;
- (4) assess past reliability performance for lessons learned;
- (5) disseminate findings and lessons learned to the electric industry to improve reliability performance; and
- (6) develop reliability performance benchmarks. The final reliability assessment reports shall be approved by the board for publication to the electric industry and the general public.

See also ROP 808 & 900; DOE 5000.3B



***DOE “Occurrence Reporting and Processing of Operations Information” (DOE M 231.1-2)
April 2003***

(as cited in DOE-NE-STD-1004-92)

*..... [reference] requires the investigation and reporting of occurrences (**including the performance of Causal Analysis**) and the selection, implementation, and follow-up of corrective actions. The level of effort expended should be based on the significance attached to the occurrence.....*

DOE = Department of Energy



DOE GUIDELINE ROOT CAUSE ANALYSIS GUIDANCE DOCUMENT - DOE-NE-STD-1004-92 February 1992

*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.*

*Every root cause investigation and reporting process should include **five phases**. While there may be some overlap between phases, every effort should be made to keep them separate and distinct.*

DOE = Department of Energy

- Problem: Power company's are expected to understand and fix problems as they occur – they are inconsistent in their understanding of the expectations, and problems keep coming back
- Why should anyone care – we have a pretty reliable electric supply (or do we??)
- Solution – help everyone gain an understanding of how to improve, to solve the problems

Why bother with RCA?



Or...When Good Pistons go Bad!



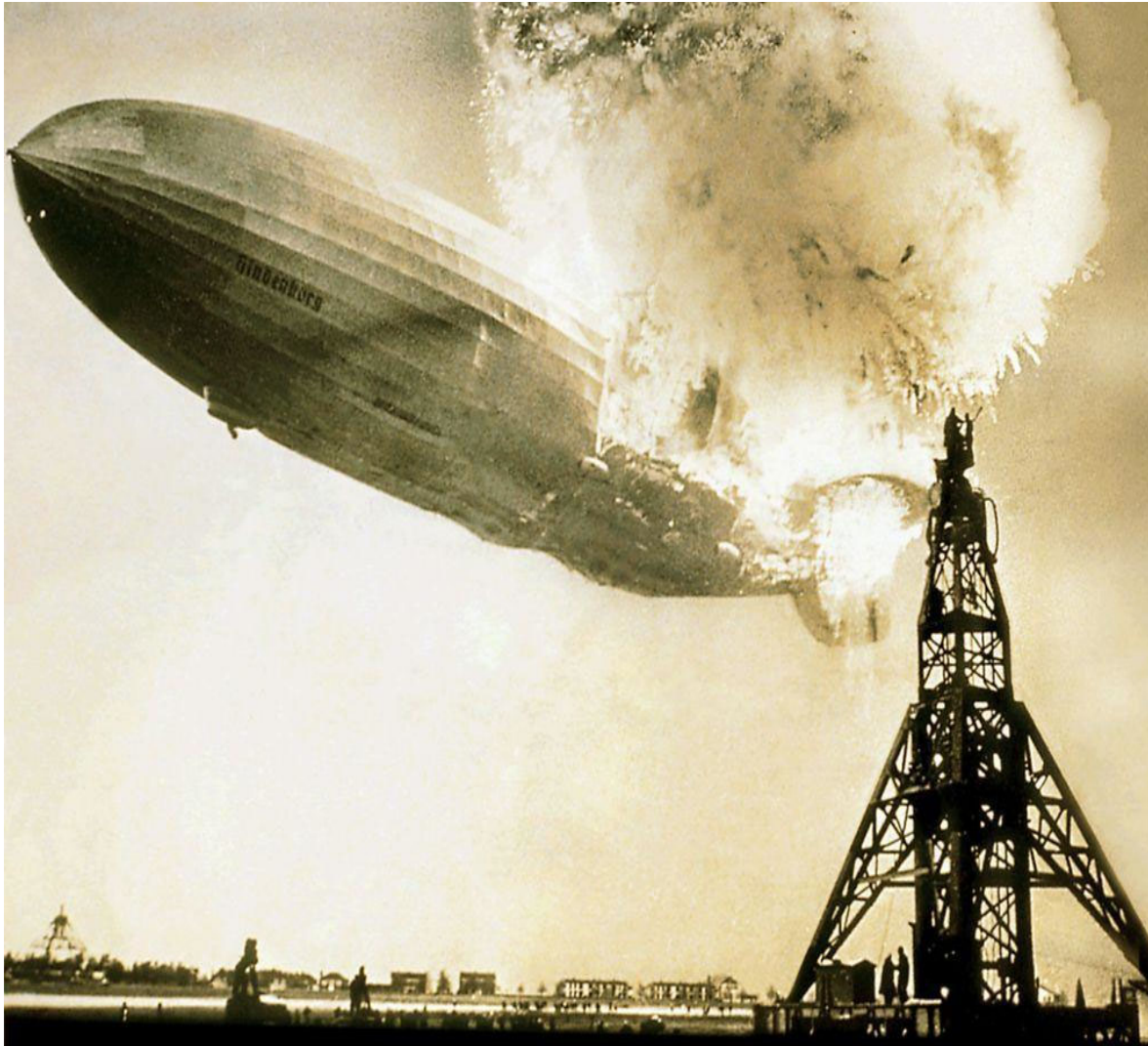
- Facts
 - Jeep had 107k miles
 - Cylinders were fine...no abrasions (whew, got lucky)
 - Approx \$2,500 to completely rebuild, same block
 - Just MTF for pistons...or maybe not...

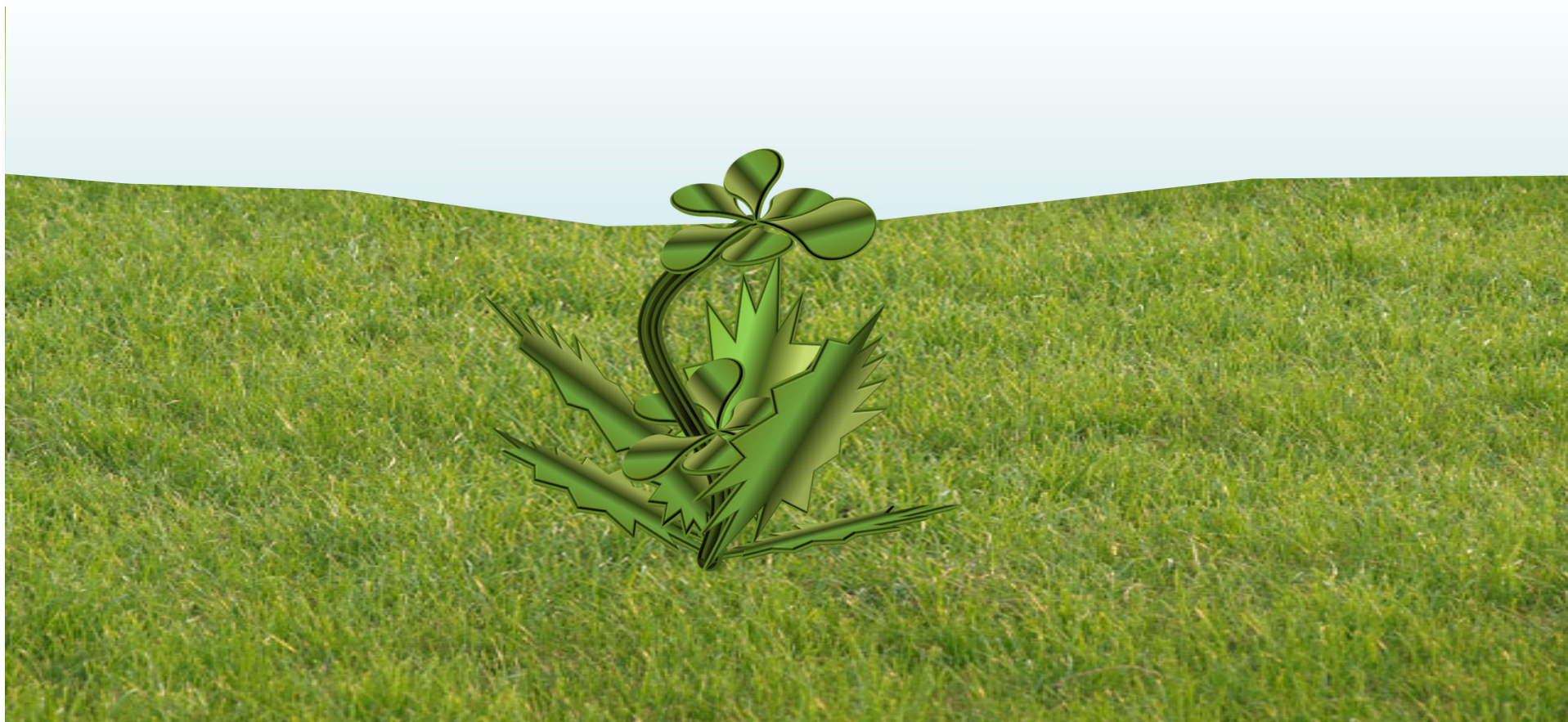
- Mechanic noticed some scalding on other pistons
- No history of ever over heating...
- **Dig deeper into equipment history**
- Jeep was hit on right side, at 70k miles....
- Right fender was replaced, radiator and fan blade..no damage to engine block
- **Check to see if something changed**
- New Fan blade was installed backwards!!!!
- Jeep was running hotter than it should...just slightly...not enough to notice...and it was new owner so there was no baseline...
- So, just MTF for piston?

*Apparent Cause
Analysis* (ACA)

VS.

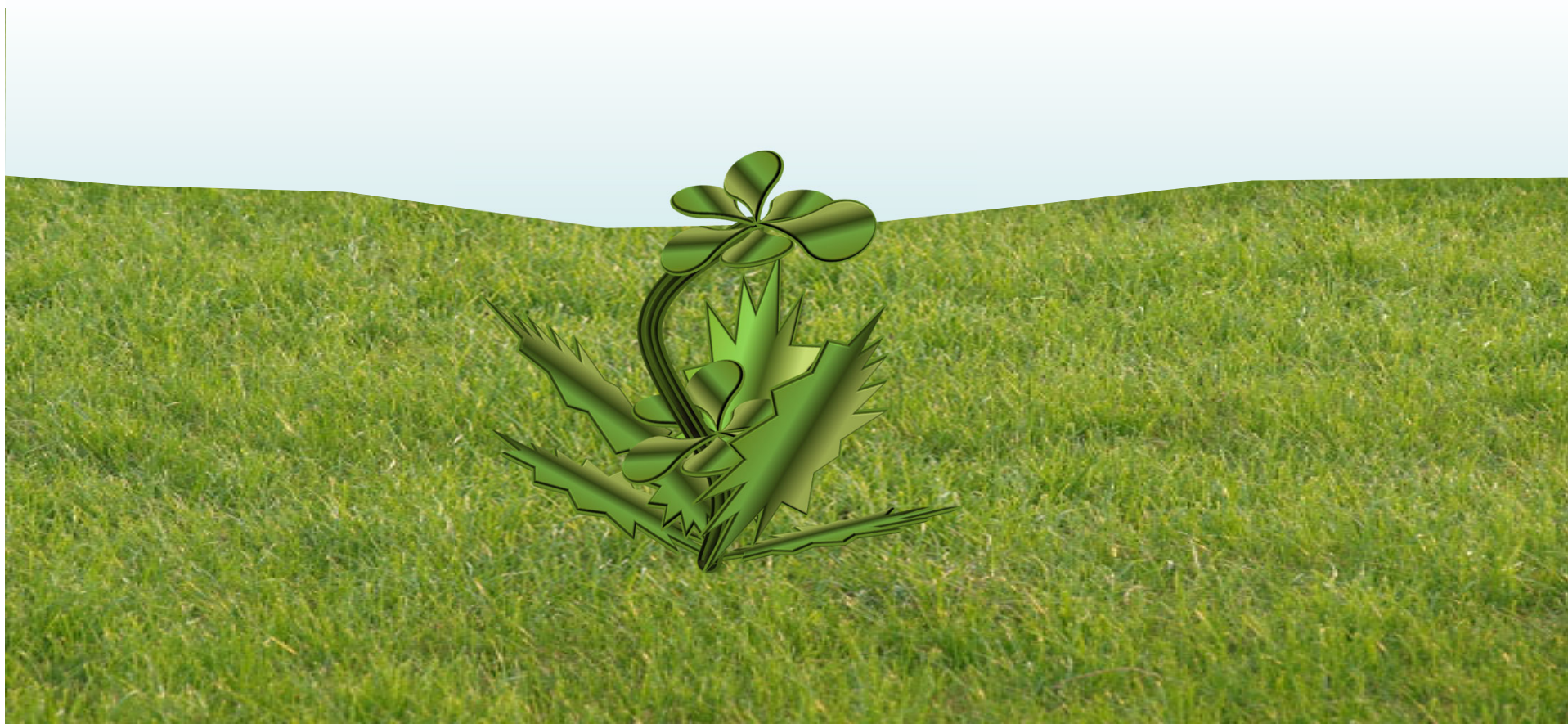
Root Cause Analysis
(RCA)





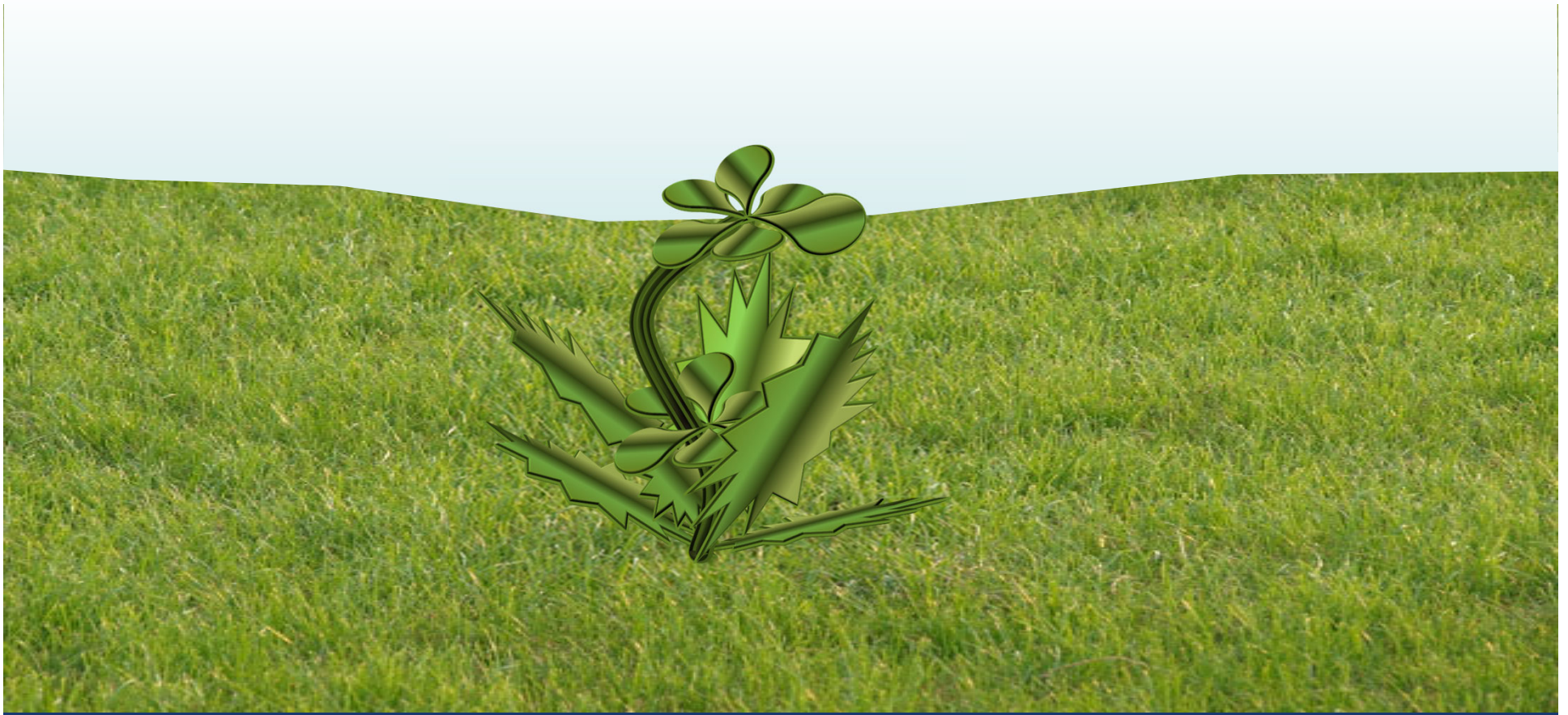
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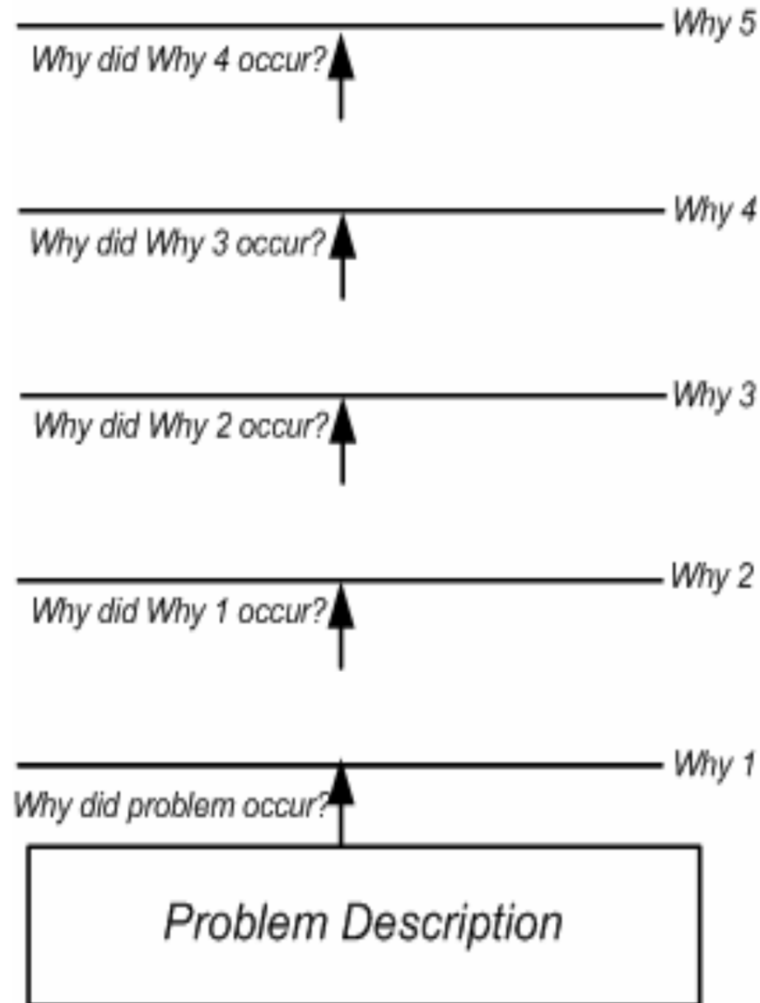




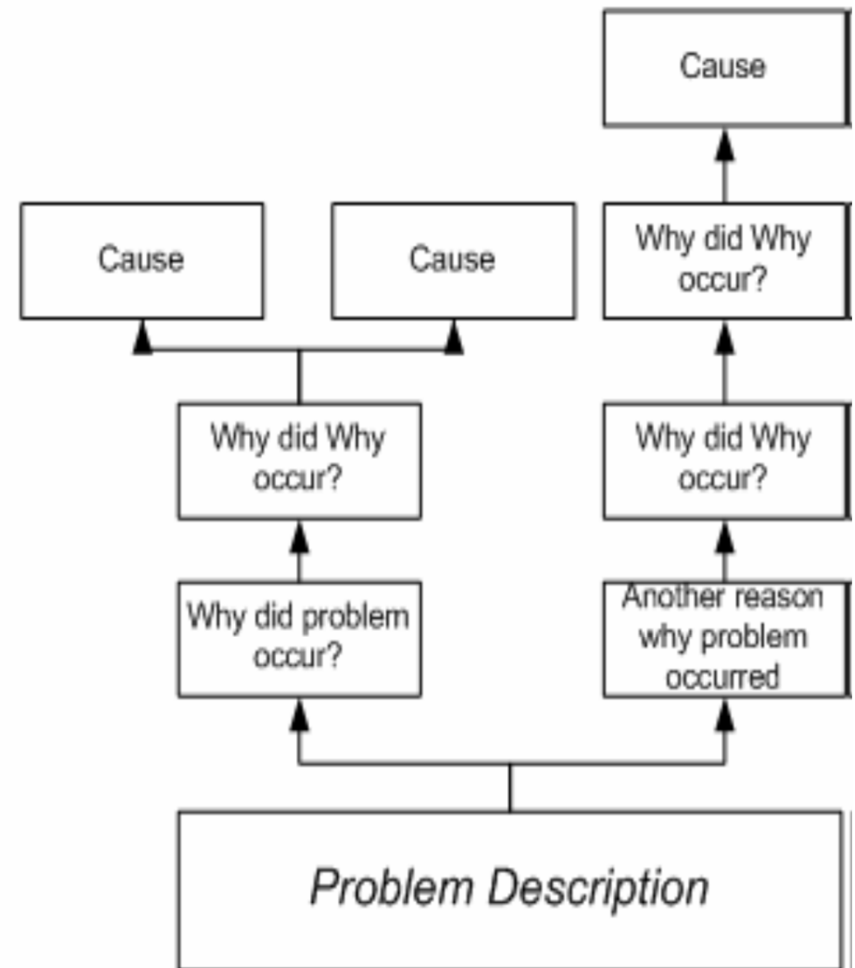
ACA seeks to determine why the problem happened based on reasonable effort and the investigator's judgment and experience. The emphasis is mainly to correct a particular event or problem without an effort to identify the underlying contributors to the problem.

NOTE: ACA is not industry standard for system disturbances or major events and is not referenced in the DOE Guidelines for Root Cause Analysis.

“Why” Staircases

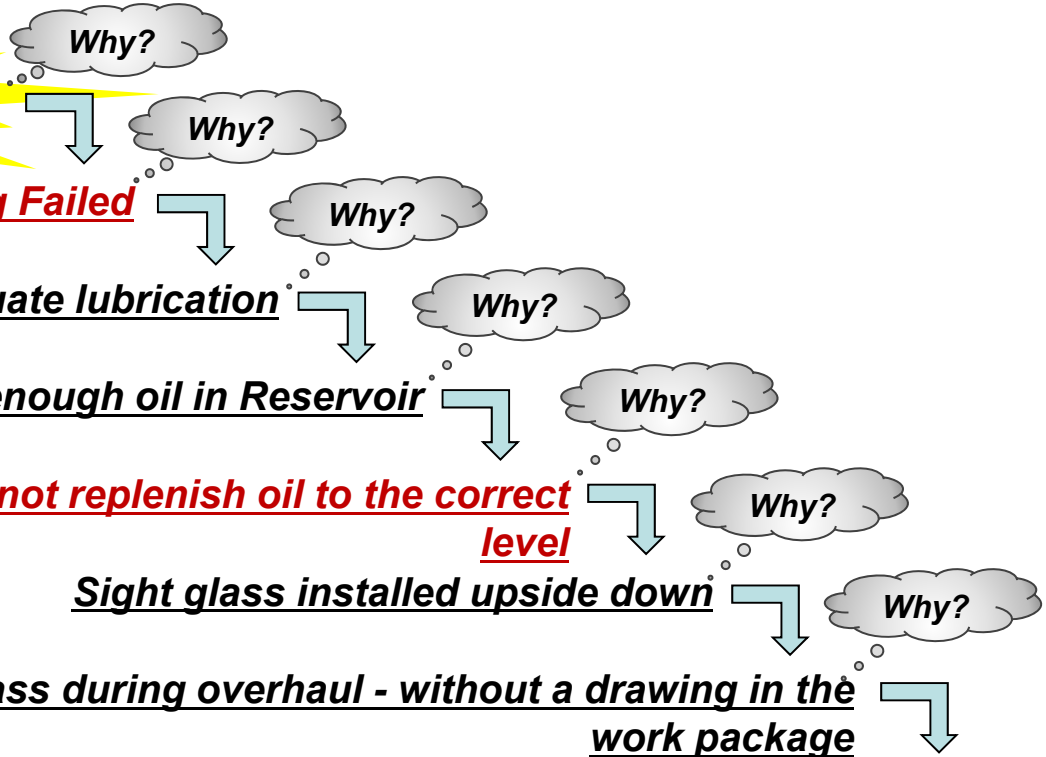


Equipment - People



Example of a “Why” Staircase for a Loss of cooling water

Lost cooling water to equipment



Document Control Back Log

Example of a “Why” Staircase for a Loss of cooling water

3 Transmission Lines trip

Why?

Line Circuit Breakers trip

Why?

Breaker Failure initiated

Why?

Protection system misoperated

Why?

Technician did not remove jumper

Why?

Technician wired according to diagram

Why?

Drawing showed jumper in place

Why?

Drawing error exists

Why?

Why?

RCA - is a process used to identify, analyze, correct, and prevent recurrence of performance problems to determine the most basic reason for an undesirable condition or problem which, if eliminated or corrected, would have prevented it from existing or occurring.

The DOE Root Cause Analysis Guidelines document is the recommended guide for root cause analysis specified by DOE Order 5000.3B, "Occurrence Reporting and Processing of Operations Information." Causal factors identify program control deficiencies and guide early corrective actions. As such, root cause analysis is central to DOE Order 5000.3B.

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*

*WHY ???
WHY ???
WHY ???
WHY ???
WHY ???
WHY ???
WHY ???
WHY ???
WHY ???
WHY ???*

- Failure Mode*:
 - The manner whereby the failure is observed
- Failure Mechanism:
 - Physical, chemical or other processes that led to the failure

Example:

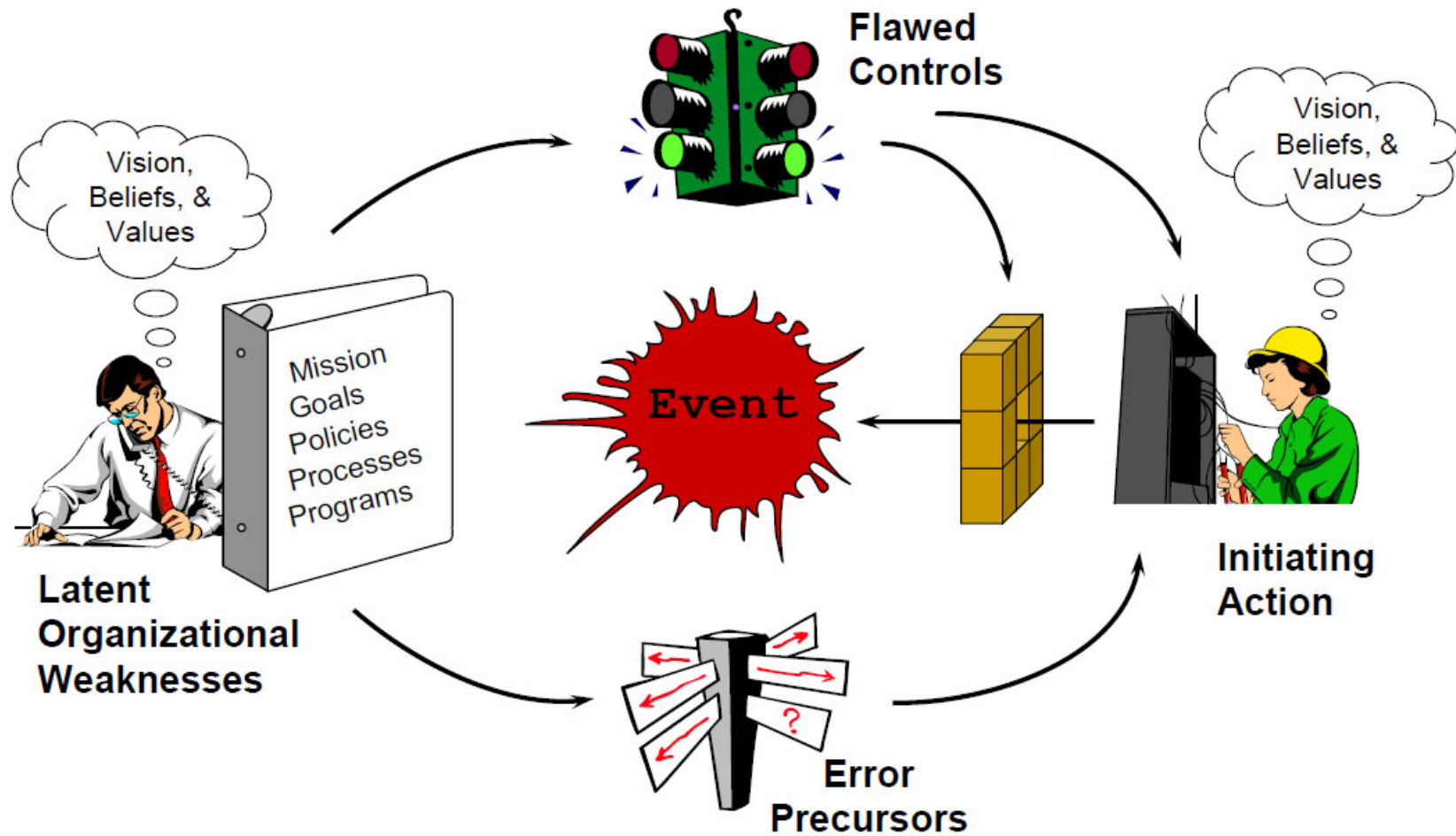
Component	Failure Mode	Failure Mechanism
Relay	Contacts fail closed	Electrical short
Computer stops processing	Virus downloaded	Virus protection not current
Transformer	Coil Shorts	Insulation breakdown
Power Supply	Loss of Output	Diode failure

** 60% stopped at failure mode during cause analysis*

- “an unwanted, undesirable change in the state of plants, systems, or components that leads to undesirable consequences to the safe and reliable operation of the plant or system”
- Often driven by
 - Deficiencies in barriers and defenses
 - Latent organizational weaknesses and conditions
 - Errors in human performance and contextual factors
 - Equipment design and/or maintenance issues

- Over-tripping
- Equipment failure
- Computer or program crash
- Relay misoperation or inadvertent operation
- EMS outage
- Vehicle accident
- Non-compliance
- Loss of data
- Argument with your spouse

Anatomy of an Event (INPO Model)



- **Determine Cause of Failure**
 - Physical
 - Operational
 - Organizational
- **Determine Class of Failure**
 - Specific
 - Generic
- **Take Corrective Action**
 - Short term (e.g., replacement, procedure)
 - Long term (e.g., stop-use, recall, redesign)

- Investigation or analysis
 - Thorough, fair, efficient
 - Timely, objective, systematic
 - Technically sound
- Documentation
 - Factual
 - Pertinent
- Focused on problem-solving, not blaming
- Identification: facts, conditions, circumstances, operational events, sequence of events
- Follow-up actions: corrective actions, design changes, dissemination of information

Prevent Equipment Damage



Prevent Personnel Injury



- The investigation or analysis
- “Event” characteristics
- Tools
- Considerations
 - Equipment-related
 - Human-related
 - Combination

- To enable the identification of corrective actions adequate to prevent recurrence
- Protect the health and safety of
 - Public
 - Workers
 - Environment
- Five phases (try to keep them distinct or separated)
 - I. Data Collection
 - II. Assessment
 - III. Corrective Actions
 - IV. Inform
 - V. Follow-up

- Multiple failures or singular failure
- Possible adverse generic implication
- Complicated, unique, not understood
- Cause unknown
- Significant system interactions
- Repetitive failures
- Deficiency in design, construction, operation
- Operational or management performance issue(s)

- Well over 100 “tools” which can be used in different circumstances
- Concentrating on “DOE-recognized” tools plus more recently-developed significant tools
- Use tools as appropriate
 - Potential for recurrence
 - Significance of issue
 - Resources available

Selection of methods (cont'd)

METHOD	WHEN TO USE	ADVANTAGES	DISADVANTAGES	REMARKS
Task Analysis	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).
Events and Causal Factor Analysis	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.
Change Analysis	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.
Barrier Analysis	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

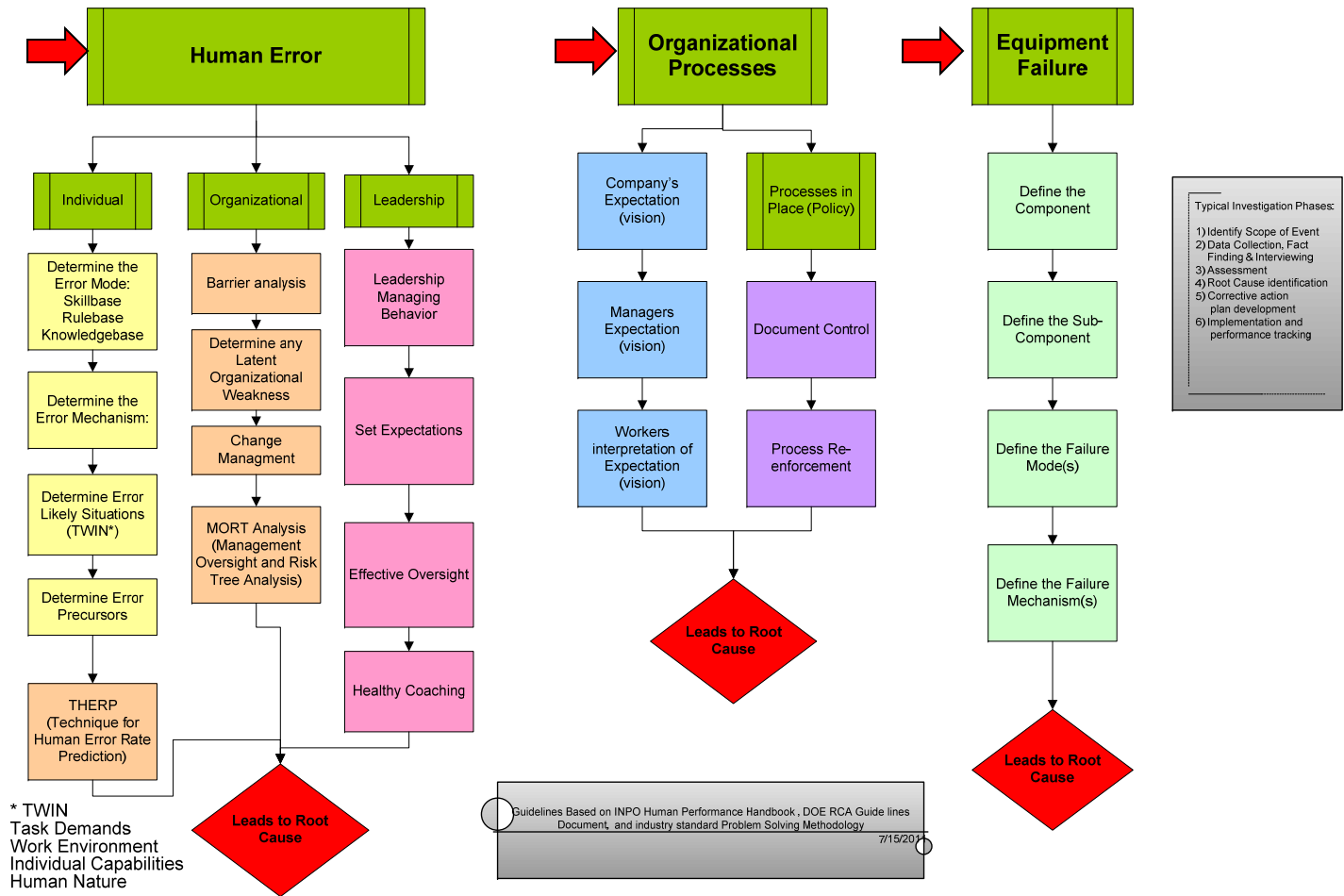
Selection of methods (cont'd)

METHOD	WHEN TO USE	ADVANTAGES	DISADVANTAGES	REMARKS
MORT/Mini-MORT	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.
Human Performance Evaluations (HPE)	Use whenever people have been identified as being involved in the problem cause.	Thorough analysis	None if process is closely followed.	Requires HPE training.
Kepner-Tregoe	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.
Fault Tree Analysis	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
Cause and Effect Charting (e.g., Reality Charting®)	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."

- Most incidents involve both equipment and human error
- Combination of methods used

Overview of Event Analysis

Event Analysis Methodology Tree





- There are 2 reasons an organization conducts a Root Cause Analysis (RCA)
 - It is required (or expected) to do so.
 - Potential Impact – only bare minimum done, so can say it was done
 - Checkbox mentality
 - They want to learn what caused the problem
 - Potential Impact – cause identified and corrected
 - Learning mentality

- Get to a safe condition
- Preservation of evidence
 - Scene/object observation
 - Testimony of personnel
- Initial Documentation
 - Field notes
 - Photographs
 - Sketches
 - Drawings
- Familiarization with facility, operation

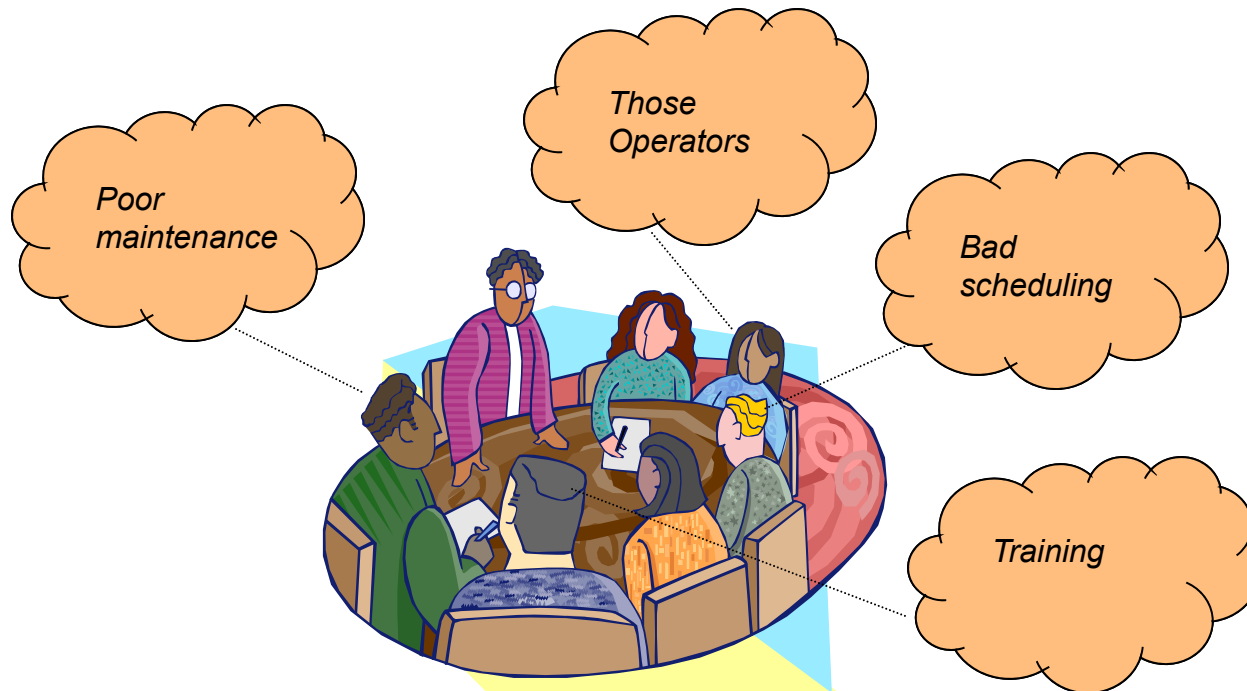
- Technical experts
 - Operators
 - Engineers
 - Field Crews
- Skills to add potential contributions
- Independent, objective
- Trained in investigative techniques

- Many tools available
 - Not going to try to address all of them
- Need to pick right ones for the job
- Our focus – DOE-cited tools (plus a few)

- DOE-cited Methods (from DOE RCA Guidance Document, 1992)
 - Events and Causal Factor (E&CF) Analysis
 - Change Analysis
 - Barrier Analysis
 - Management Oversight & Risk Tree (MORT) / Mini-MORT
 - Kepner-Tregoe[®] (K-T)
 - Human Performance Evaluations (HPE)
- Other Methods & Tools
 - Task Analysis
 - Fault Tree Analysis (FTA)
 - Cause and Effect Charting

- Tools to use may be dependent on problem type
- Select the tool which is right for you and for the situation
- Not here to make you experts, but to make you aware
 - the tools and methods,
 - the need for a structured approach

- We all know what the problem is, so let’s fix it once & for all!!



- What
- When
- Where
- Significance

- Define the Problem!
 - What is the problem?
 - A problem is a Gap between actual & desired (the Goal)!
 - So, we need to ensure we are all in agreement as to the goal

- Define the Problem!
 - What is the problem?
- *This is the Primary Effect, the reason we are here*

Example: Protection System not tested

- Define the Problem!
 - What is the problem?
 - When did it happen?
- *To set the timeframe*
 - *May be a time, or a step in a sequence*
 - *We all need to be talking about the SAME event*

*Example: Protection System not tested **since 2009***

- Define the Problem!
 - What is the problem?
 - When did it happen?
 - Where did it happen?
- *Again, for additional clarification; are all the “players” known?*

*Example: Protection System for **Plant ABC’s XYZ #2**
Generator overspeed protection not tested since 2009*

- Define the Problem!
 - What is the problem?
 - When did it happen?
 - Where did it happen?
 - What is the significance of the problem?

- *Why are we even here talking about this? Be as specific as possible (example: Protection System for Plant ABC’s XYZ #2 Generator overspeed protection not tested since 2009, **resulting in undetected improper settings and inadvertent trip of this generator**)*

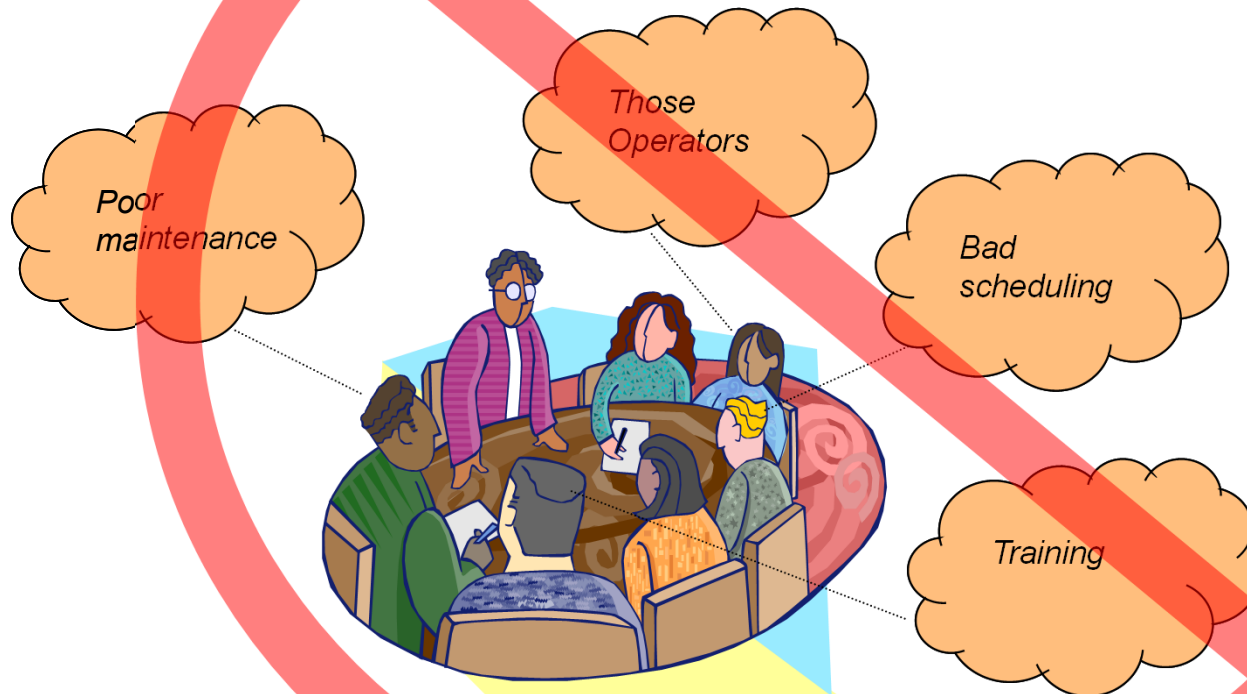
- **Define the Problem!**
 - **WHAT** is the problem?
 - **WHEN** did it happen?
 - **WHERE** did it happen?
 - What is the **SIGNIFICANCE** of the problem?

- **What the Problem Definition Does Not Contain**
 - **WHO** - There is no need to ask “Who” unless you are asking who knows the answer to a question. This is important to mention because of the strong tendency to place blame, which detracts from the focus on prevention.
 - **WHY** - Asking “Why” at this stage detracts from defining the problem and is part of the analysis step that will be addressed soon after defining the problem.
 - **No SPECULATION**, stick to facts as you know them



*“A problem well stated is a problem half-solved.”
— Charles Kettering*

- We all know what the problem is, so let's fix it once & for all!!





DOE GUIDELINE ROOT CAUSE ANALYSIS GUIDANCE DOCUMENT - DOE-NE-STD-1004-92 February 1992

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*Every root cause investigation and reporting process **should include five phases**. While there may be some overlap between phases, every effort should be made to keep them separate and distinct.*

DOE = Department of Energy

Five phases:

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

Ref: DOE-NE-STD-1004-92

Five phases:

I. Data Collection

II. Assessment

III. Corrective Actions

IV. Inform

V. Follow-up

Ref: DOE-NE-STD-1004-92

- It is important to begin the data collection phase of cause analysis immediately following the occurrence identification to ensure that data are not lost. (Without compromising safety or recovery, data should be collected even during an occurrence.)
- The information that should be collected
 - conditions before, during, and after the occurrence;
 - personnel involvement (including actions taken);
 - environmental factors;
 - and other information having relevance to the occurrence.

- Areas to be considered when determining information needed
 - Activities related to the occurrence
 - Initial or recurring problems (problem history)
 - Hardware (equipment) or software (programmatic-type issues)
 - Recent changes (admin or equipment)
 - Physical environment or circumstances

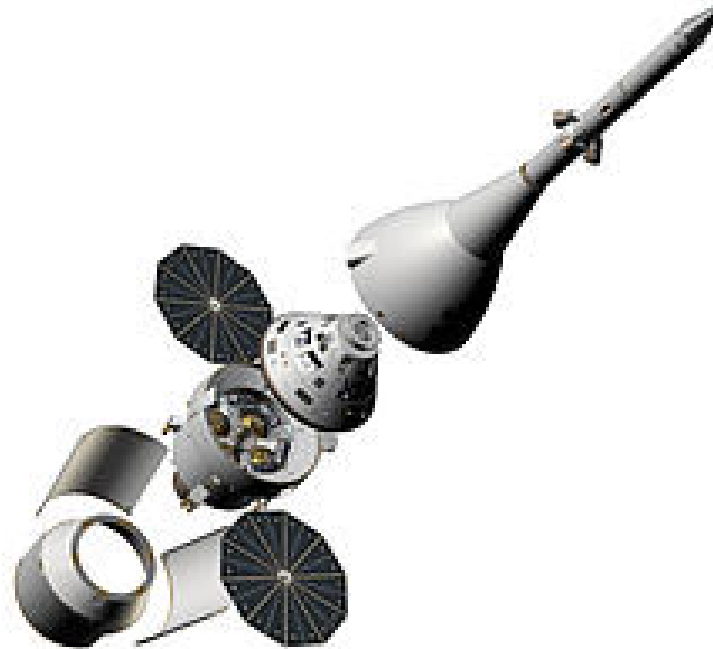
- Methods of gathering information
 - Interviews
 - **fact-finding, NOT fault-finding in nature**
 - Preferably in person, one-on-one
 - People most familiar with the problem
 - Consider “walk-through”
 - *Steps: Preparation, Opening, Questioning, Closing*
 - Reviewing Records
 - Operating logs, alarm sequences, correspondence, Inspection/surveillance records,
 - Maintenance records, Equipment history records, Work orders, Meeting minutes, computer data
 - Procedures and instructions, Vendor manuals, Drawings & specifications
 - **Consider “artifacts”**
 - Not intended to be all-inclusive list

QV&V all sources of data when doing a Cause Analysis!

- *Question*
- *Verify*
 - *Verification is a process of ensuring that the data provided is consistent with the process being analyzed.*
- *Validate*
 - *Validation involves the actual testing where we check the program design to see if it is according to the intended design*

One piece of extraneous data can lead to wrong conclusions !!!

- Verify – is it there? (Does our spacecraft have everything it needs to?)



- Validate – Does it really work?

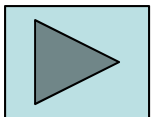


Five phases:

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

Ref: DOE-NE-STD-1004-92

- Purpose
 - Analyze the data
 - Identify causal factors
 - Summarize the findings
 - Group the findings by cause categories (cause codes, used for Trending)
- RCA done here



- Task Analysis
 - Change Analysis
 - Barrier Analysis
 - Events and Causal Factor Analysis
 - MORT / Mini-MORT
 - Kepner-Tregoe[®] (K-T)
 - Fault Tree Analysis (FTA)
 - Cause and Effect Charting
 - Human Performance Evaluations (HPE)

- Task Analysis is a method in which personnel conduct a step-by-step reenactment of their actions for the observer without carrying out the actual function.
- If appropriate, it may be possible to use a simulator for performing the walk-through rather than the actual work location.
- Objectives include:
 - Determining how a task was really performed
 - Identifying problems in human-factors design, discrepancies in procedural steps, training, etc.

- Cognitive Task Analysis
 - What was the person thinking while conducting the task?

- Contextual Task Analysis
 - What was happening while the task was being performed?

- Identifies aspects of system design that place heavy demands on the user's cognitive resources including memory, attention, and decision-making
- Determines the thought processes that users follow to perform tasks at various levels, from novice to expert
- Examines the system from the viewpoint of the user performing a specific task.

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Contextual Task Analysis



Max Whittaker for The New York Times



Hydro Quebec

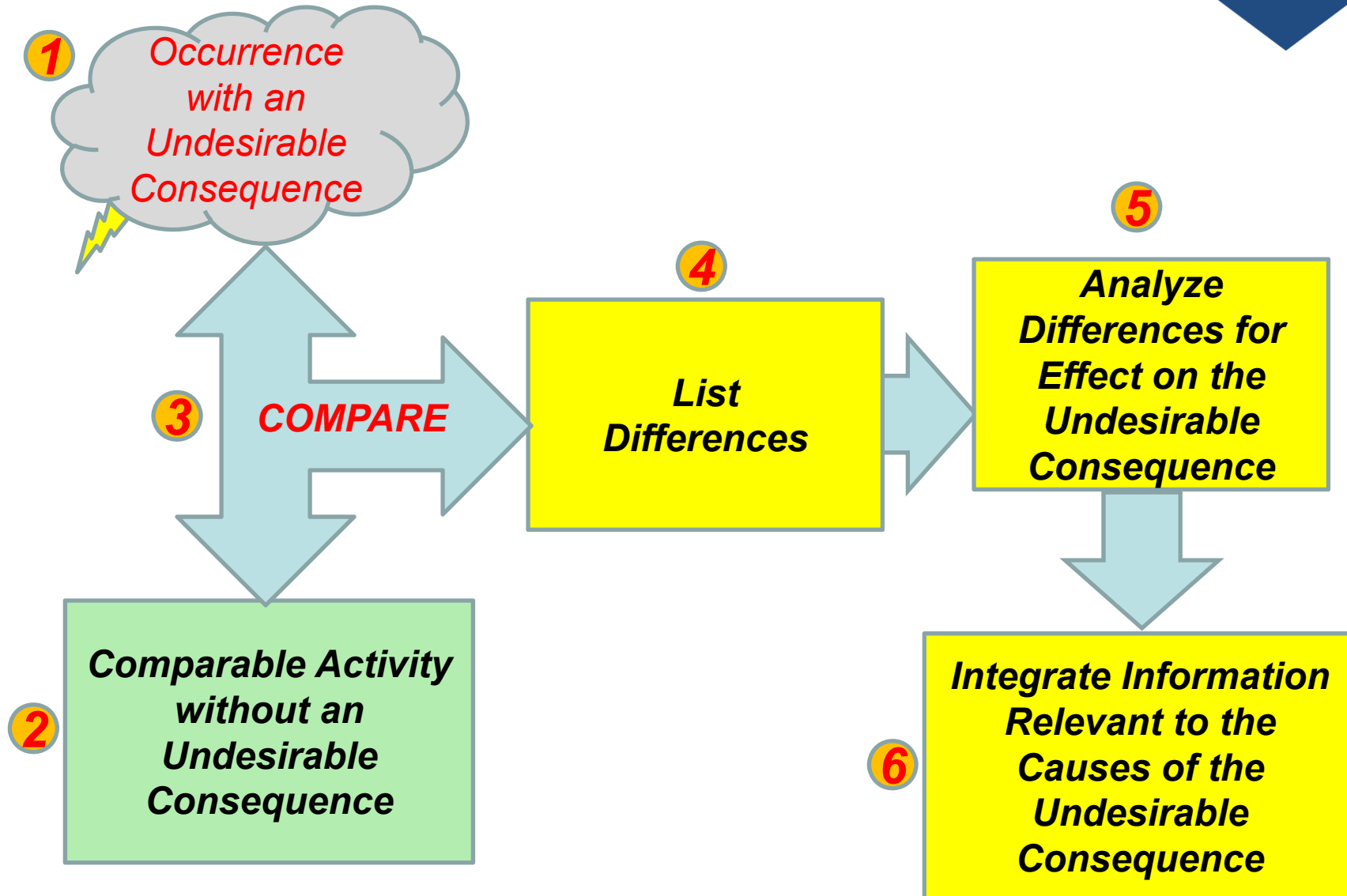


- Physical work environment(s)
 - workstation design lighting
 - heat / cold noise level
 - distractions
 - interruptions
- Socio cultural work environment
 - Morale
 - Motivation
 - inter-user support and team work
 - past experience and attitudes towards automation
- Job context
 - tasks and subtasks
 - task sequencing
 - frequency and importance of tasks within overall job
 - artifacts supporting tasks
 - workarounds / bottlenecks

- Task Analysis
- Change Analysis
- Barrier Analysis
- Events and Causal Factor Analysis
- MORT / Mini-MORT
- Kepner-Tregoe[®] (K-T)
- Fault Tree Analysis (FTA)
- Cause and Effect Charting
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- *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*

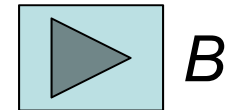
Six Steps of Change Analysis



Change Analysis – Worksheet example

Change Factor	Difference / Change	Effect	Questions to Answer
What ? (Conditions, occurrence, activity, equipment)			
When ? (Occurred, identified, plant status, schedule)			
Where ? (Physical location, environmental conditions)			
How ? (Work practice, omission, extraneous action, out of sequence procedure)			
Who ? (Personnel involved, training, qualification, supervision)			

- Exercise
 - Conduct Change Analysis
 - *Change Analysis worksheet*



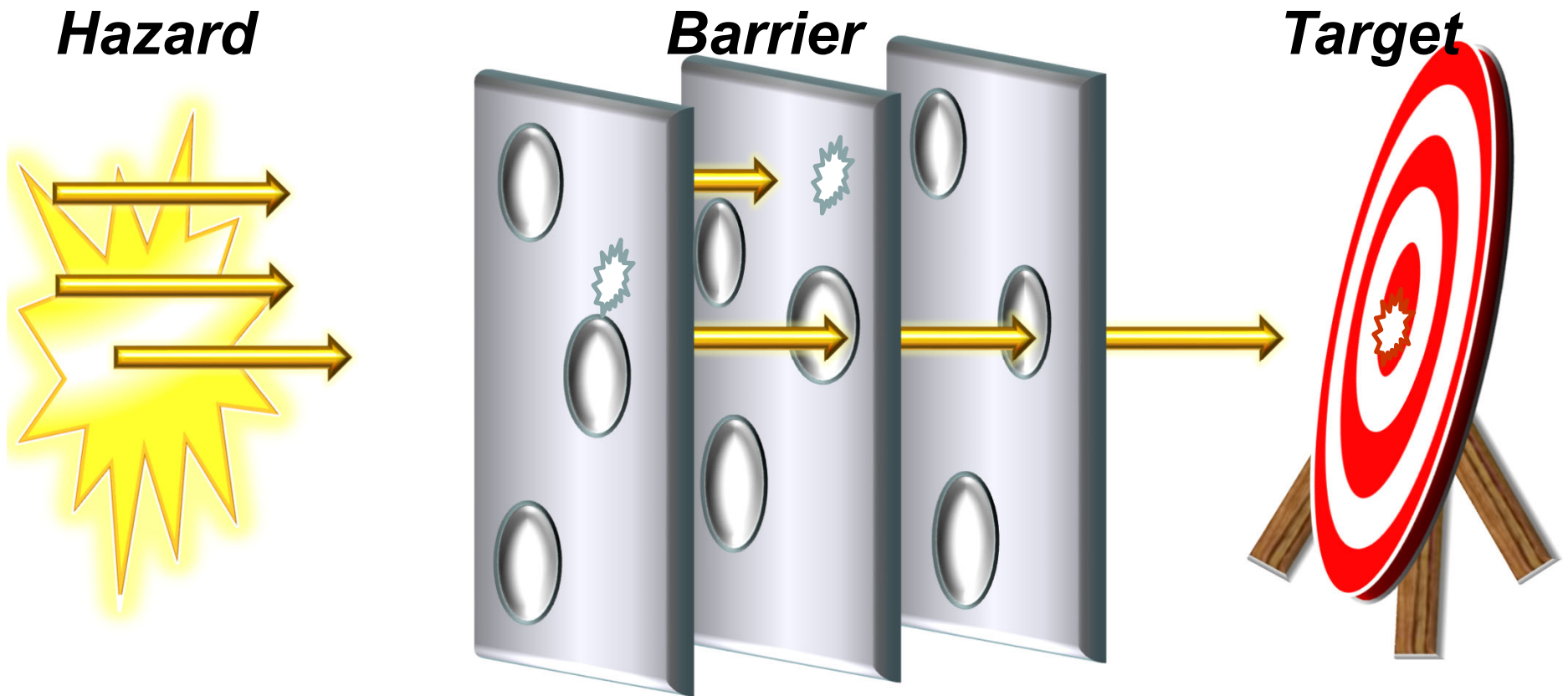
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- Cause and Effect Charting
- Human Performance Evaluations (HPE)

HAZARD AND BARRIER ANALYSIS GUIDANCE DOCUMENT



- ***Used to identify physical, administrative, and procedural barriers or controls that should have prevented the occurrence.***
- ***Especially useful in evaluating human performance error events***
- ***Requires familiarity with process to be effective***

Note: term “Barrier” is also known as “Defense”; use depends on audience; the intent is to be conversant with either term



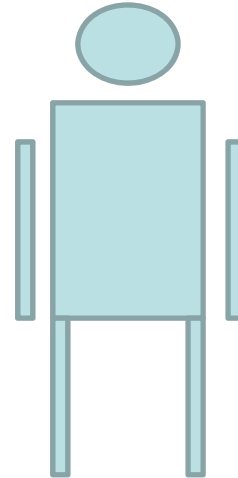
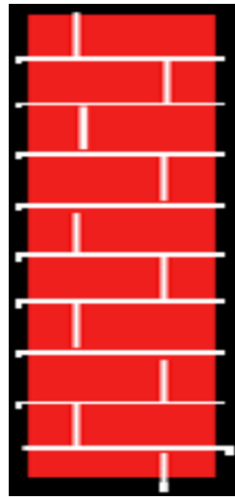
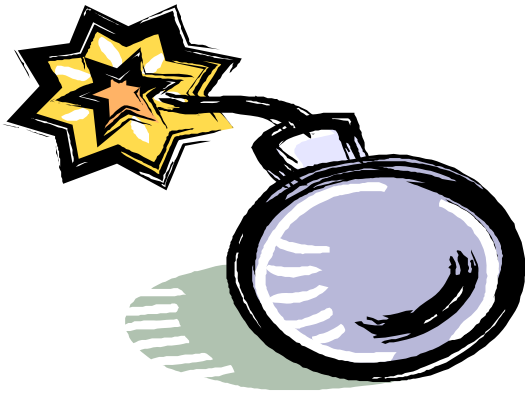






- Identify and list the consequences.
- Identify and list the failed barriers in place for each consequence
- Determine why (causes) the barriers failed (e.g., procedure not followed correctly).
- Verify the results.
- Develop corrective actions for each of the causes.

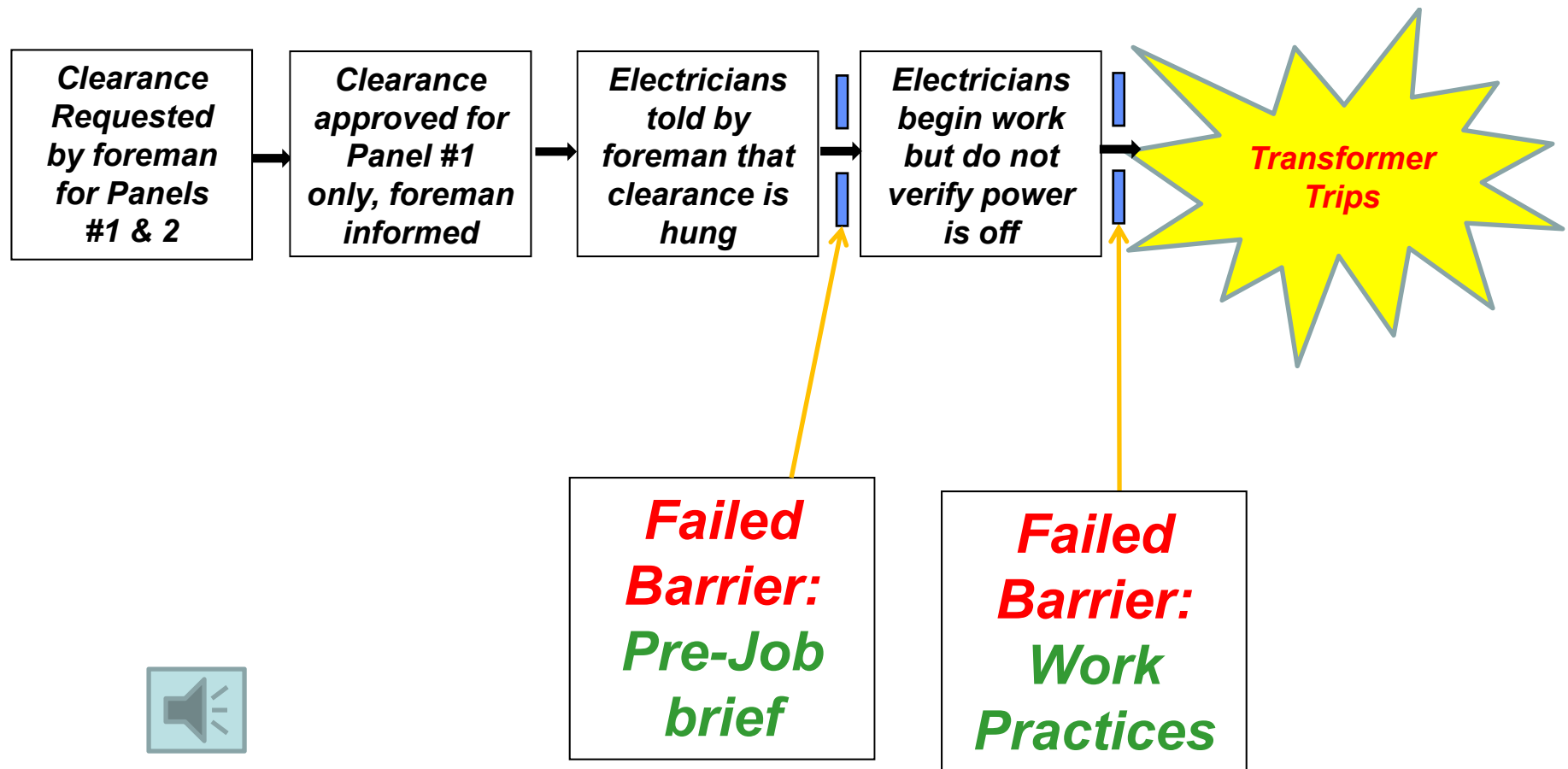
Barriers prevent the threats from reaching the targets



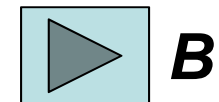
Barrier Analysis – Example

Work Request: Clean Station Services Panel #1 & #2 @ Substation #34

Event: Transformer # 2 tripped



- Exercise
 - Conduct Barrier Analysis
 - *Barrier Analysis worksheet*





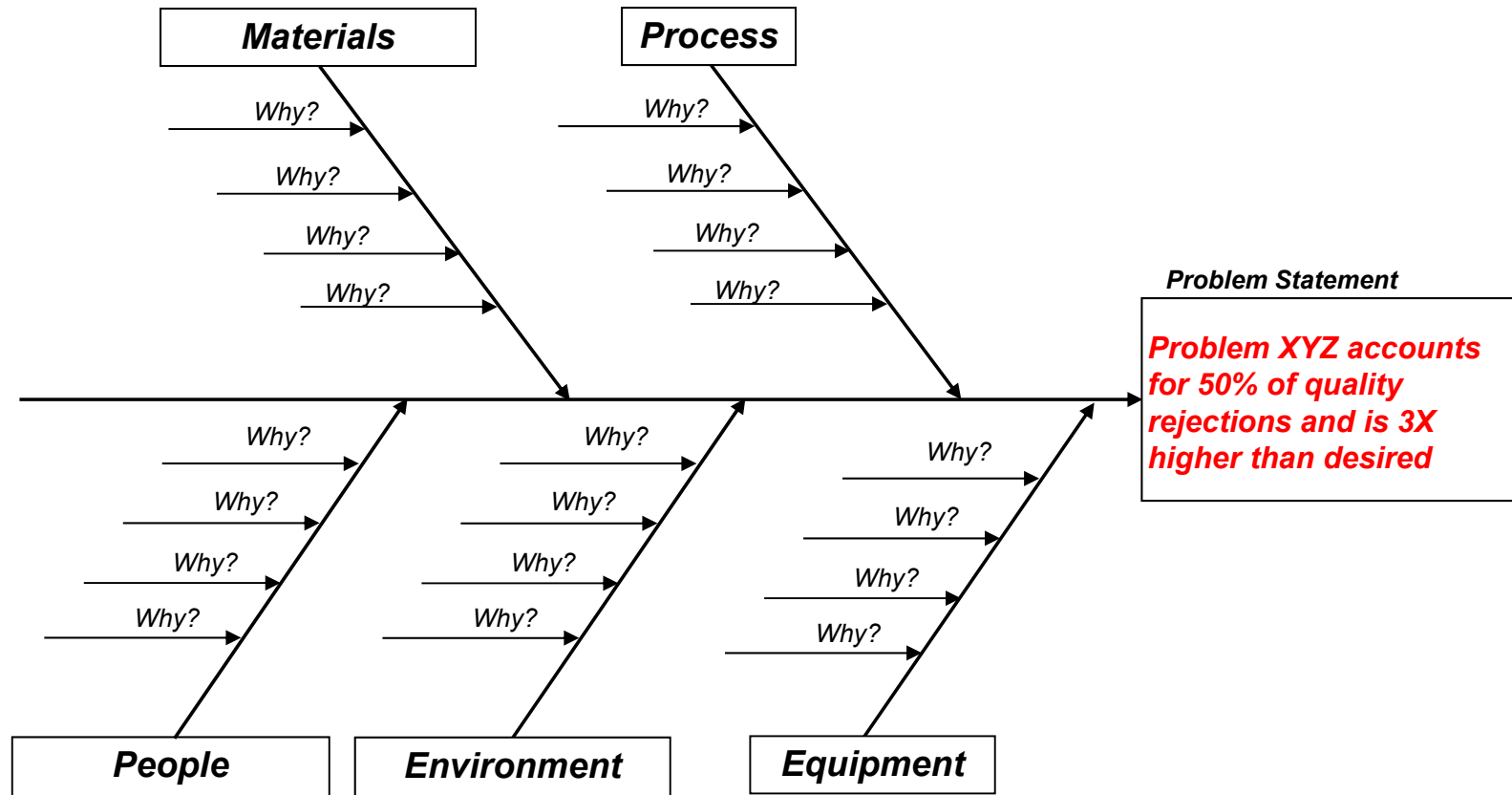
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Events and Causal Factors Analysis

Technical Research and Analysis Center
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WHEN TO USE	ADVANTAGES	DISADVANTAGES	REMARKS
Use for multi-faceted problems with long or complex causal factor chain.	Provides visual display of analysis process. Identifies probable contributors to the 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.

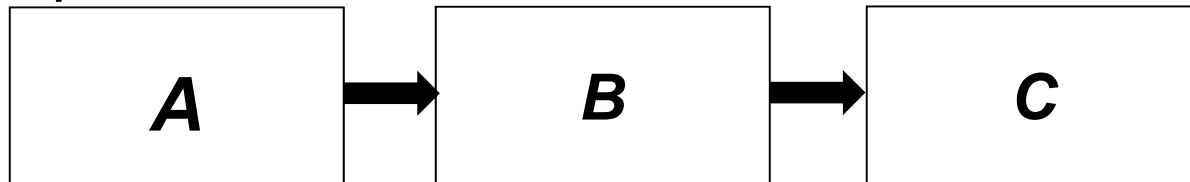
Fishbone (Cause and Effect Analysis) Diagram



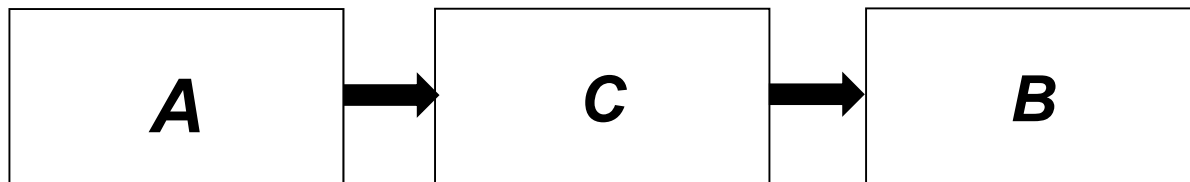
(Also known as "Ishikawa diagram")

Flowchart Diagram - Sequence of Events

Expected:

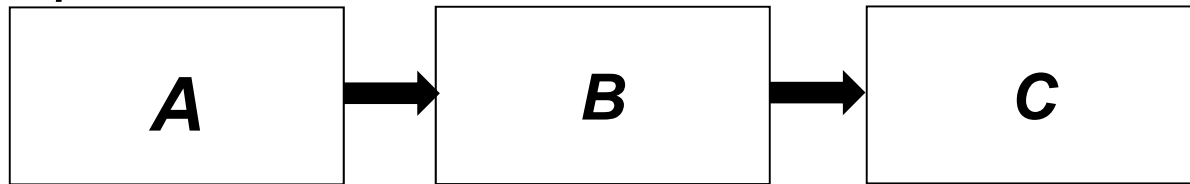


Observed:

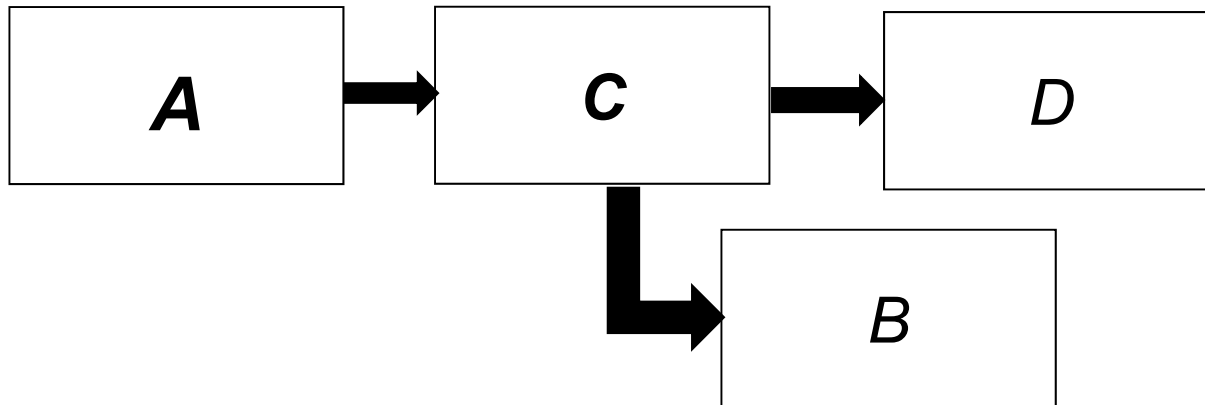


Flowchart Diagram - Timing of Events

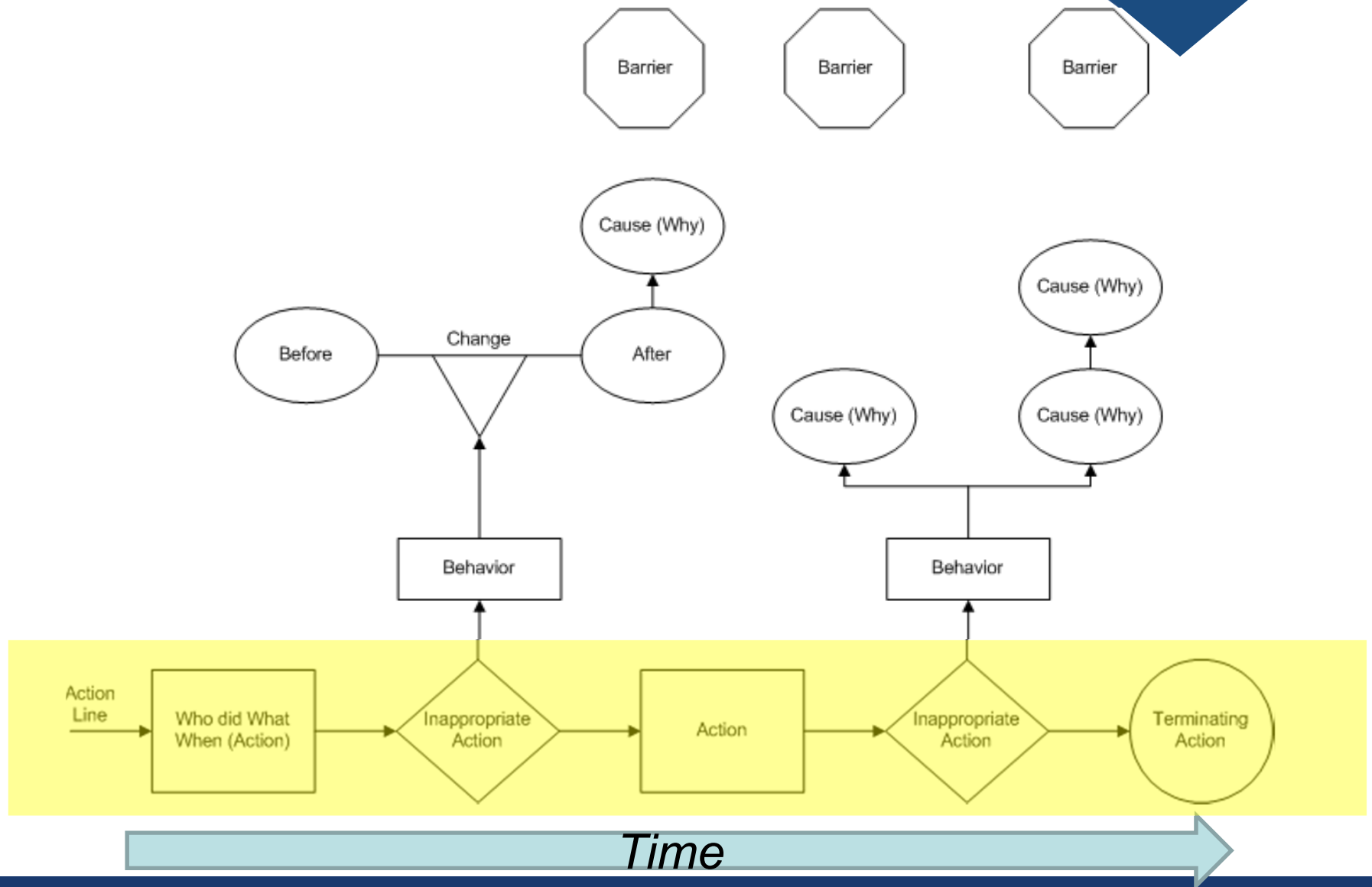
Expected:



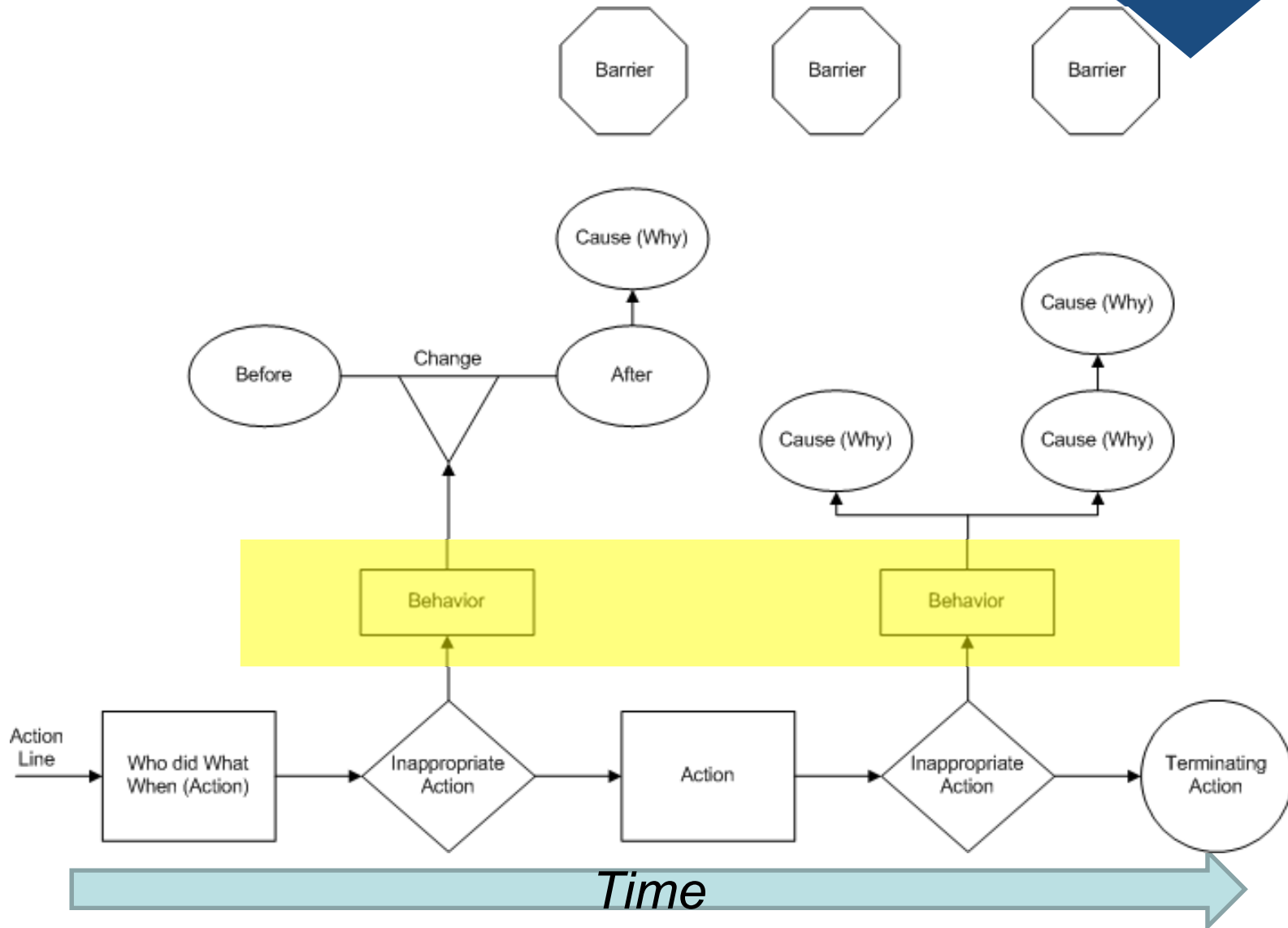
Observed:



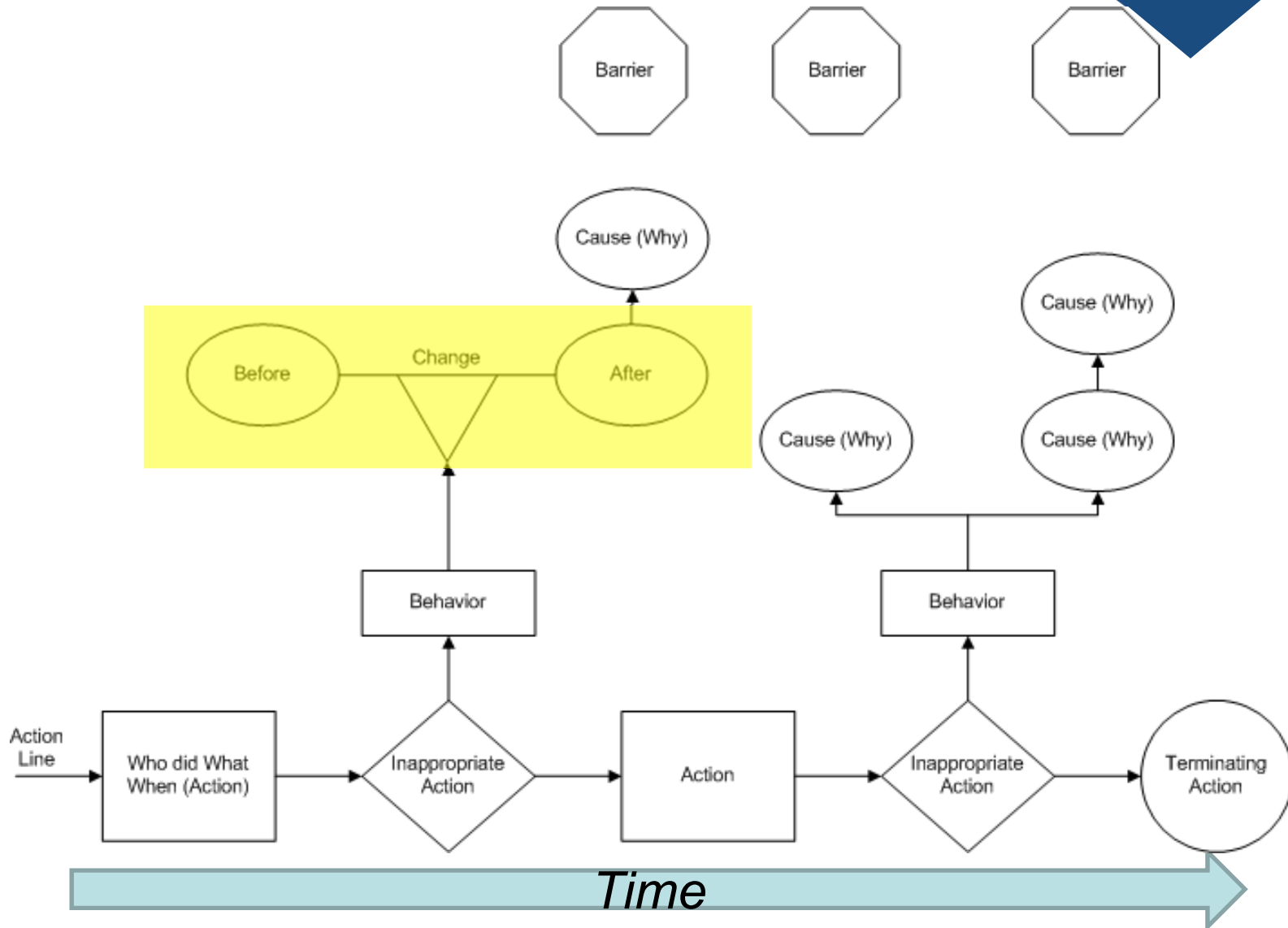
Events and Causal Factor Analysis



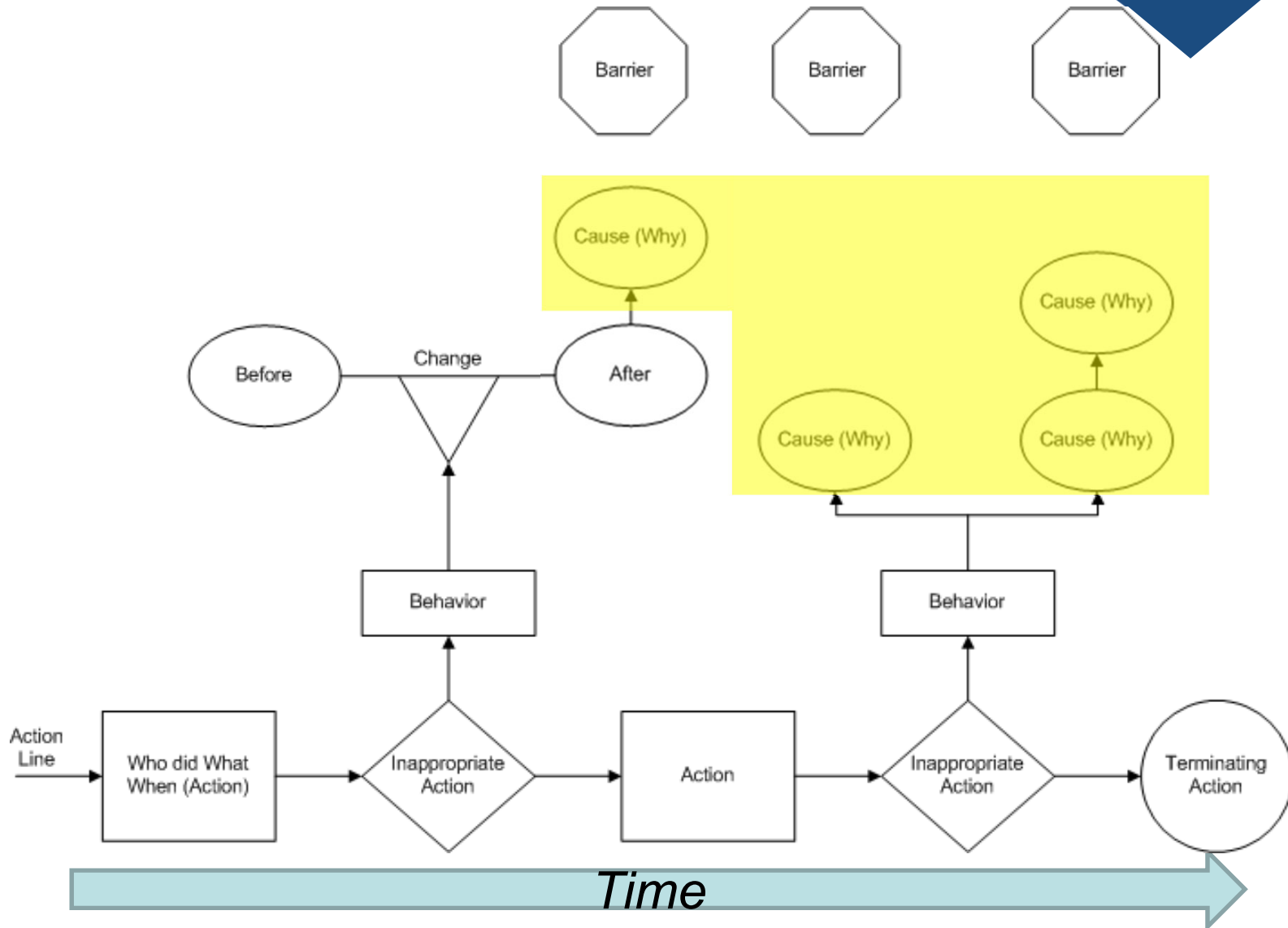
Events and Causal Factor Analysis



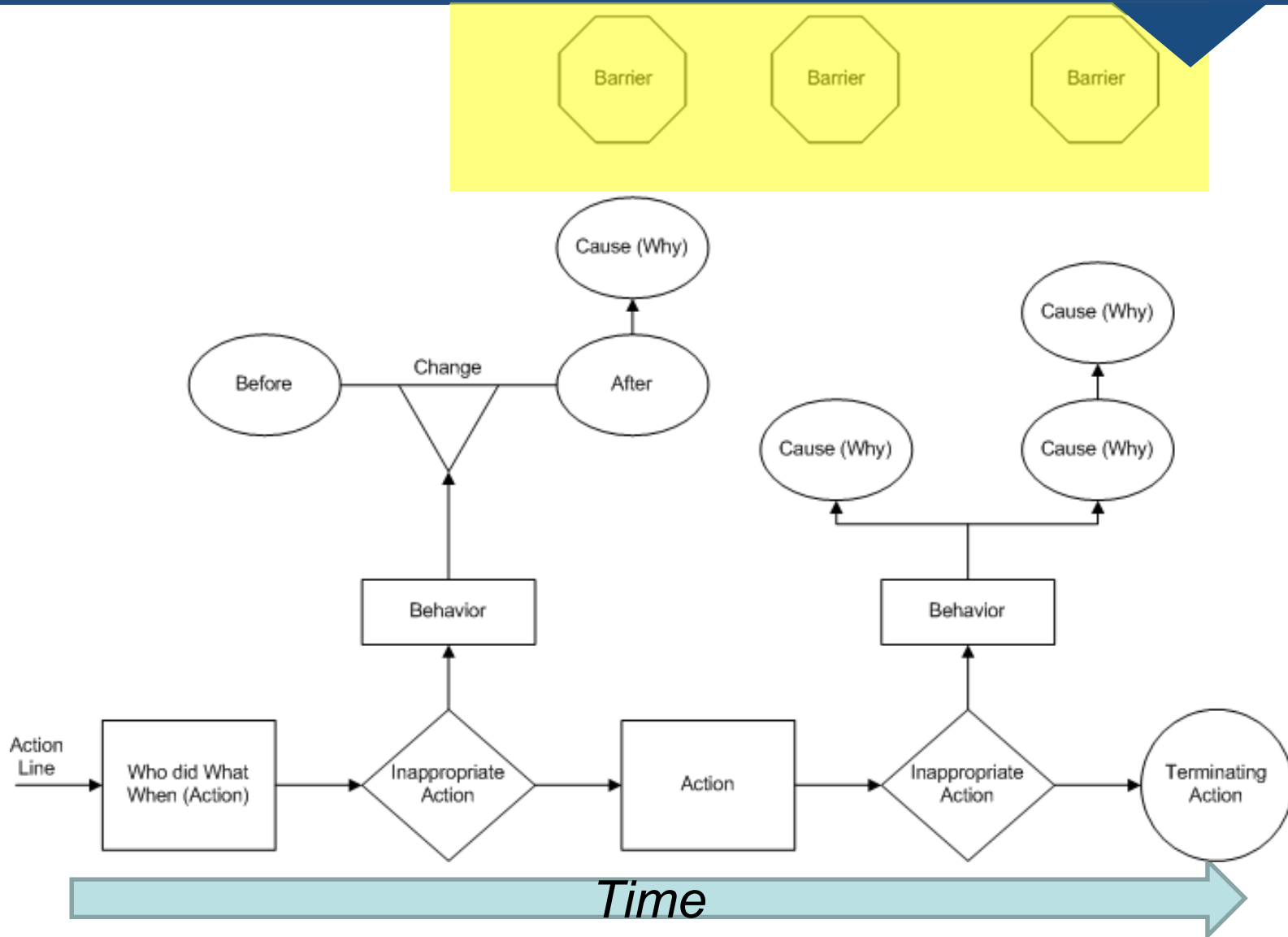
Events and Causal Factor Analysis



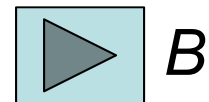
Events and Causal Factor Analysis



Events and Causal Factor Analysis



- Exercise
- Develop basic E&CF diagram



- Task Analysis
- Change Analysis
- Barrier Analysis
- Events and Causal Factor Analysis
- Management Oversight & Risk Tree (MORT) / Mini-MORT
- Kepner-Tregoe[®] (K-T)
- Fault Tree Analysis (FTA)
- Cause and Effect Charting
- Human Performance Evaluations (HPE)

NRI-1 (2009)

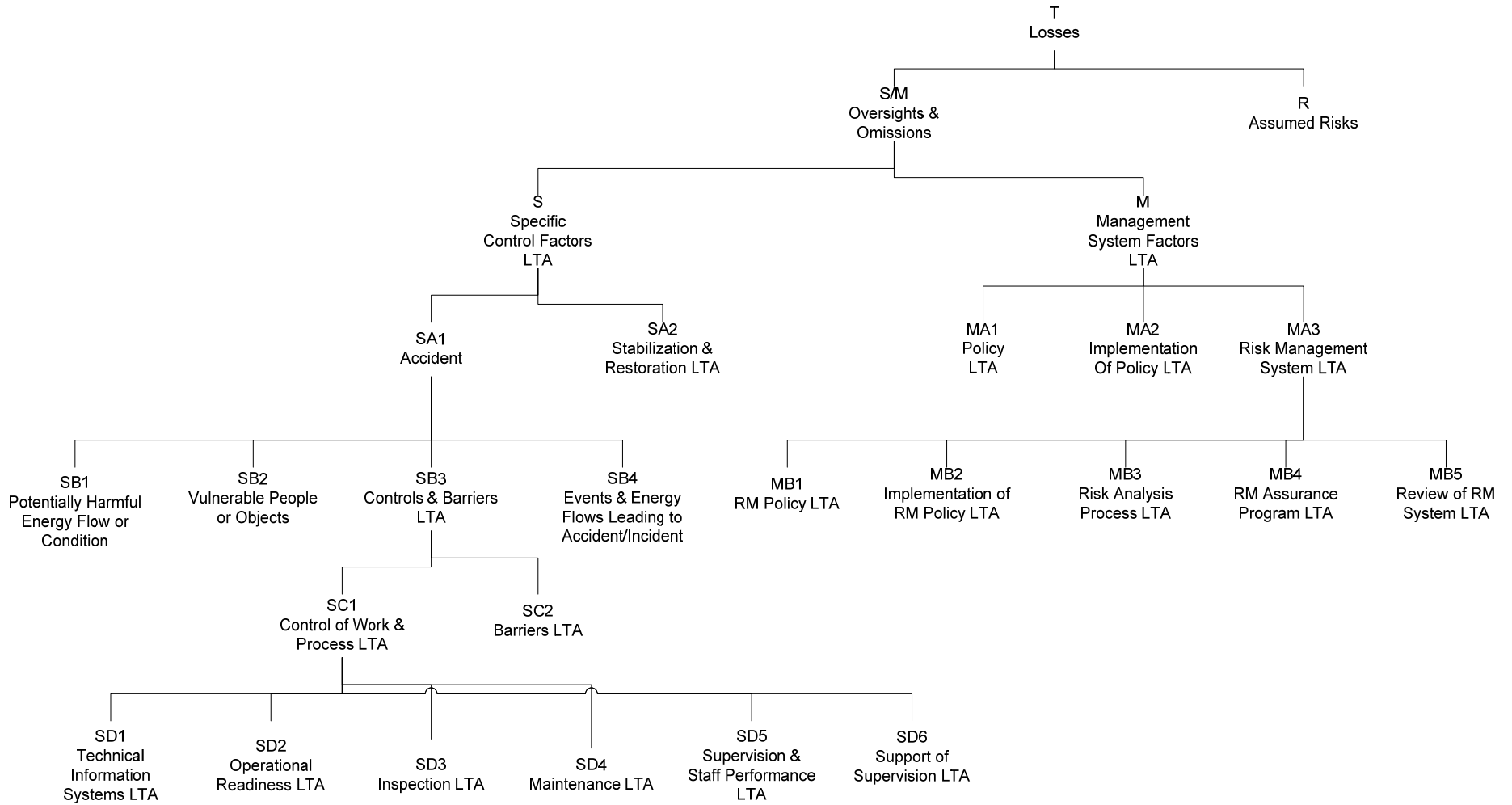
NRI MORT User's Manual

**For use with the
Management Oversight
& Risk Tree
analytical logic diagram**

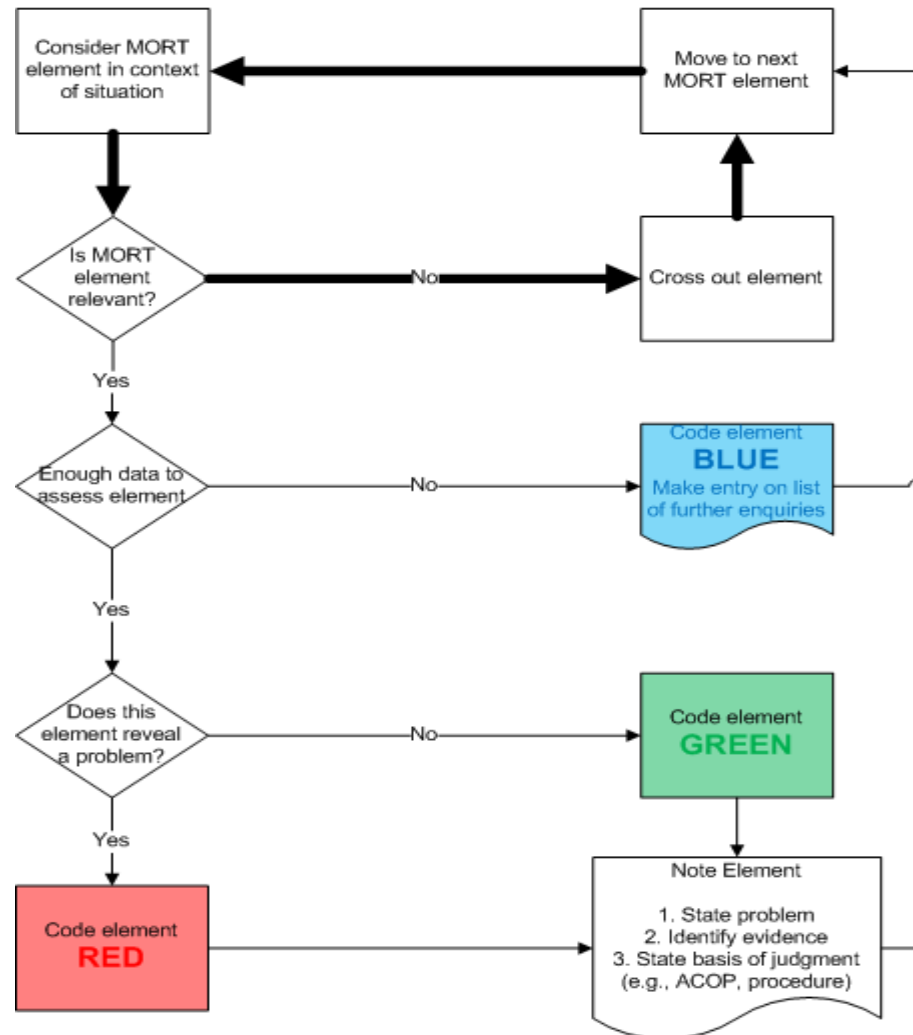
Second Edition

- MORT analysis needs a secure picture of “what happened” (a good “sequencing” method) as a basis (e.g. E&CF)
- A Barrier analysis is an essential preparation for MORT analysis
- With these in hand, MORT steps through a flow chart and series of associated questions to analyze problems

The Main Branches of the MORT Tree



Sequence for work through the MORT chart



- Task Analysis
- Change Analysis
- Barrier Analysis
- Events and Causal Factor Analysis
- MORT / Mini-MRT
- Kepner-Tregoe[®] (K-T)
- Fault Tree Analysis (FTA)
- Cause and Effect Charting
- Human Performance Evaluations (HPE)

Problem Solving process (in sequence)

1. State the deviation
2. Specify the problem (what is, where is, when is, & extent)
3. Then, what is NOT, where is NOT, when is NOT
4. Distinctions (compare “What is” with “What is not”)
5. Identify changes in distinctions (including dates – when)
6. Develop possible causes
7. Test for probable cause
8. Determine most probable cause
9. Identify steps to verify true cause

<u>K-T (Kepner-Tregoe) Problem Analysis</u>				
STATE DEVIATION:				
Specify the Problem	IS	IS NOT	Distinctions of IS compared with IS NOT	Changes in distinctions (list Dates)
What identity Where location When timing Extent magnitude				
Develop Possible Causes from experience, changes, distinctions			Test for Probable Cause Against specifications (list assumptions from destructive test)	
1 2			Does not explain:	Explains only if:
Determine Most Probable Cause:			Verify True Cause (steps): 1 2 3 4	

- Task Analysis
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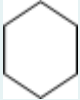



NUREG-0492

Fault Tree Handbook







**U.S. Nuclear Regulatory
Commission**

- Top-down approach
- Graphical representation of the events which might lead to failure
- Steps followed:
 1. Define the top event (problem, or primary effect or primary event)
 2. Establish boundaries
 3. Examine the system
 4. Construct the fault tree
 5. Analyze the fault tree
 6. Prepare corrective action plan
 7. Implement the plans

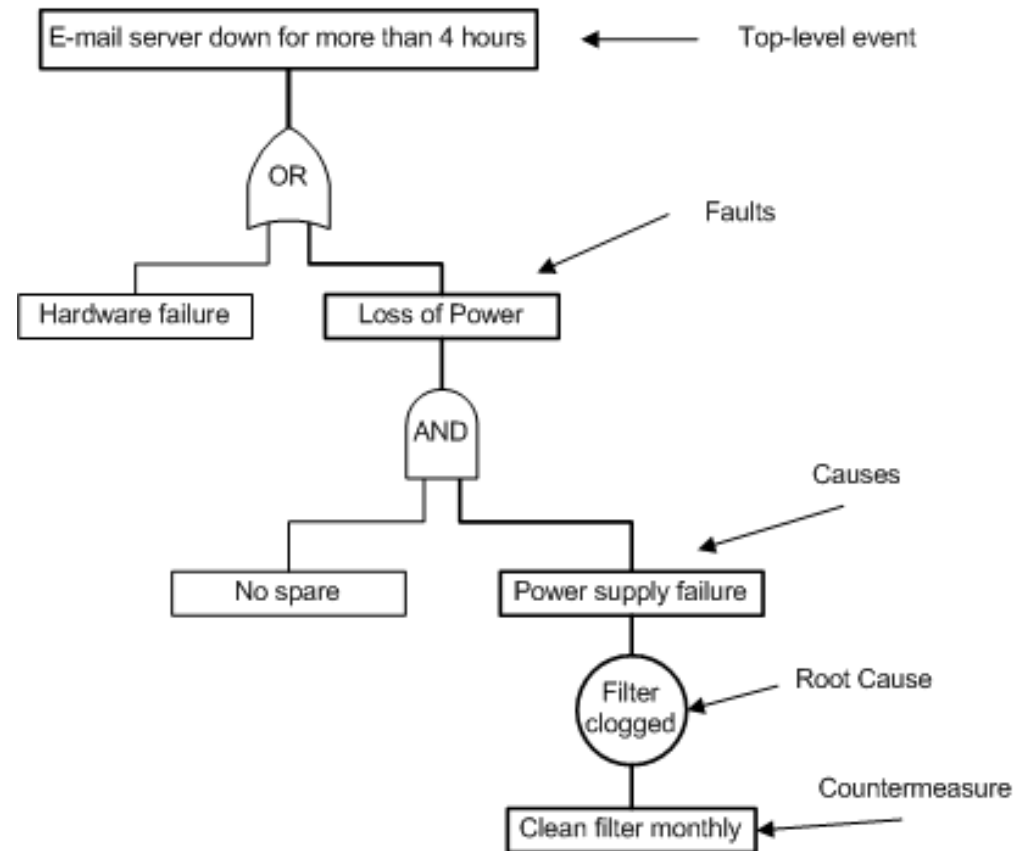
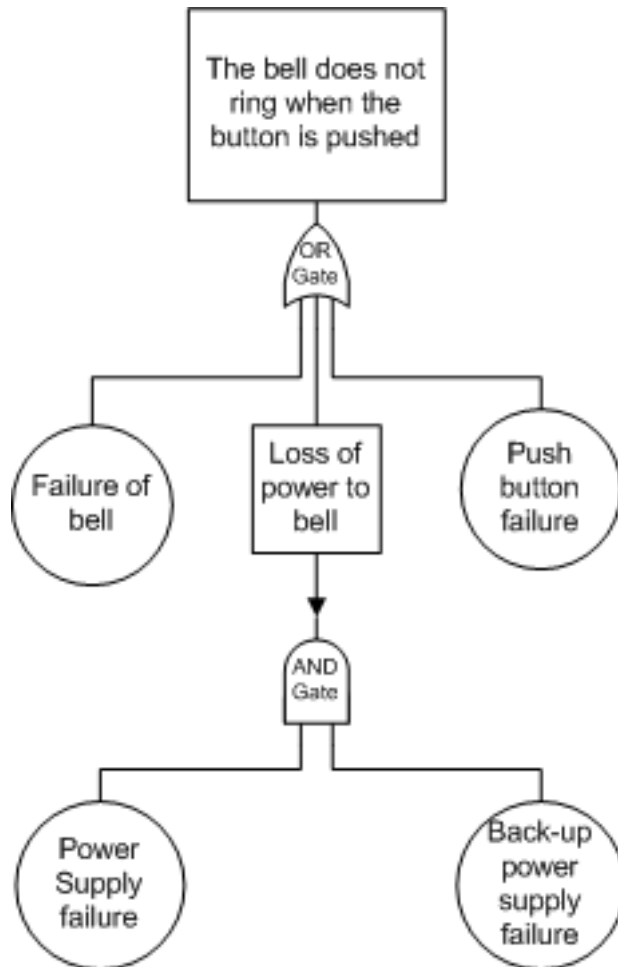
Fault Tree Analysis (symbols)

Gate Symbol	Gate Name	Causal Relations
	AND gate	Output event occurs if all of the inputs occur simultaneously
	OR gate	Output event occurs if any one of the input event occurs
	Inhibit gate	Input produces output when conditional event occurs
	Priority AND gate	Output event occurs if all input events occur in the order from left to right
	Exclusive OR gate	Output event occurs if one, but not both, of the input events occur
	<i>m</i> -out-of- <i>n</i> gate (voting or sample gate)	Output event occurs if <i>m</i> -out-of- <i>n</i> input events occur

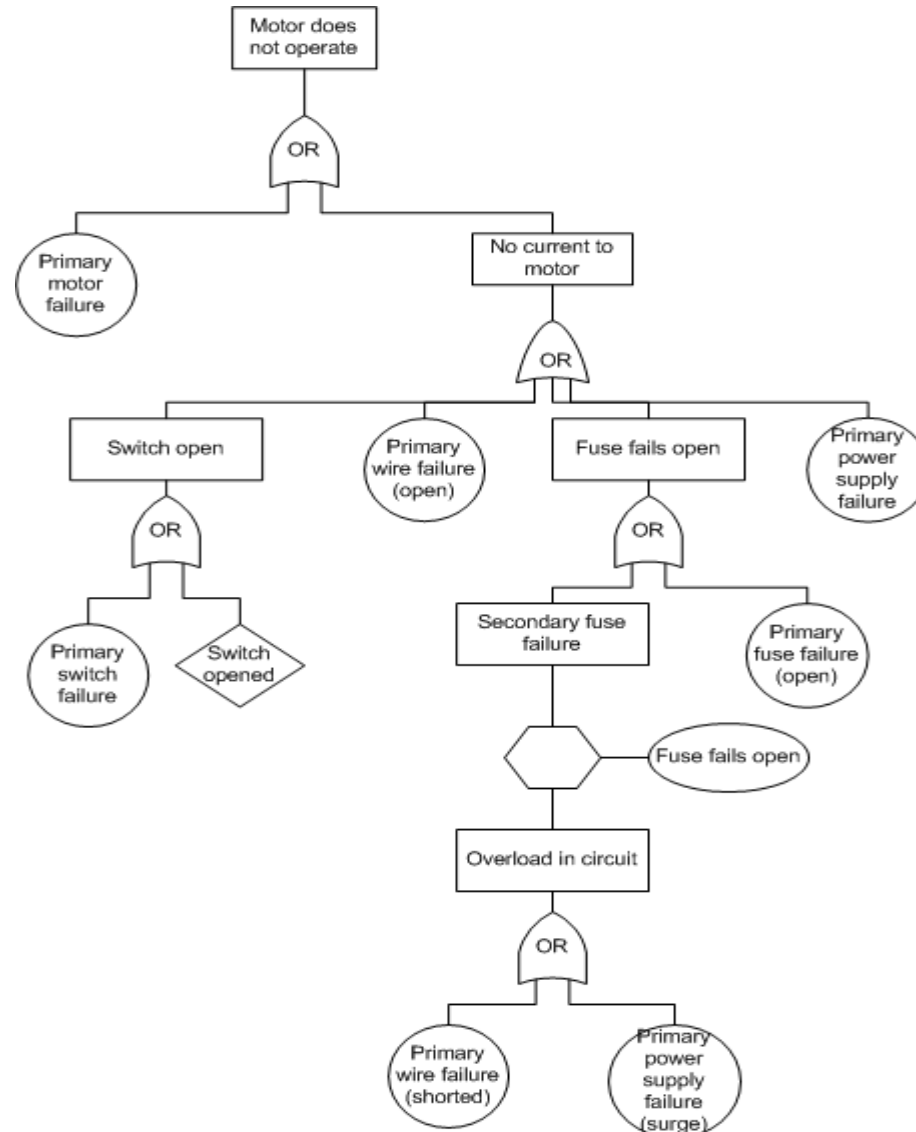
Fault Tree Analysis (symbols)

Event Symbol	Meaning
	Event represented by a gate
	Basic event with sufficient data
	Undeveloped event
	Either occurring or not occurring
	Conditional event used with inhibit gate
	Transfer symbol

Fault Tree Analysis (example)

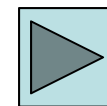


Fault Tree Analysis (example)



- Exercise

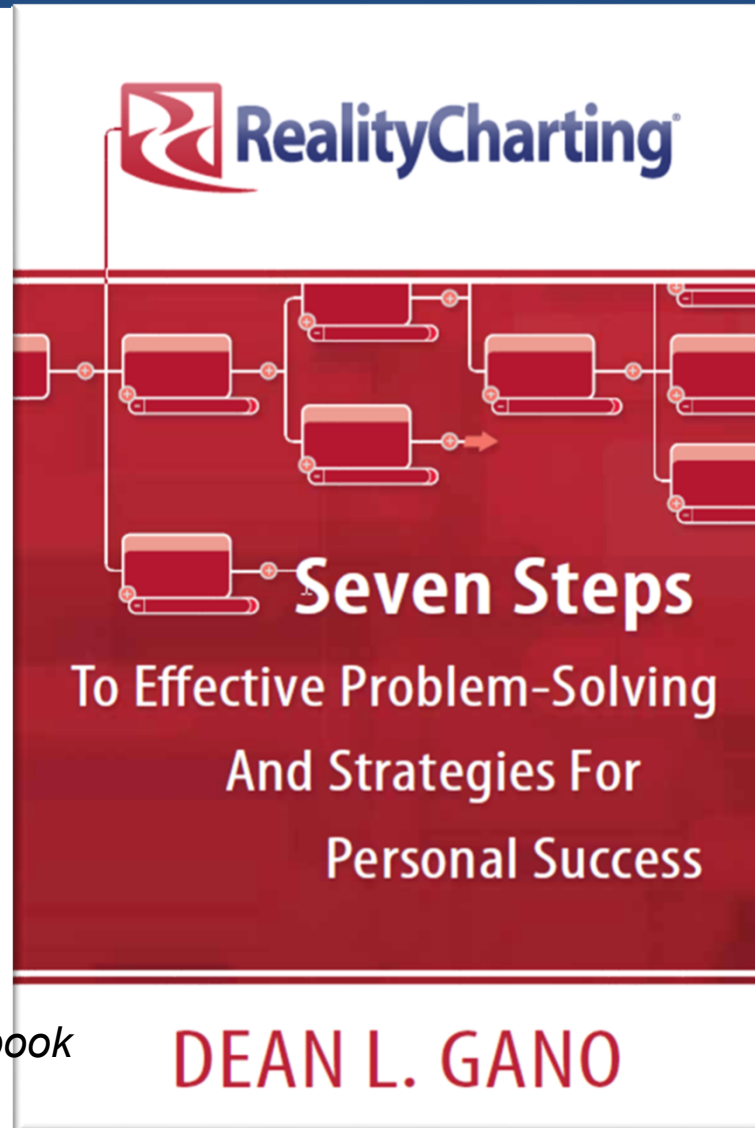
➤ Develop basic FTA



B

- Task Analysis
- Change Analysis
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- FFM video



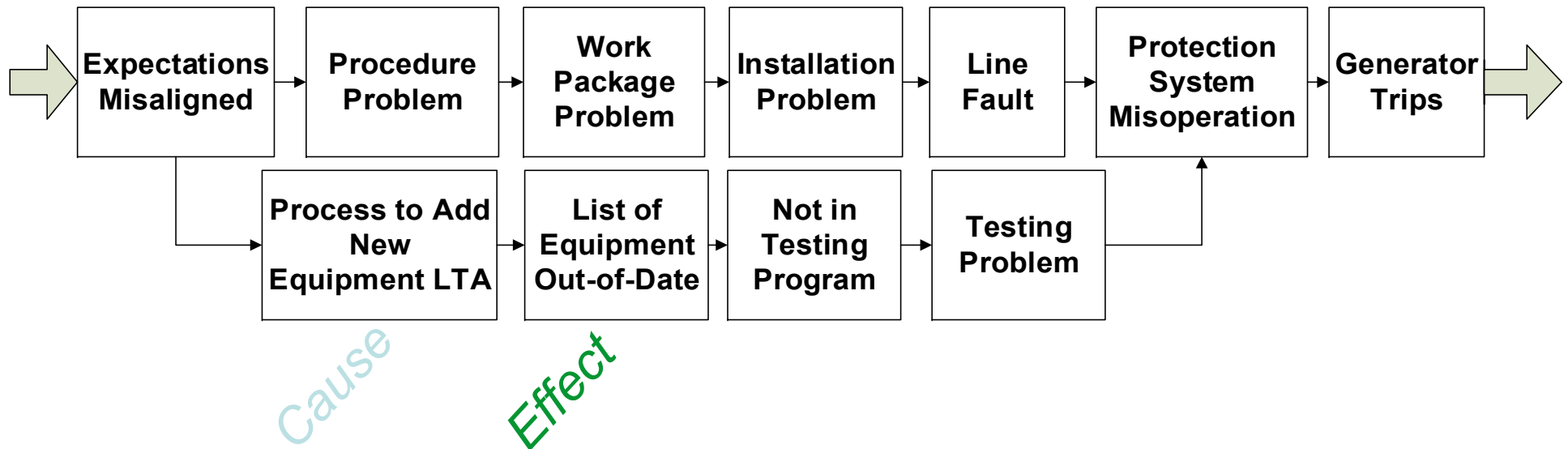
www.realitycharting.com/rcbook

Code: JJA212

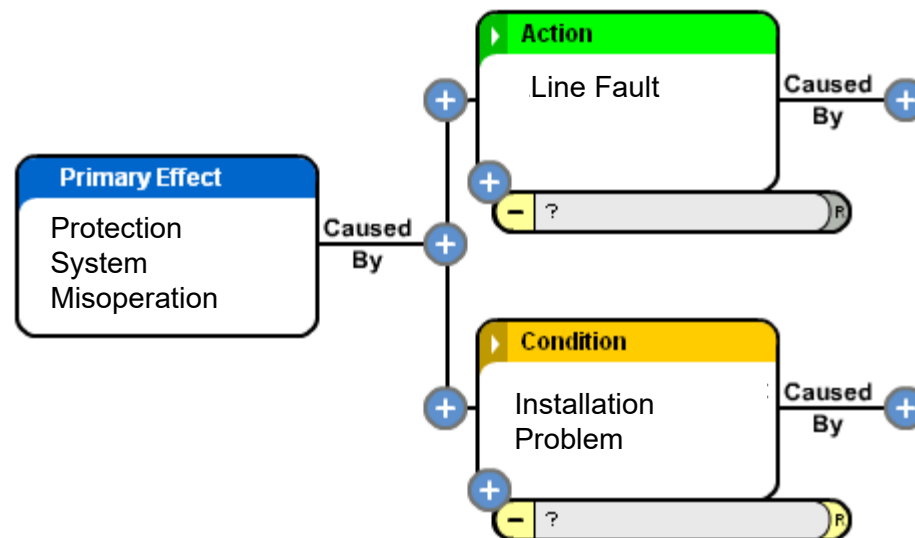
– Cause and Effect are the same thing

Effect		Cause
Generator Trips	Caused by	Protection System Misoperation
Protection System Misoperation	Caused by	Incorrect Signal
Incorrect Signal	Caused by	Bad Installation
Bad Installation	Caused by	Work Package Issue
Work Package Issue	Caused by	Procedure Problem
Procedure Problem	Caused by	Expectation Misunderstanding

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



- Cause and Effect are the same thing
- Causes and effects are part of an infinite continuum of causes
- Each effect has at least 2 causes in the form of actions and conditions



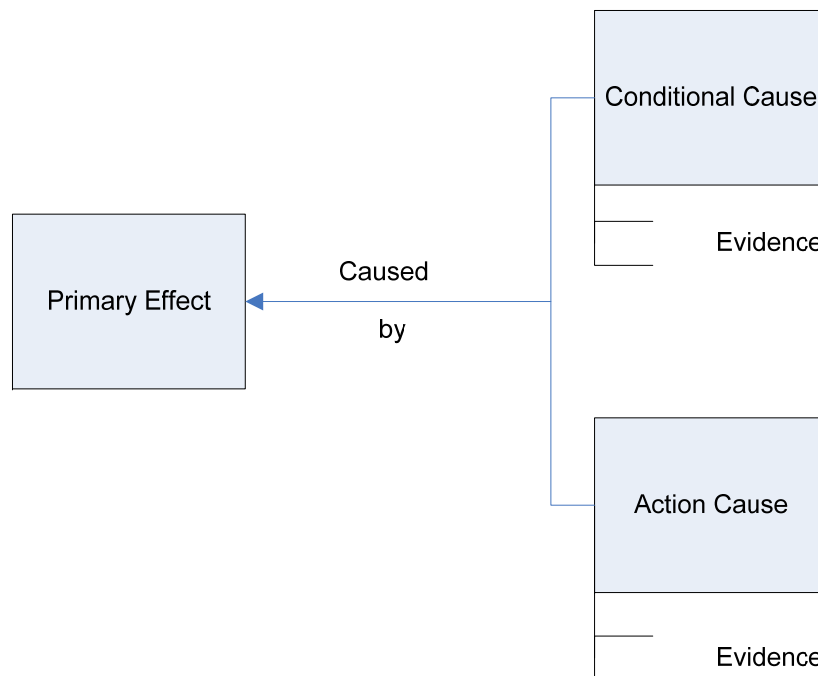
- Cause and Effect are the same thing
- Causes and effects are part of an infinite continuum of causes
- Each effect has at least 2 causes in the form of actions and conditions
- An Effect exists only if its causes exist at the same point in time and space

In previous example:

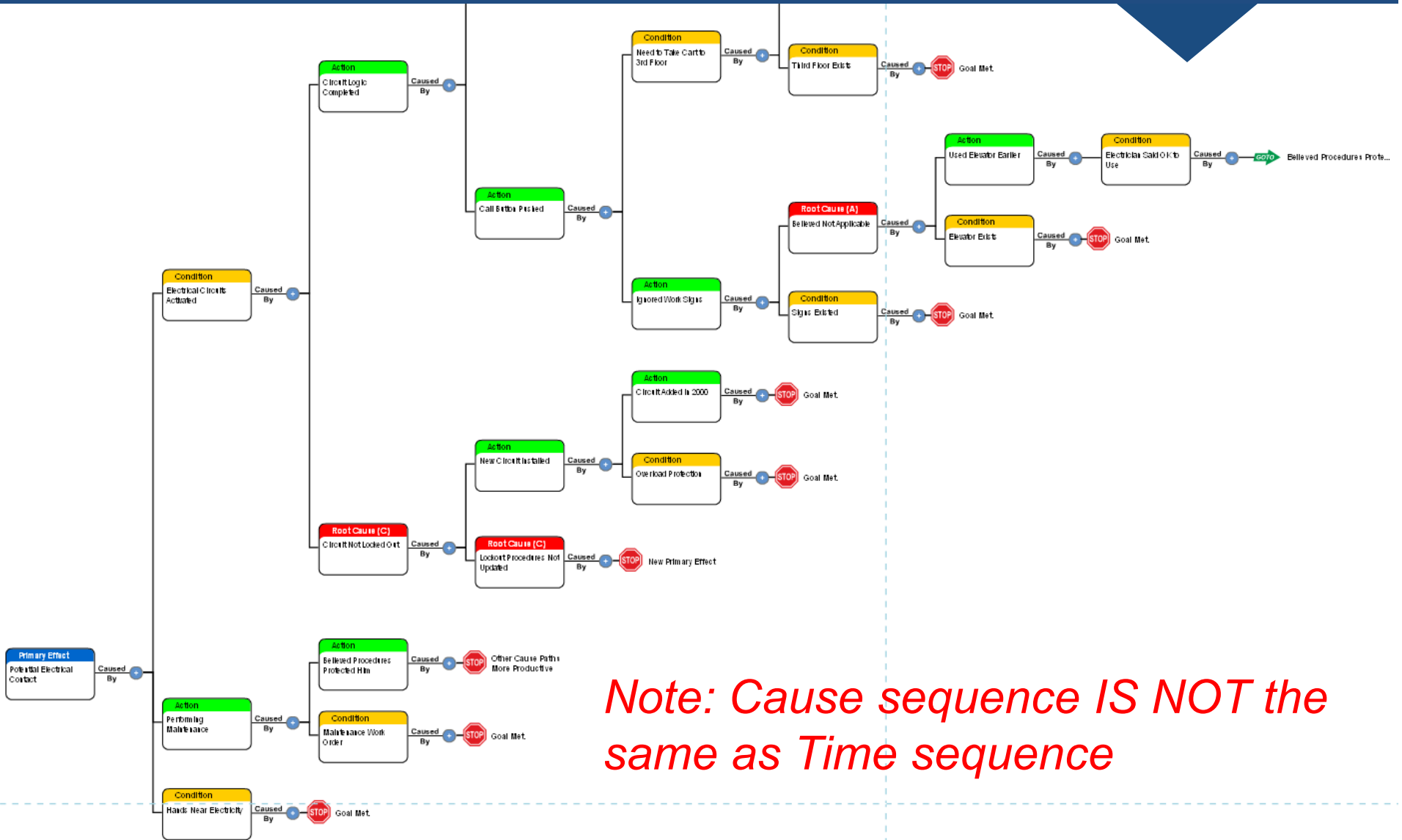
If there was not an existing installation problem on the day the line fault occurs – nothing happens.

If there was an existing installation problem on the day the line fault occurs, something does happen

- Creating a Cause & Effect Chart
 - For each primary effect, ask “Why?”
 - Look for causes in actions and conditions
 - Connect all causes with “caused by”
 - Support all causes with evidence, or use a “?”

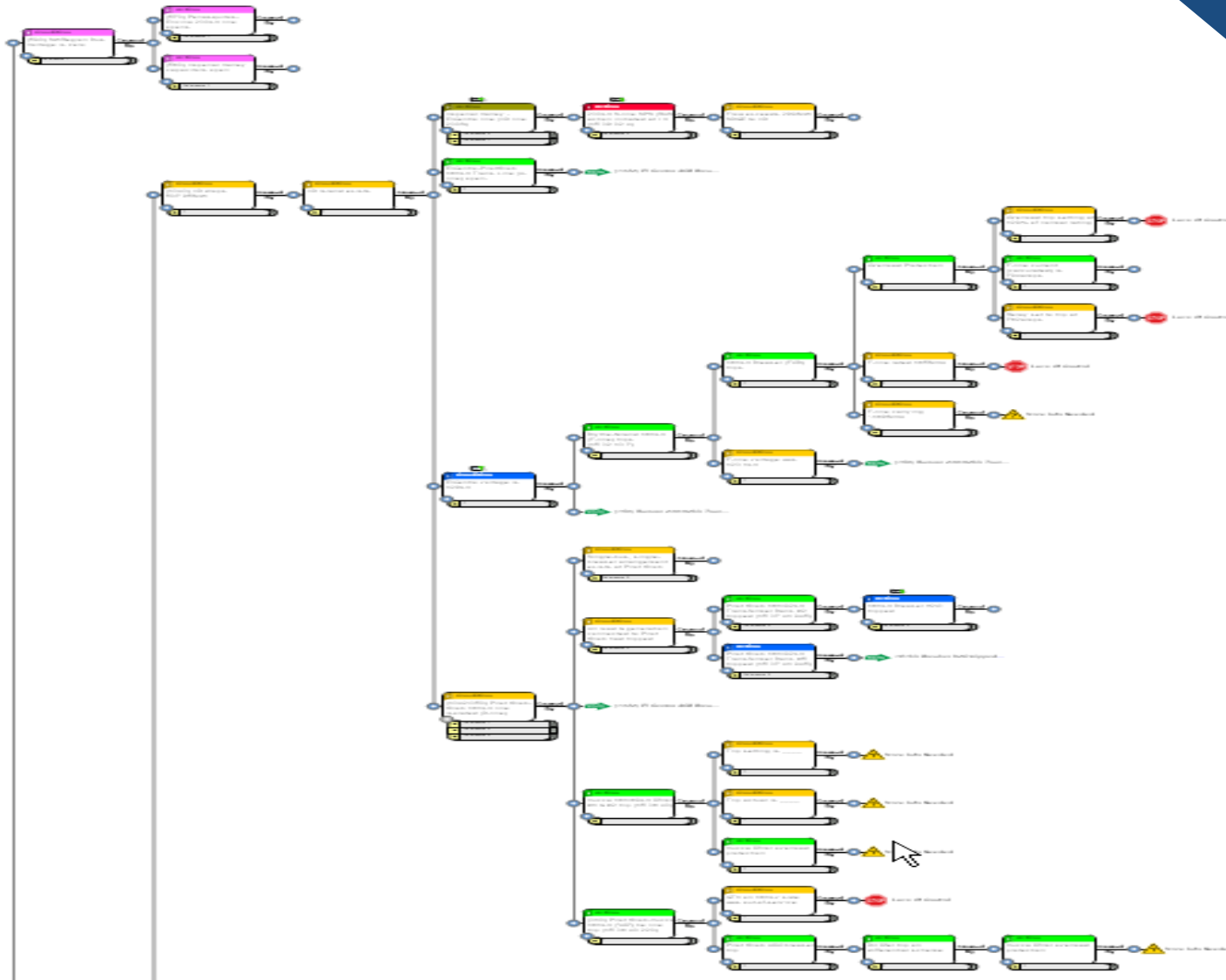


Cause and Effect Charting (example)



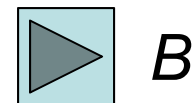
Note: Cause sequence IS NOT the same as Time sequence

Cause and Effect Charting (real-life)



- Exercise

- Develop basic Cause & Effect chart



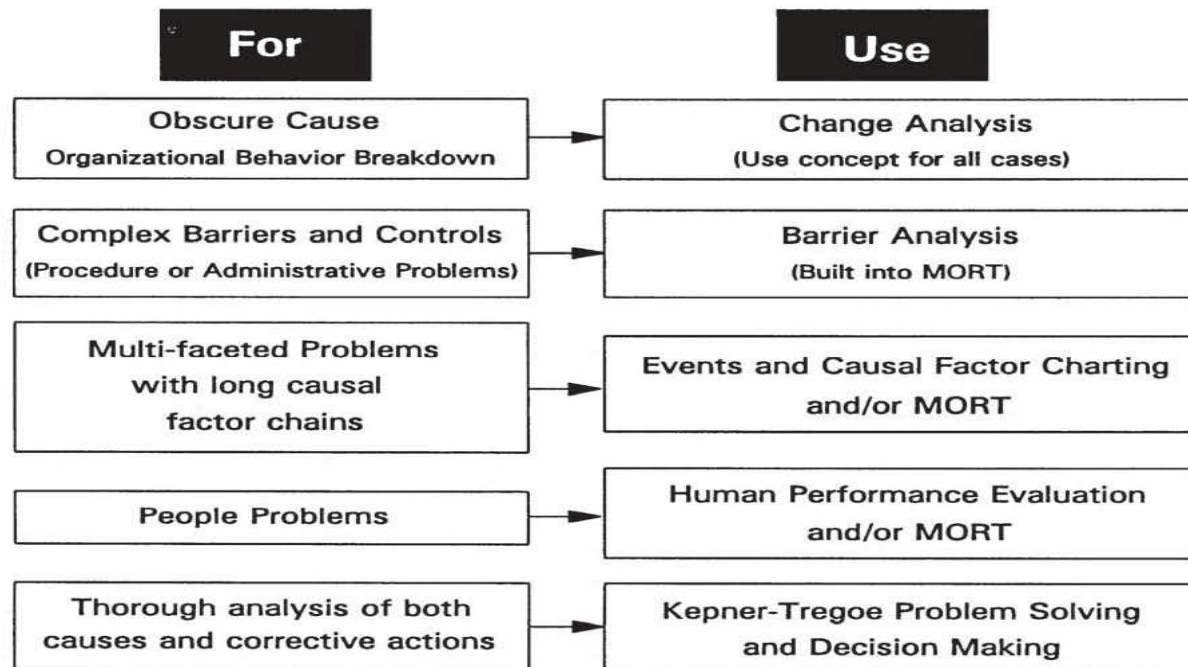
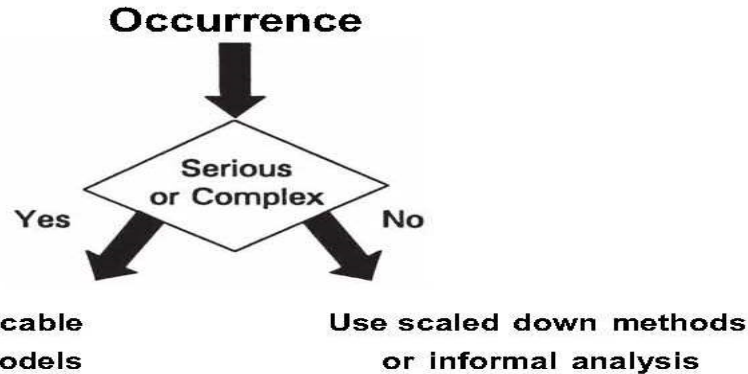


Five phases:

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

Ref: DOE-NE-STD-1004-92

- Task Analysis
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- Use Kepner-Tregoe[®] , Cause and Effect Charting, or similar equipment failure method
 - State Problem
 - Quantify “what are” conditions (identity, location, timing, magnitude)
 - Quantify “what is not” conditions
 - Determine difference
 - Does difference suggest a change?
 - List all possible causes
 - Test possible causes (“if..., then ...” questions)
 - Verify most probable causes

- Single or multiple events?
 - Problem statement
 - Incident or incidents to be evaluated identified
 - If multiple incidents, group by consequence if possible
 - Initiate charting of problem (Cause & Effect or E&CF – keep it updated)
 - Task analysis
 - Barrier analysis
 - Change analysis
 - Interviews

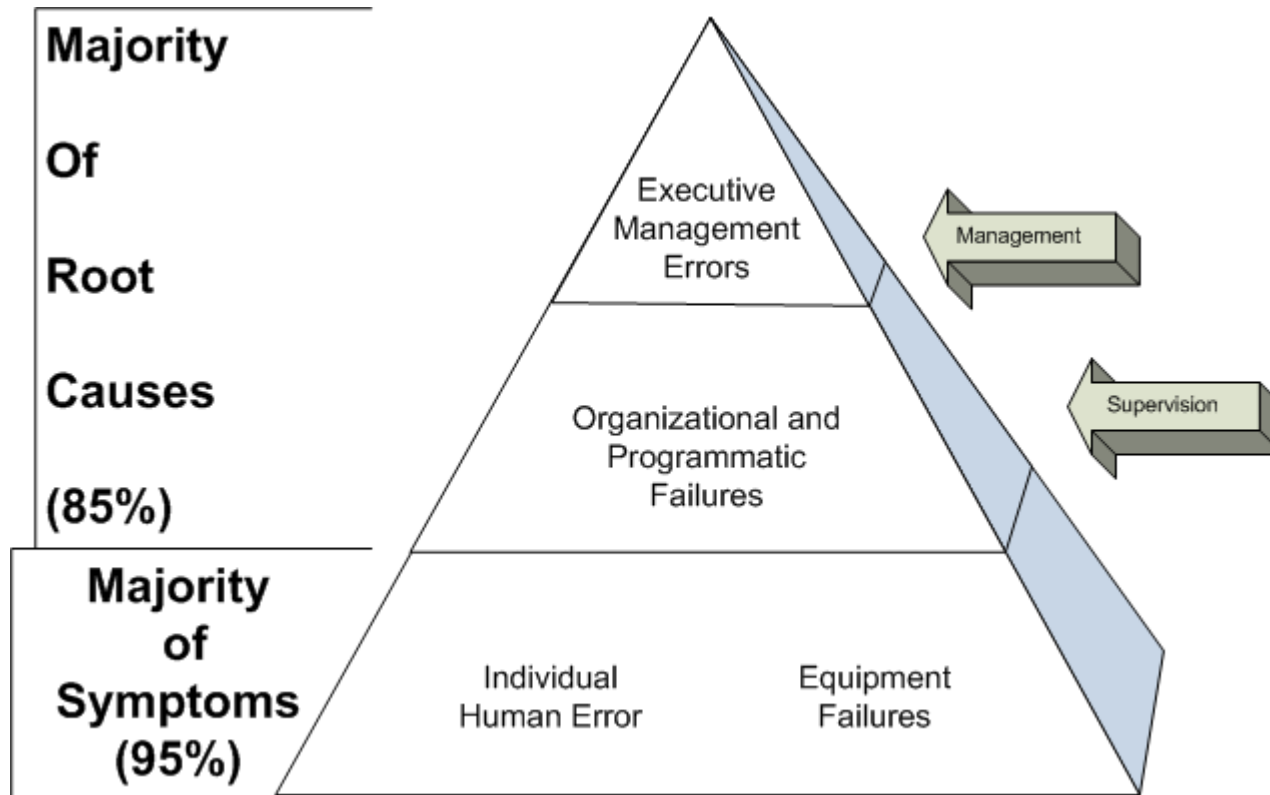
- Identify barriers (human-error barriers)
- Determine error types
- Identify human-error drivers
- Look for organizational and programmatic deficiencies

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- to identify factors that influence task performance
- most frequently used for human-machine interface studies
- focus is on operability and work environment

Sometimes it is a Human



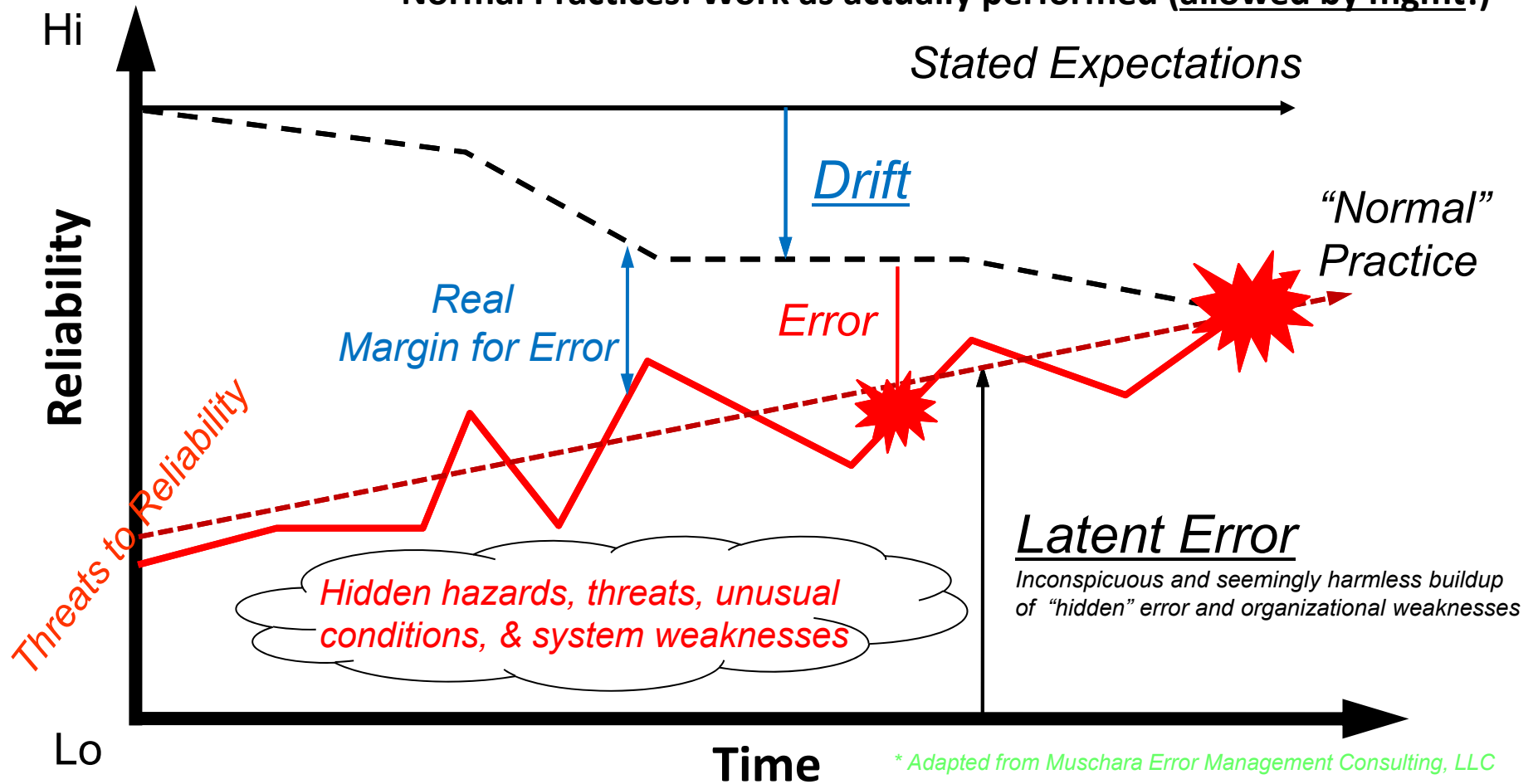


The PII Performance Pyramid™

Drifting to Failure*

Expectations: Desired approach to work (as imagined)



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



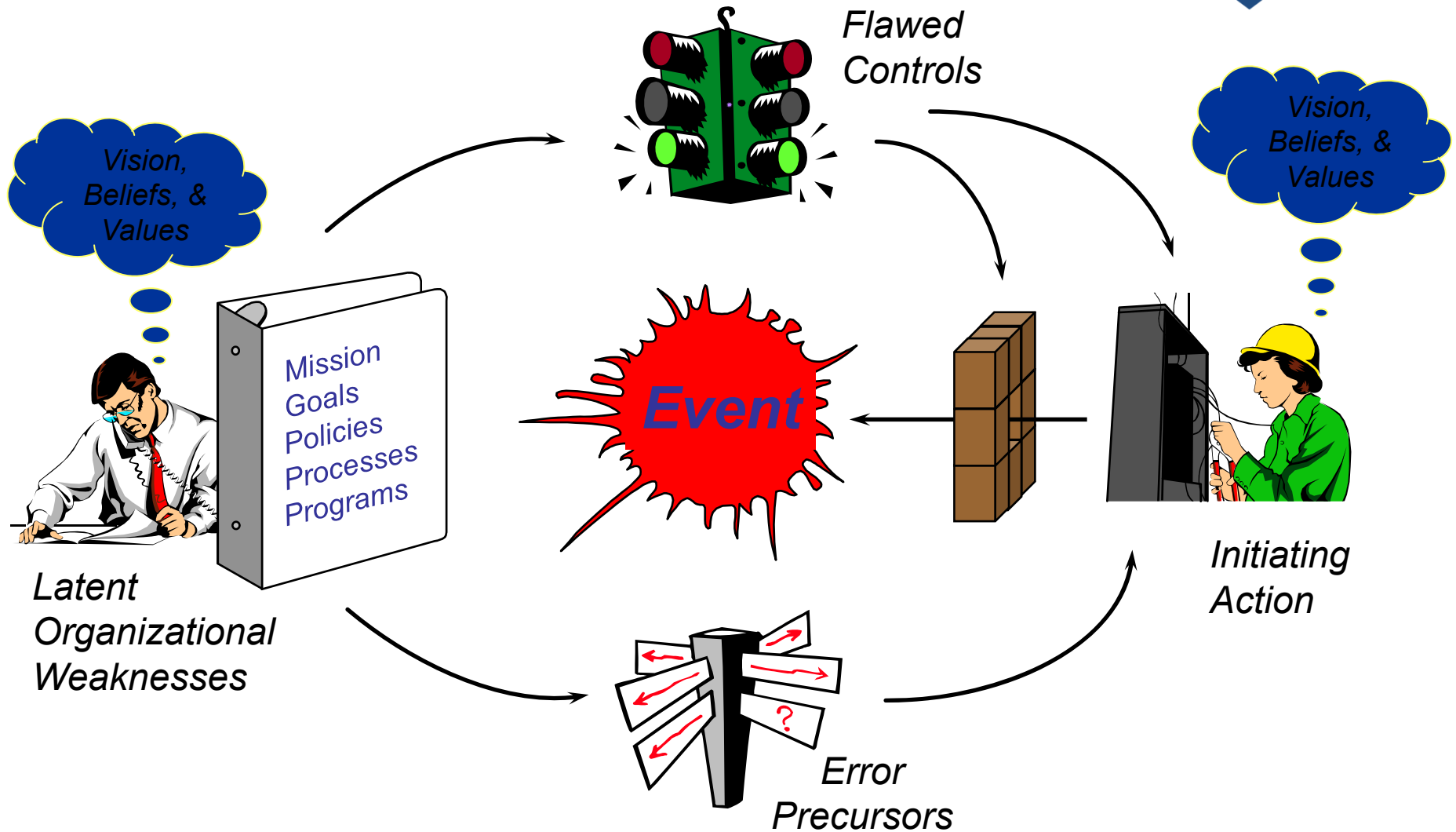
Example of Drift





- People are fallible, and even the best people make mistakes
- Error-likely situations are predictable, manageable, and preventable 
- Individual behavior is influenced by organizational processes and values 
- People achieve high levels of performance largely because of the encouragement and reinforcement received from leaders, peers, and subordinates
- Events can be avoided through an understanding of the reasons mistakes occur and application of the lessons learned from past events (or errors)

Anatomy of an Event



- An event is defined as “an unwanted, undesirable change in the state of plants, systems or components that leads to undesirable consequences to the safe and reliable operation of the plant or system”.
- The anatomy of an event is often driven by:
 - Deficiencies in barriers / defenses
 - Latent organizational weaknesses and conditions
 - Errors in human performance and/or human factors
 - Equipment design / maintenance issues.

Events are not typically the outcome of one person's actions. More commonly, it is the result of a combination of faults in management and organizational activities.

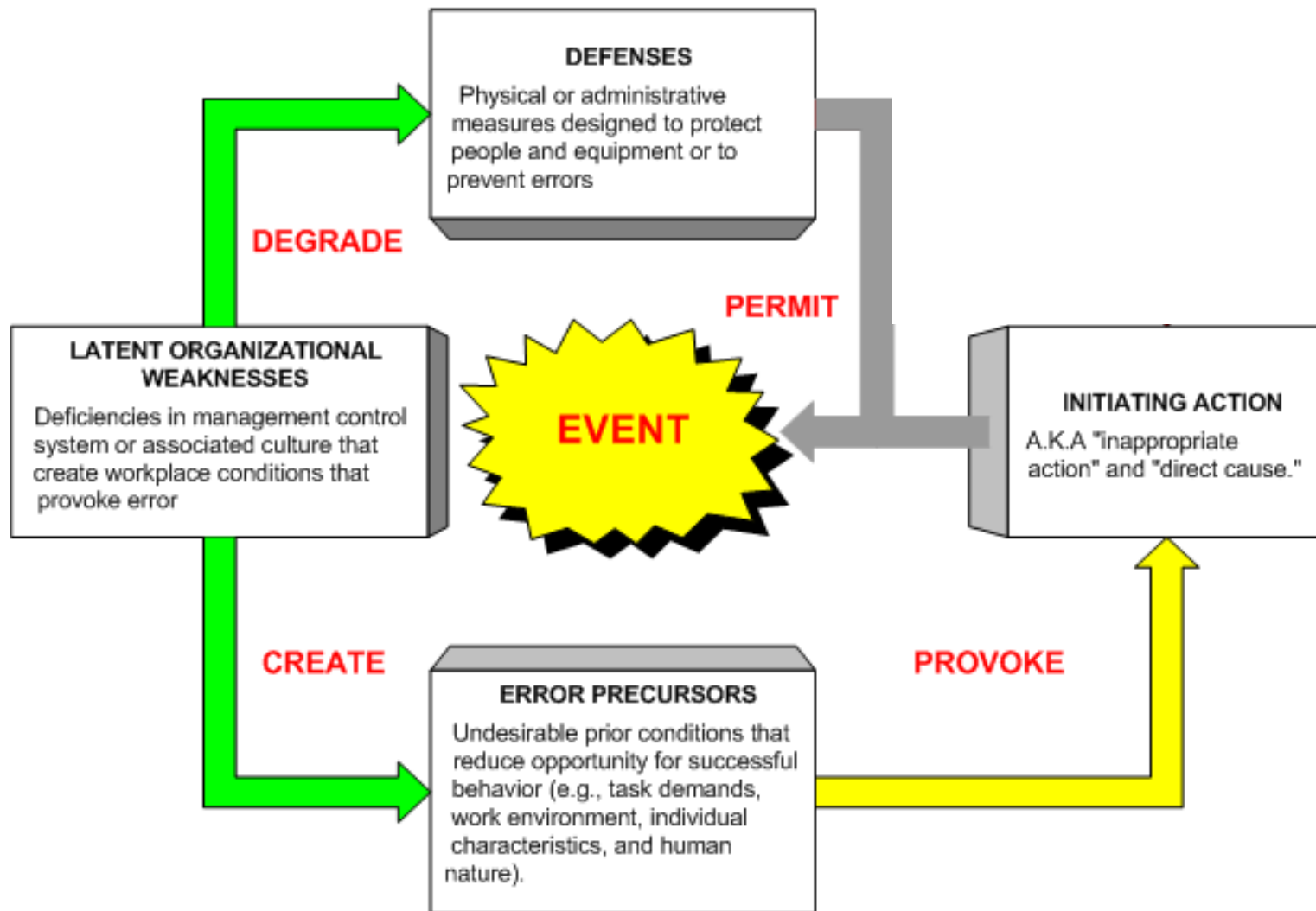
Turner & Pidgeon - Man Made Disasters

Events can be avoided through:

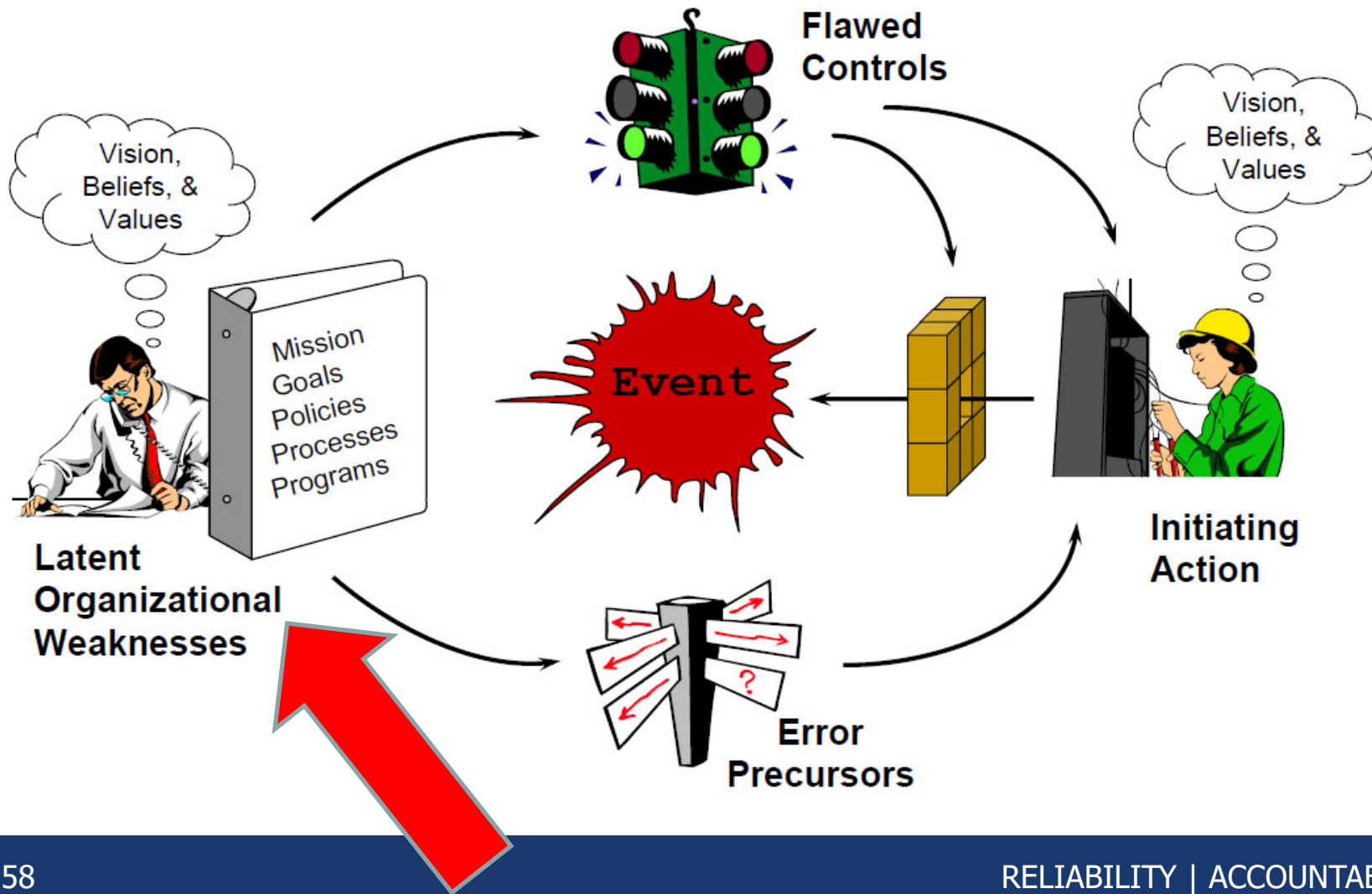
- An understanding of the reasons mistakes occur (proactive) and
- Application of lessons learned from past events or errors and actions derived from event analysis of disturbances and system events (reactive)
- A combination of proactive and reactive methods is the best strategic approach for identifying and eliminating latent organizational weaknesses and error likely situations that provoke human error and degrade barriers/defenses against error and the events they trigger.

Another way of looking at an Event

The INPO Anatomy of an Event Model



Anatomy Of An Event – INPO Model

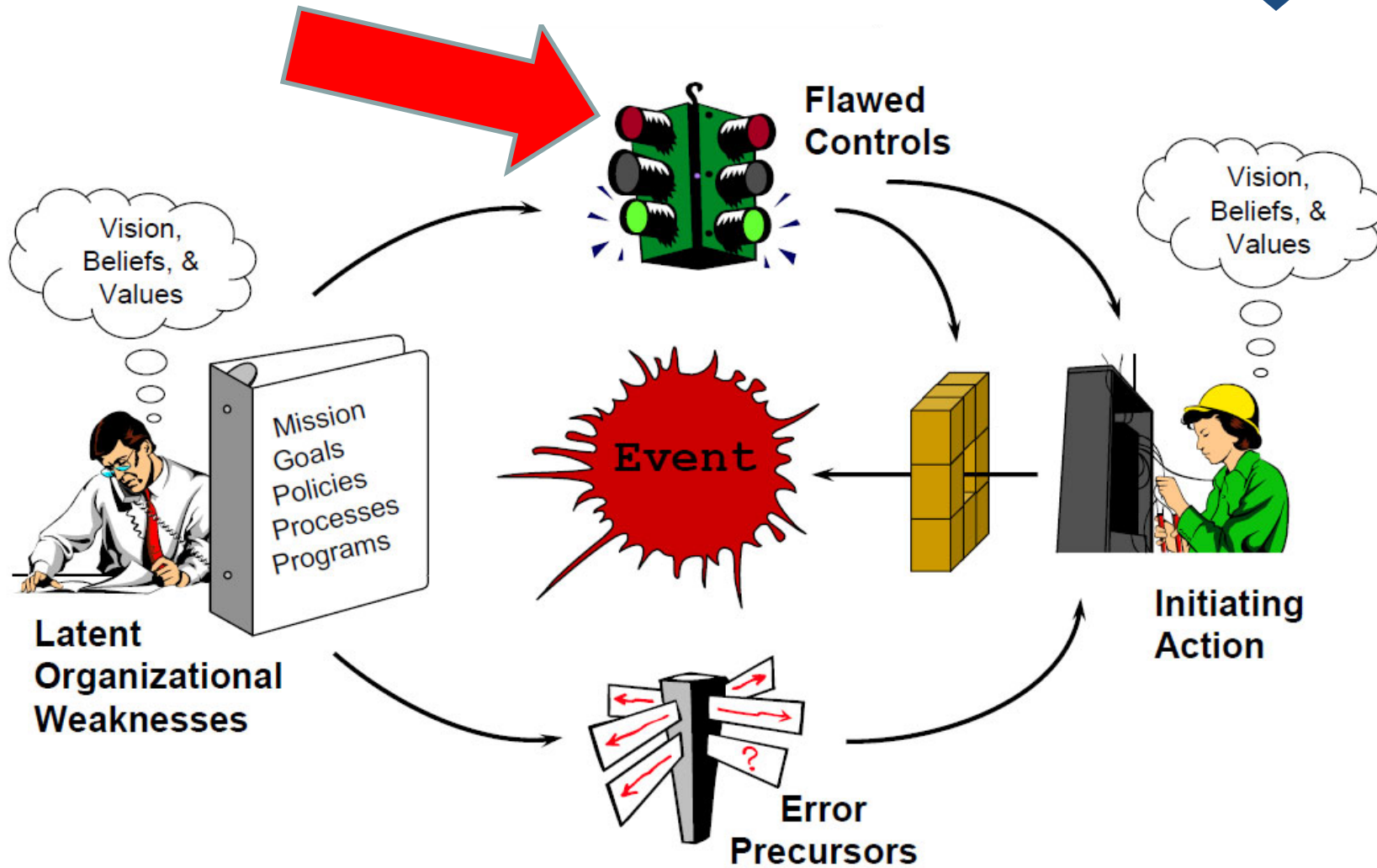


Pre-Job Briefing	Values & Norms
Communications – Oral & Written	Maintenance Processes
Work Planning & Scheduling	Procedure Development
Controls, Measures and Monitoring	Goals & Priorities
Design & Modifications	Organizational Structure
Task Structure	Roles & Responsibilities
Written Guidance: Rules, Policies and Practices	Training & Qualification

- *A review of the INPO industry event data base reveals that **events occur more often due to error-prone tasks and error-prone work environments than from error-prone individuals***
- *Error-prone tasks and work environments are typically created by latent organizational weaknesses.*

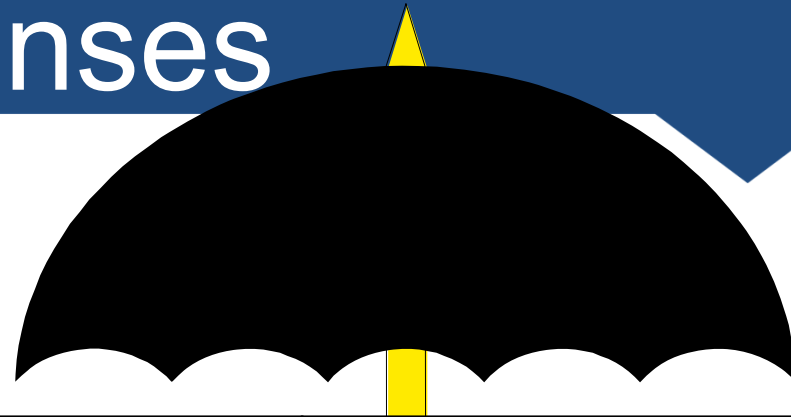
Source: Reason – 1991 (modified)

Anatomy Of An Event – INPO Model



Defenses

Consider using applicable defenses when the hazard cannot be eliminated



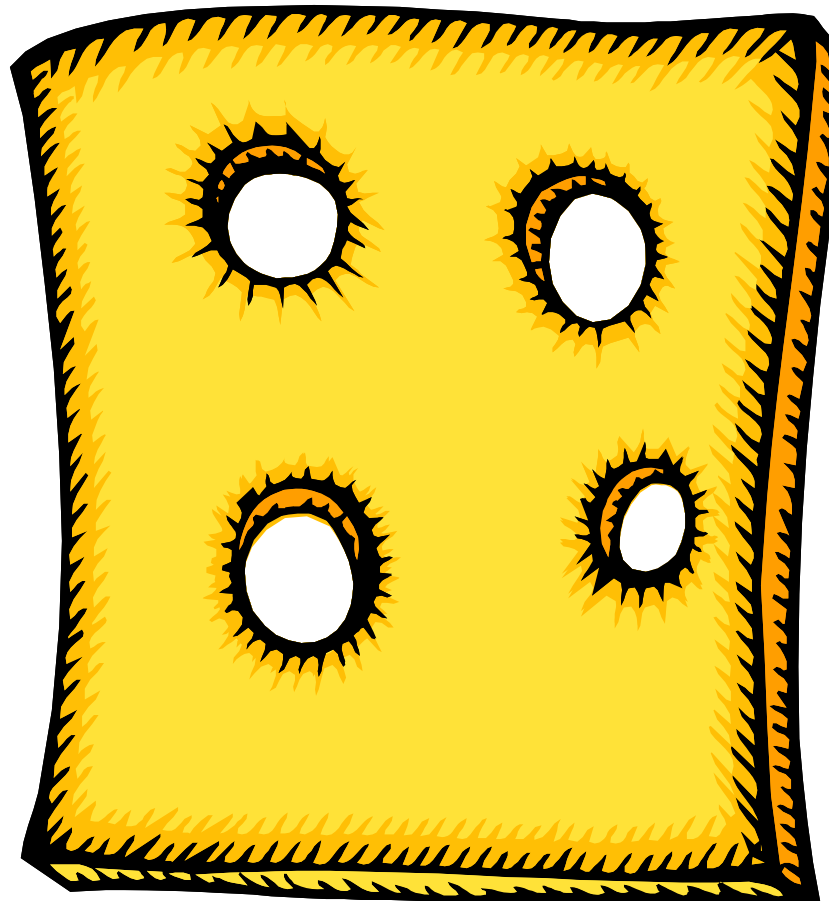
	Physical	Administrative
Create Awareness		
Detect and Warn		
Protect		
Recover		
Contain		
Enable Escape		

Source: Maurino (1995)

Flawed defenses allow inappropriate acts or their consequences to occur.

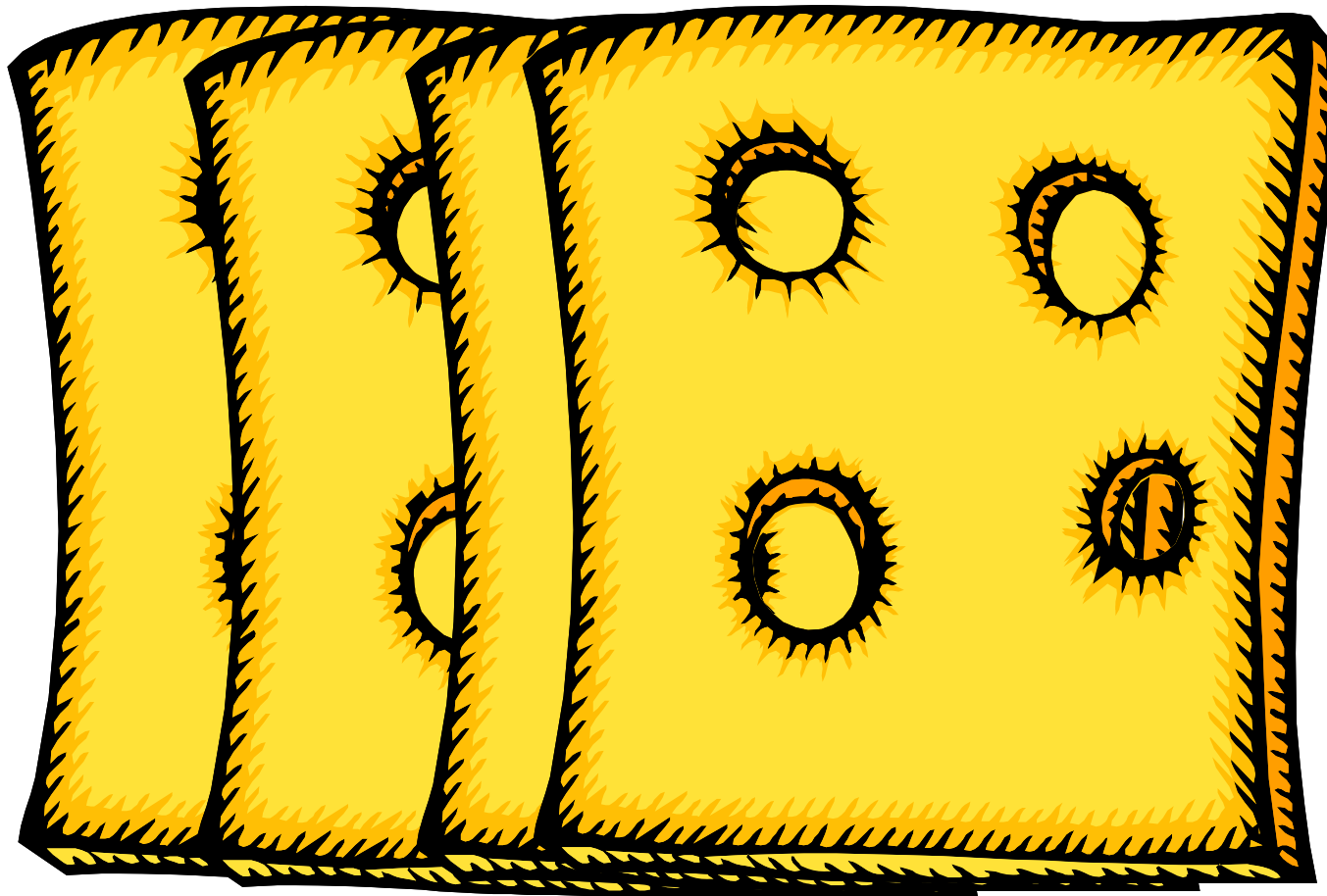


***Even the best defenses are fallible and
can have holes.....***



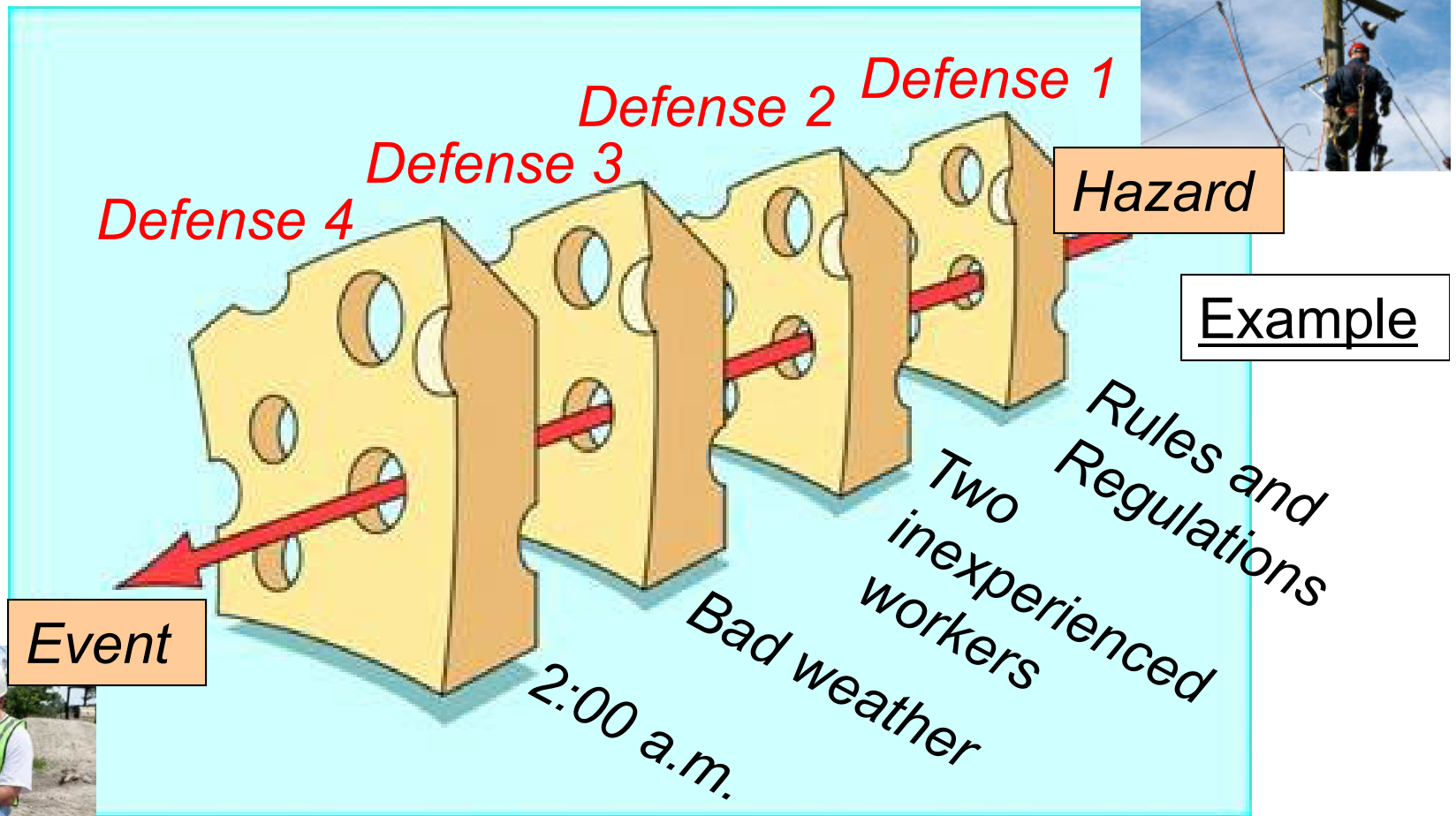
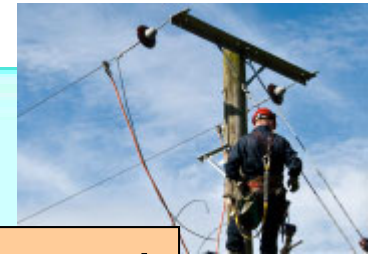
Defense in Depth

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



Defenses

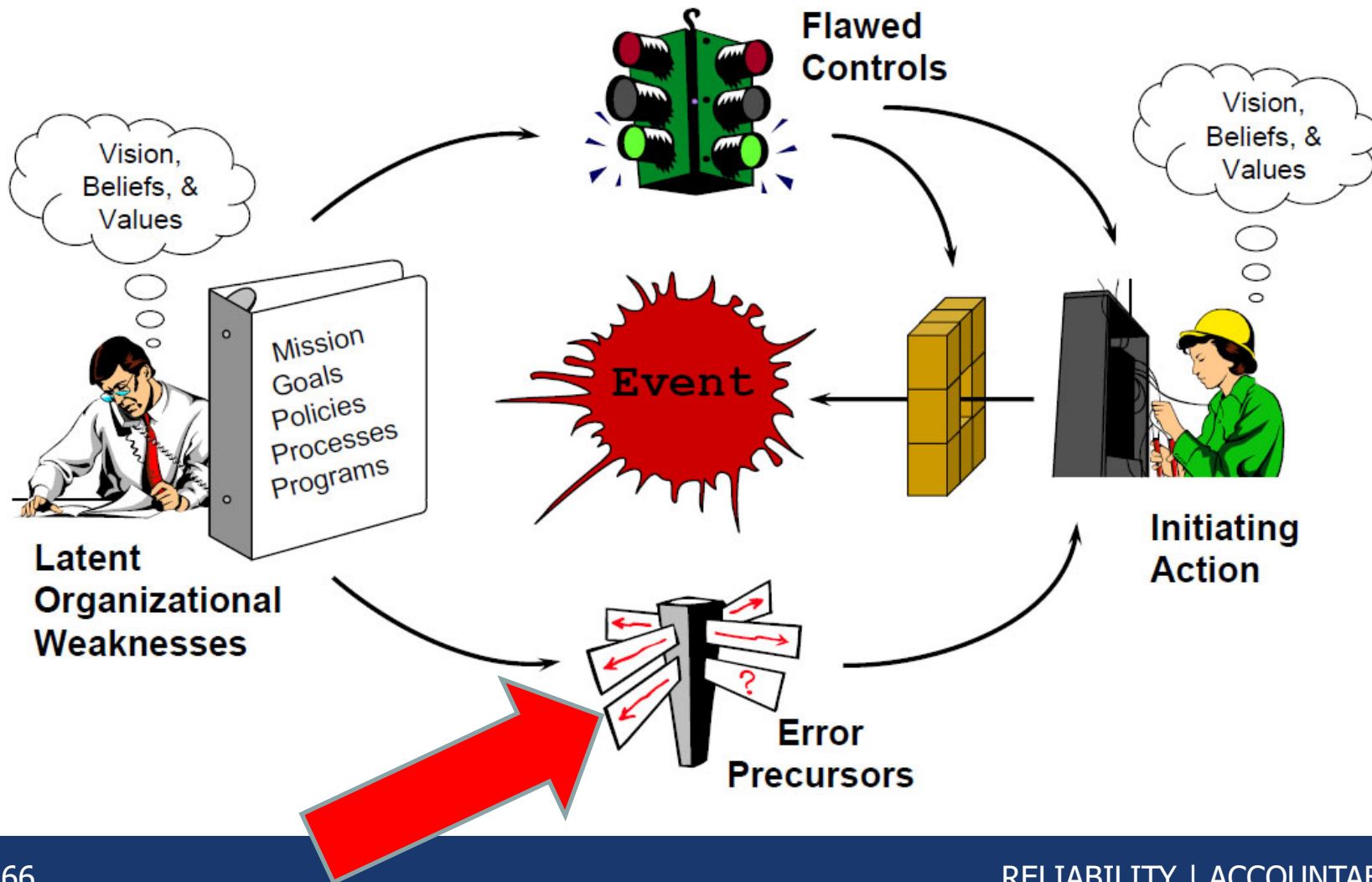
But it is possible that under the wrong set of circumstances, an event could occur....



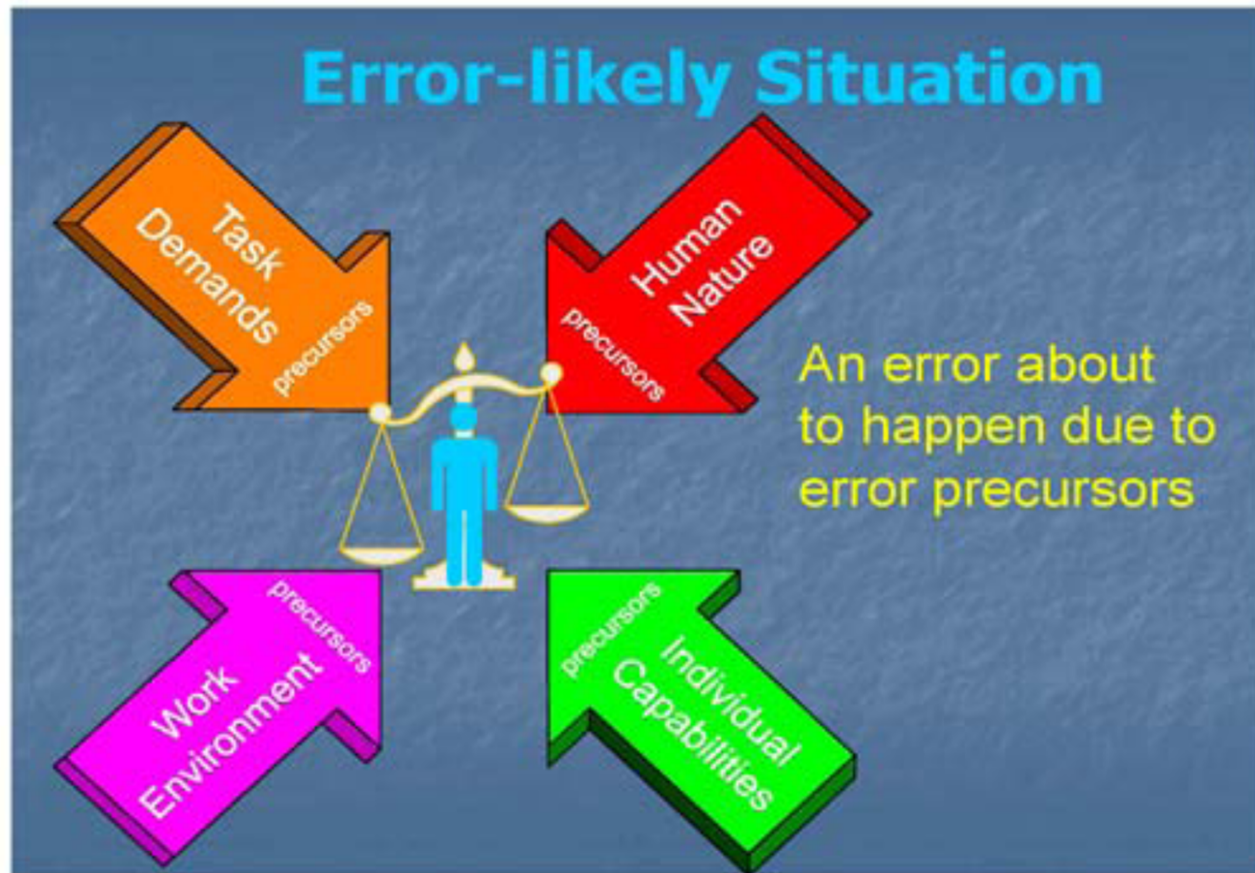
Eliminating Shots on Goal



Anatomy Of An Event – INPO Model



Error-Likely Situations

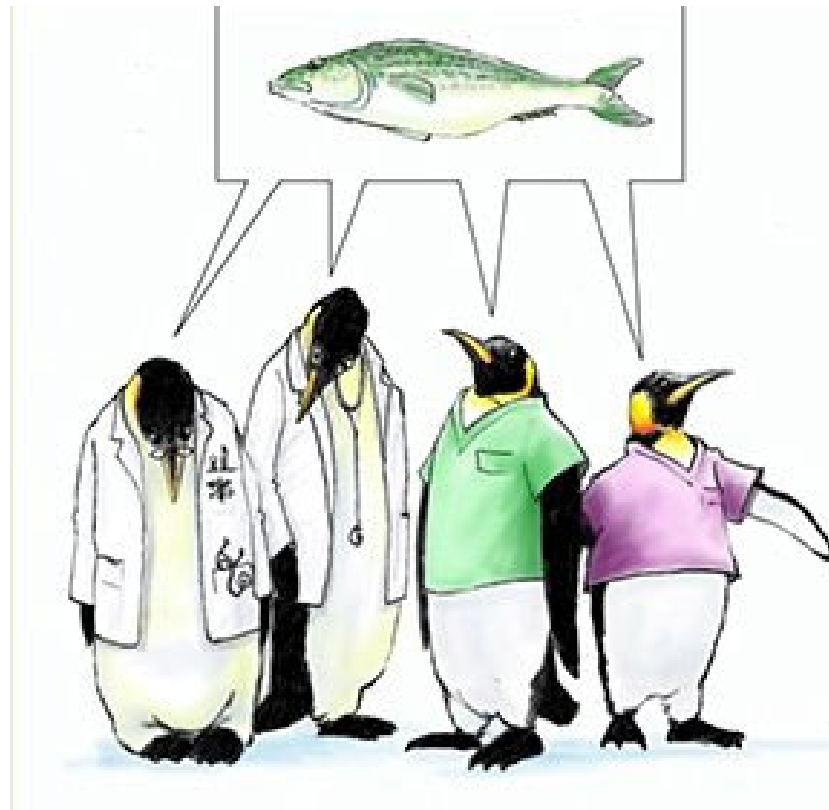


TWIN - Error Precursors

Task Demands	Work Environment
Time pressure (in a hurry)	Distractions / Interruptions
High workload (memory requirements)	Changes / Departure from routine
Simultaneous, Multiple tasks	Confusing displays / control
Repetitive actions (monotony)	Work - arrounds
Unclear goals, roles, or responsibilities	Unexpected equipment conditions
Lack of or unclear standards	Back shift or recent shift change
Complex / High information flow	
Individual Capabilities	Human Nature
Unfamiliarity with task (first time)	Stress
Lack of knowledge (faulty mental model)	Habit patterns
Imprecise communication habits	Assumptions
Lack of proficiency; inexperience	Complacency / over confidence
Overzealousness for safety critical task	Inaccurate risk perception
Illness or fatigue – Fitness for duty	Communication shortcuts
Lack of big picture	

- *One's understanding of a system, how it operates, its characteristics, performance parameters, couplings within itself and other systems and how one interacts with it.*
- *It is a representation of the surrounding world, the relationships between its various parts and a person's intuitive perception about his or her own acts and their consequences.*
- *Our mental models help to shape our behavior and define our approach to solving problems (a personal algorithm) and carrying out tasks, especially within a system.*
- *Mental models are like opinions, they can be partially or completely right or wrong, complete or incomplete and most often are unique for each individual.*

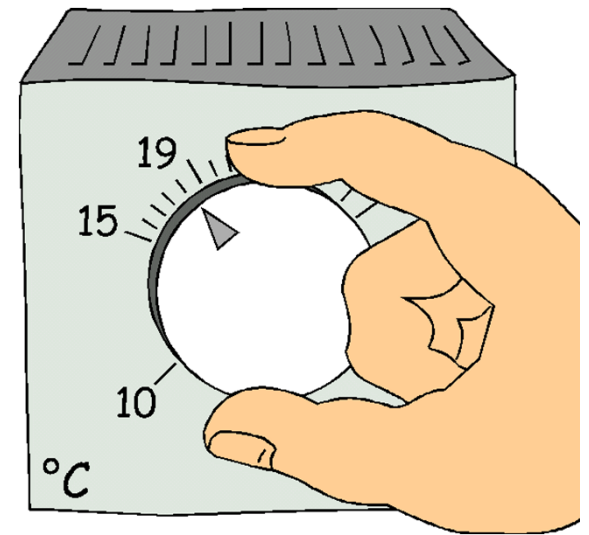
Perfectly Aligned Mental Model



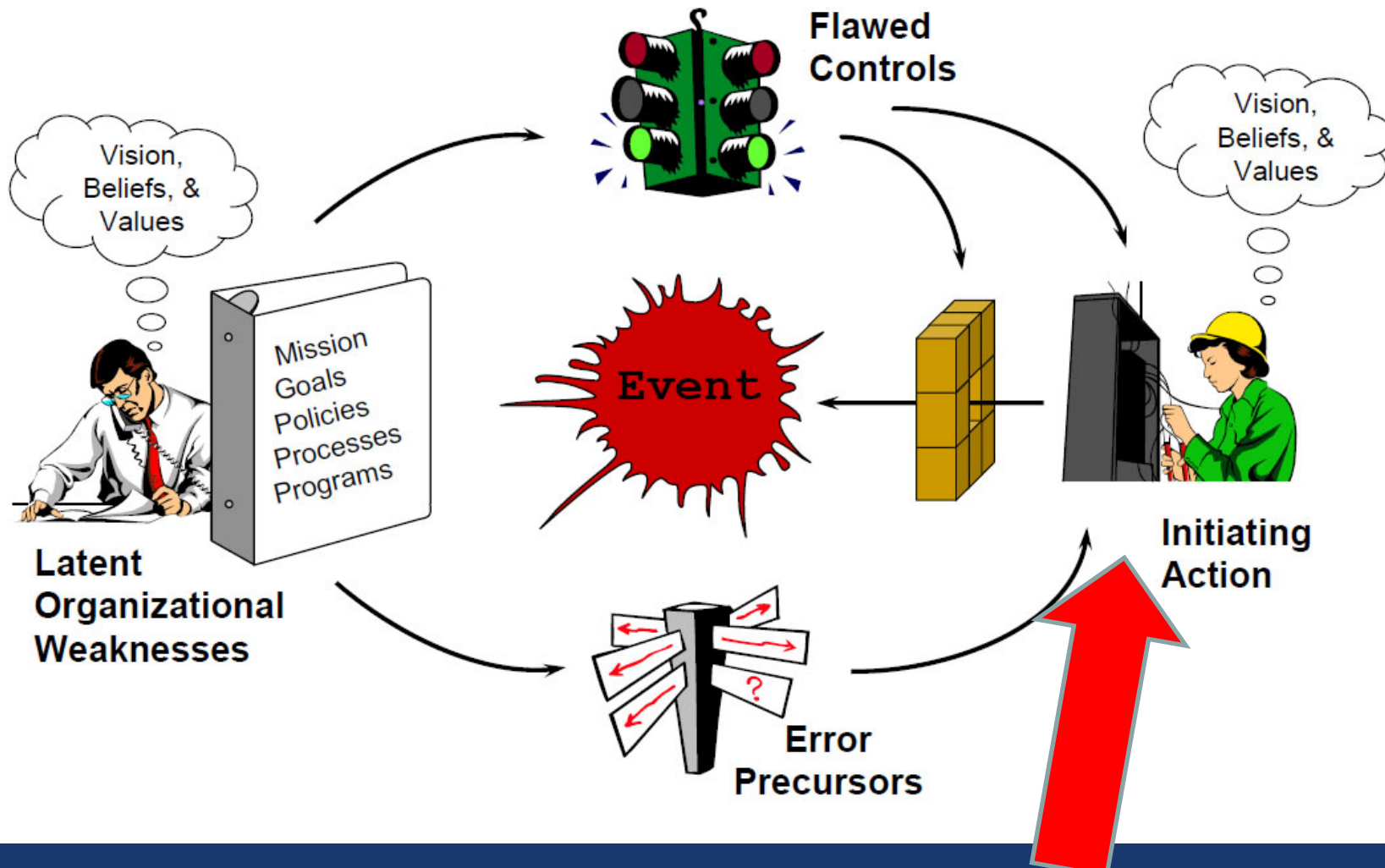
Improper Mental Model Example



Some people believe that you can heat/cool a room faster by setting the thermostat to a higher/lower temperature than you really want, as if the thermostat were a valve for the heating/cooling system that lets more heat/cool air into the room the higher/lower you set it. In fact, the thermostat is simply an on/off switch for the heat/cool. It turns on as long as the room temperature is below/above the thermostat setting, and turns off when the thermostat setting is reached.



Anatomy Of An Event – INPO Model



Types of Errors

- Active Errors – immediate, undesired consequences, unfavorable results
- *Latent Errors – unnoticed at the time made; often deeply or embedded within system*

Nature of Errors

- Slips – actions not carried out as intended or planned
 - *Examples: Tool slides off its mark; telling someone to go “right” when you meant to say “left”*
- Lapses – omissions or missed actions
 - *Examples: forgetting to reset a breaker, or to close a gate*
- Mistakes – faulty intention or plan
 - *Examples: Over-torquing a bolt by not knowing or looking up the standard, under-filling the reservoir of lubricating oil because the appropriate level could not be determined*

Performance Modes individuals use to process information related to one's level of familiarity and one's level of attention given to a specific task

- *Skill Based*
- *Rule Based*
- *Knowledge Based*

Rasmussen's Model

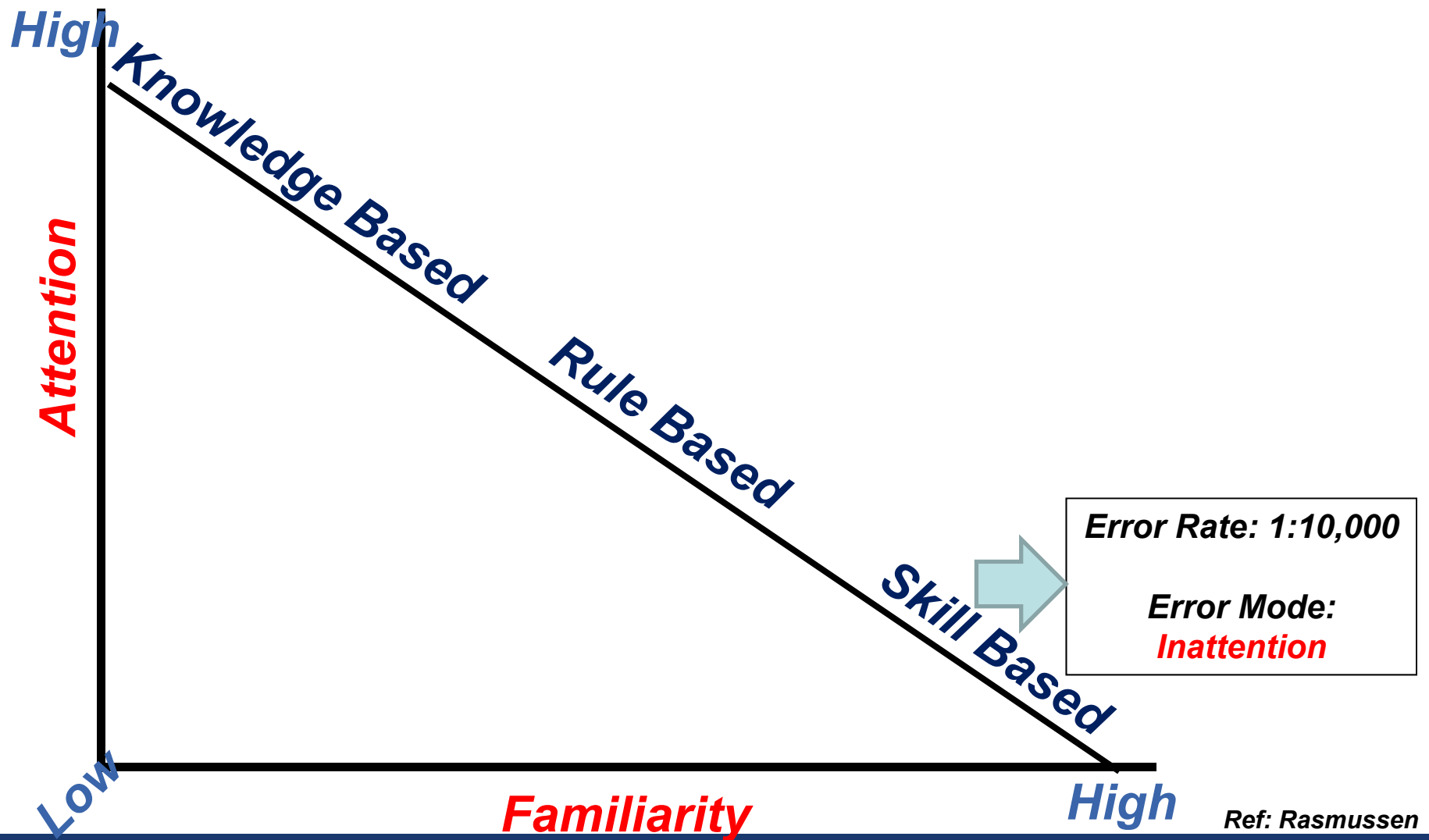
Skill Based:

Behavior associated with highly practiced actions in a familiar situation usually executed from memory without significant conscious thought

The “desired” state (where we want to be)



Human Performance Modes



Ref: Rasmussen

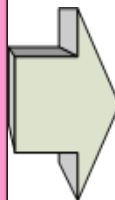
Human Performance Errors

Identify the Type of Error Made



Skill – Based Error Symptoms

Execution type errors
Correct understanding of the situation
Unintentional omissions
Inadvertent Slips
Pre-occupation results in missing a changing condition
Over-attentive such that pertinent information is missed



Skill – Based Error

Suggestions for Corrective Action

Install blocking devices
Identify the Critical Steps
Increase Supervision
Avoid multi-mode switches
If distracted, re-read previous 2 or 3 steps in procedure
Improve planning
Improve personal experience with the task
Eliminate unnecessary time pressure through scheduling
Rotate individuals
Practice using skills to maintain proficiency
Promote the use of Peer Checking
Improve human factors identification and layout of controls

Rule Based:

Behavior based on selection of stored rules derived from one's recognition of the situation; the rule-based mode, typically relies on written guidance to perform the work activity

The minimum level of competence

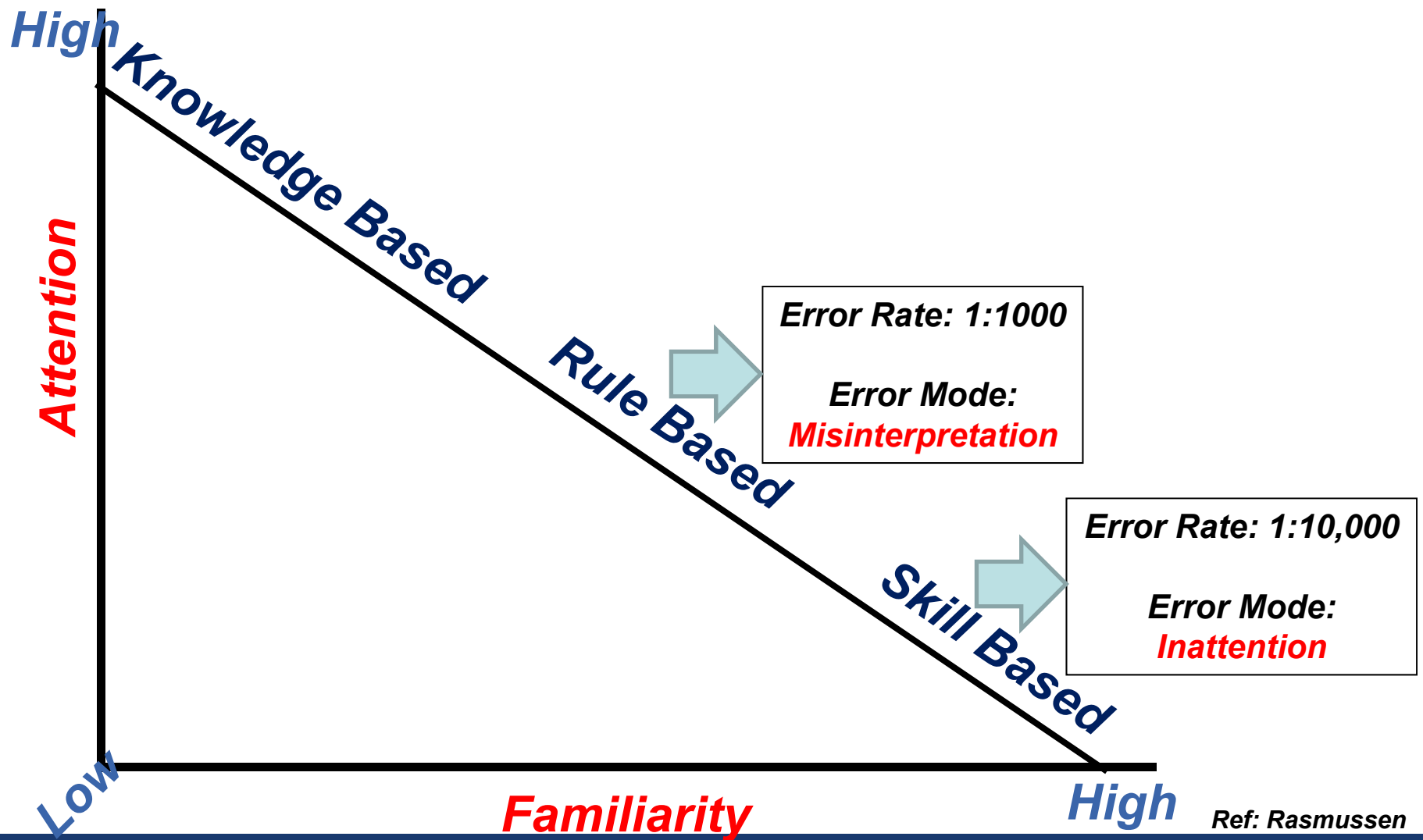
Rule Based:

The work situation has changed such that the previous activity (skill) no longer applies. This problem is likely to be one that they have encountered before, or have been trained to deal with, or which is covered by the procedures.

It is called the rule-based level because people apply memorized or written rules.



Human Performance Modes



Ref: Rasmussen

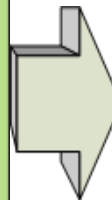
Human Performance Errors

Identify the Type of Error Made



Rule – Based Error Symptoms

Interpretation errors
Not fully understanding or detecting conditions calling for a particular response
Responding to a deviation to a plan
Applying the wrong procedure to the situation
Applying the correct procedure to an inaccurately perceived situation



Rule – Based Error

Suggestions for Corrective Action

Clearly delineate key decision points in a procedure
Eliminate procedure inconsistencies
Simplify procedure
Train individuals to Skill-based mode fluency
Eliminate drawing and technical manual errors
Improve knowledge of procedure basis
Practice using multiple, alternative indications
Promote practice of verbalizing intentions
Practice on transitions between procedures
Eliminate use of “rules of thumb”

Knowledge Based:

Behavior based on unfamiliarity, therefore individual must rely on experience, perceptions, and perspective;

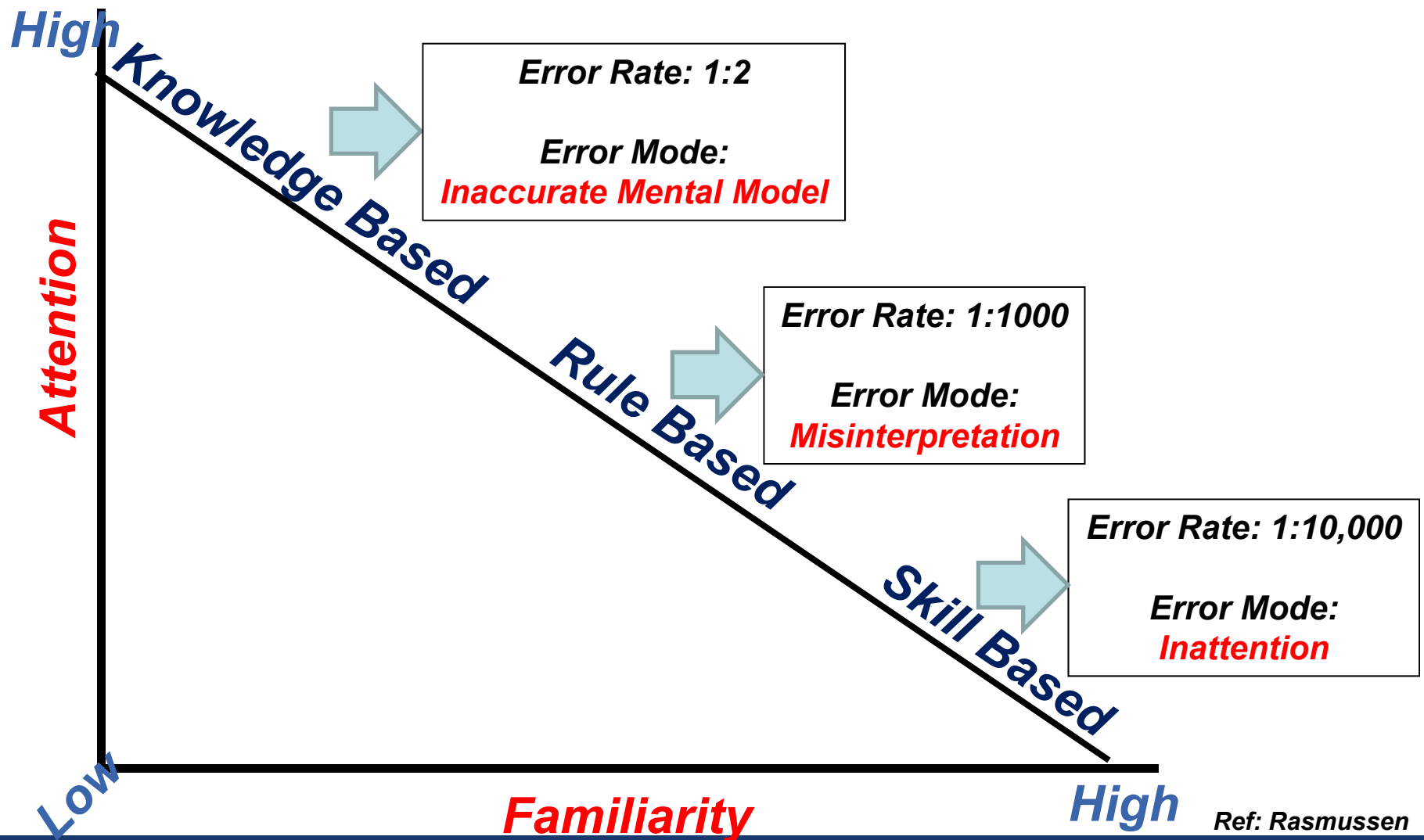
(more appropriately, this mode describes a “lack of” knowledge)



Knowledge-based :

- *response to a totally unfamiliar situation (no skill or rule is recognizable to the individual)*
- *uncertain about what to do*
- *need for information becomes paramount*
- *puzzling and unusual to the individual*
- *attention must become more focused*

Human Performance Modes



Ref: Rasmussen

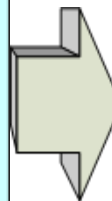
Human Performance Errors

Identify the Type of Error Made



Knowledge – Based Error Symptoms

Diagnosis errors
Flaws in problem-solving and decision-making based on erroneous mental representation of the plant or system status (bad Mental Model)



Knowledge – Based Error Suggestions for Corrective Action

Practice, practice, practice using methodical problem solving techniques
Design displays to enhance use without keyboarding
Practice using team and communication skills
Assign the role of “Devil’s advocate”
Train on, and verify accuracy of, system and social mental model
Use system/component knowledge and fundamental principles of science in unfamiliar problem situations

Why the concern about HP Modes?

HUMAN PERFORMANCE ERRORS

IDENTIFY THE TYPE OF ERROR MADE

SKILL BASED ERROR SYMPTOMS
Execution type errors.
Correct understanding of the situation.
Unintentional omissions.
Inadvertent slips.
Preoccupation results in missing changing conditions.
Over attentive such that pertinent information is missed.

RULE BASED ERROR SYMPTOMS
Interpretation errors.
Not fully understanding or detecting conditions calling for a particular response.
Responding to a deviation to a plan.
Applying the wrong procedure to the situation.
Applying the correct procedure to an inaccurately perceived situation.

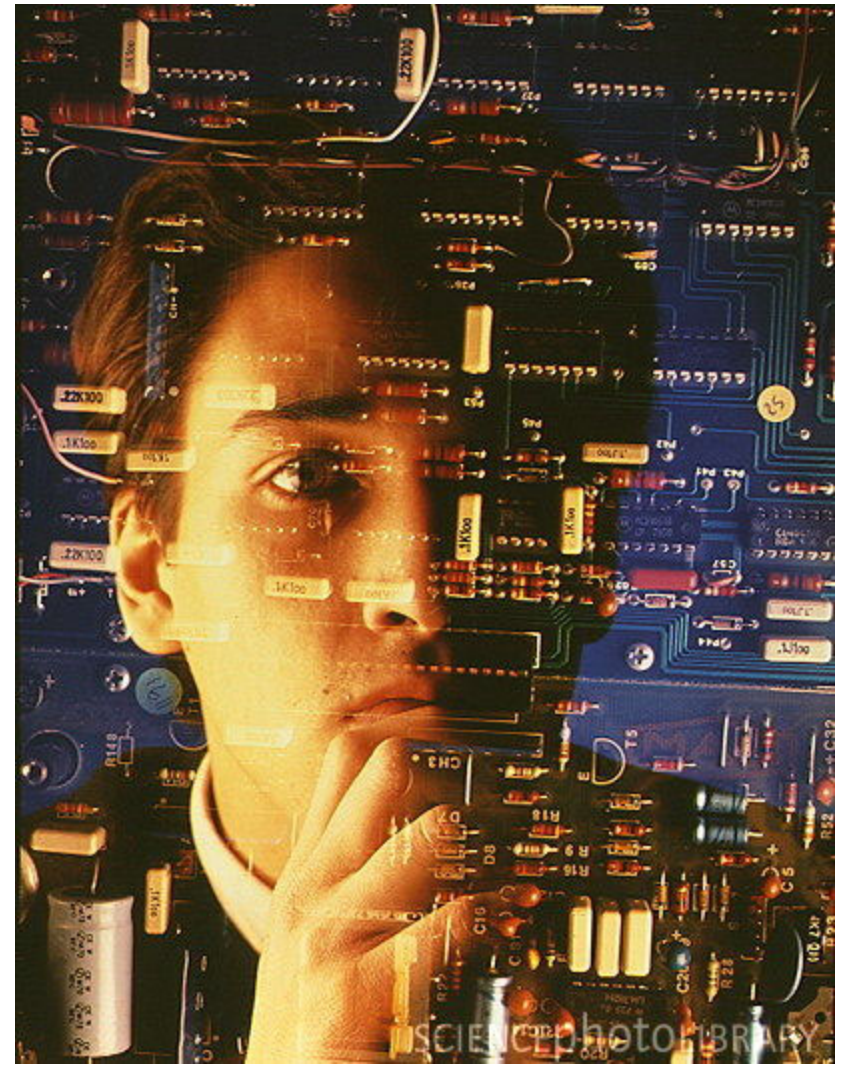
KNOWLEDGE BASED ERROR SYMPTOMS
Diagnosis errors.
Flaws in problem solving and decision making based upon erroneous mental representation of the plant status or system.
Typically based upon insufficient information about the true plant or equipment status.

**Skill Based Errors
Suggestions for Corrective Action**
Install blocking devices
Identify the critical steps
Increase supervision
Avoid multi-mode switches
If distracted, re-read previous 2 or 3 steps in the procedure.
Improve planning
Improve personal experience with the task
Eliminate unnecessary time pressure through scheduling
Rotate individuals
Practice using skills to maintain job proficiency.
Promote the value of peer checking.
Improve human factors identification and layout of controls.

**Rule Based Errors
Suggestions for Corrective Action**
Clearly delineate key decision points in a procedure.
Eliminate procedure inconsistencies.
Simplify procedures
Train individuals to skill-based mode (fluency).
Eliminate drawing and technical manual errors.
Improve knowledge of procedure bases.
Practice using multiple, alternative indications.
Promote practice of verbalizing intentions.
Practice on transitions between procedures.
Eliminate use of "rules of thumb"

**Knowledge Based Errors
Suggestions for Corrective Action**
Practice, practice, practice using methodical problem solving techniques.
Design displays to enhance use without keyboarding.
Practice using team and communication skills.
Assign the role of Devil's advocate.
Train on and verify accuracy of system and social mental model.
Use system/component knowledge and fundamental principles of science in unfamiliar problem situations.

- Skill - Does not really effect
- Rule – Usually not a factor
- Knowledge – Real problem



What were they thinking?

- Switching orders
- Diagnostics as a Balancing Authority (BA)
- Skill, Rule or Knowledge Based
- Incomplete information
- Poor understanding
- Fatigue
- Time pressure

Cognitive Biases? Heuristics??



Common Decision-making and Behavioral Biases

Automation bias	The tendency to trust information provided via electronic information systems over intuition or humans; accepting information derived from the use of automation as a “best guess” instead of vigilant information seeking and processing
Bandwagon effect	The tendency to do (or believe) things because other people do, with the goal of gaining in popularity or being on the winning side
Confirmation bias	The tendency to search for or interpret information in a way that confirms one’s preconceptions or course of action.
Professional deformation	The tendency to look at things according to the conventions of one’s profession, ignoring broader points of view
Denial	The tendency to disbelieve or discount an unpleasant fact or situation
Expectation bias	The tendency to believe, certify results or analysis that agree with one’s expectations of an outcome and to disbelieve, discard, or downgrade corresponding weightings for information that appears to conflict with those expectations
Extreme aversion	The tendency to avoid extremes, being more likely to choose an option if it is the intermediate choice
Framing effect	The drawing of different conclusions based on how data are presented
Illusion of control	The tendency to believe that one can control or at least influence outcomes that one clearly cannot
Information bias	The tendency to seek information even when it cannot affect action

Cognitive Biases (cont'd)

Loss aversion	The disutility of giving up an object is greater than the utility associated with acquiring it
Normalcy bias	The tendency to discount novelty and to respond to such events with only routine procedures
Neglect of probability	The tendency to completely disregard probability when making a decision under uncertainty
Not invented here	The tendency to ignore that a product or solution already exists because its source is seen as an adversary
Reactance	The urge to do the opposite of what someone wants one to do out of a need to resist a perceived attempt to constrain one's freedom of choice
Selective perception	The tendency for expectations to affect perception
Unit bias	The tendency to want to finish a given unit of a task or an item often resulting in sequential behavior limiting simultaneous tasks
Wishful thinking	The formation of beliefs and making decisions according to what might be pleasing to imagine instead of by appealing to evidence or rationality
Zero-risk bias	Preference for reducing a small risk to zero instead of seeking a greater reduction in a larger risk

- Back to our Exercise
- Interview results
- Exercise e-mail
- With what you know about “Decision-making and Behavioral biases”, what might be going on at this facility?



B

- Anchoring – the common human tendency to rely too heavily, or "anchor," on one trait or piece of information when making decisions.
- Attentional Bias – implicit cognitive bias defined as the tendency of emotionally dominant stimuli in one's environment to preferentially draw and hold attention.
- Bandwagon effect – the tendency to do (or believe) things because many other people do (or believe) the same. Related to groupthink and herd behavior.
- Bias blind spot – the tendency to see oneself as less biased than other people.
- Choice-supportive bias – the tendency to remember one's choices as better than they actually were.
- Confirmation bias – the tendency to search for or interpret information in a way that confirms one's preconceptions.
- Congruence bias – the tendency to test hypotheses exclusively through direct testing, in contrast to tests of possible alternative hypotheses.
- Contrast effect – the enhancement or diminishing of a weight or other measurement when compared with a recently observed contrasting object.
- Denomination effect – the tendency to spend more money when it is denominated in small amounts (e.g. coins) rather than large amounts (e.g. bills).
- Distinction bias – the tendency to view two options as more dissimilar when evaluating them simultaneously than when evaluating them separately.
- Endowment effect – "the fact that people often demand much more to give up an object than they would be willing to pay to acquire it".
- Experimenter's or Expectation bias – the tendency for experimenters to believe, certify, and publish data that agree with their expectations for the outcome of an experiment, and to disbelieve, discard, or downgrade the corresponding weightings for data that appear to conflict with those expectations.
- Focusing effect – the tendency to place too much importance on one aspect of an event; causes error in accurately predicting the utility of a future outcome.
- Framing effect – drawing different conclusions from the same information, depending on how that information is presented.
- Hostile media effect - the tendency to see a media report as being biased due to one's own strong partisan views.
- Hyperbolic discounting – the tendency for people to have a stronger preference for more immediate payoffs relative to later payoffs, where the tendency increases the closer to the present both payoffs are.
- Illusion of control – the tendency to overestimate one's degree of influence over other external events.
- Impact bias – the tendency to overestimate the length or the intensity of the impact of future feeling states.
- Information bias – the tendency to seek information even when it cannot affect action.
- Irrational escalation – the phenomenon where people justify increased investment in a decision, based on the cumulative prior investment, despite new evidence suggesting that the decision was probably wrong.
- Loss aversion – "the disutility of giving up an object is greater than the utility associated with acquiring it".
- Mere exposure effect – the tendency to express undue liking for things merely because of familiarity with them.
- Money illusion – the tendency to concentrate on the nominal (face value) of money rather than its value in terms of purchasing power.
- Moral credential effect – the tendency of a track record of non-prejudice to increase subsequent prejudice.
- Negativity bias – the tendency to pay more attention and give more weight to negative than positive experiences or other kinds of information.
- Neglect of probability – the tendency to completely disregard probability when making a decision under uncertainty.
- Normalcy bias – the refusal to plan for, or react to, a disaster which has never happened before.
- Omission bias – the tendency to judge harmful actions as worse, or less moral, than equally harmful omissions (inactions).
- Outcome bias – the tendency to judge a decision by its eventual outcome instead of based on the quality of the decision at the time it was made.
- Planning fallacy – the tendency to underestimate task-completion times.
- Post-purchase rationalization – the tendency to persuade oneself through rational argument that a purchase was a good value.
- Pseudocertainty effect – the tendency to make risk-averse choices if the expected outcome is positive, but make risk-seeking choices to avoid negative outcomes.
- Reactance – the urge to do the opposite of what someone wants you to do out of a need to resist a perceived attempt to constrain your freedom of choice.
- Restraint bias – the tendency to overestimate one's ability to show restraint in the face of temptation.
- Selective perception – the tendency for expectations to affect perception.
- Semmelweis reflex – the tendency to reject new evidence that contradicts an established paradigm.
- Social comparison bias – the tendency, when making hiring decisions, to favour potential candidates who don't compete with one's own particular strengths.

- Status quo bias – the tendency to like things to stay relatively the same (see also loss aversion, endowment effect, and system justification).
- Unit bias — the tendency to want to finish a given unit of a task or an item. Strong effects on the consumption of food in particular.
- Wishful thinking – the formation of beliefs and the making of decisions according to what is pleasing to imagine instead of by appeal to evidence or rationality.
- Zero-risk bias – preference for reducing a small risk to zero over a greater reduction in a larger risk.
- Ambiguity effect – the tendency to avoid options for which missing information makes the probability seem "unknown."
- Anchoring effect – the tendency to rely too heavily, or "anchor," on a past reference or on one trait or piece of information when making decisions (also called "insufficient adjustment").
- Attentional bias – the tendency to neglect relevant data when making judgments of a correlation or association.
- Availability heuristic – estimating what is more likely by what is more available in memory, which is biased toward vivid, unusual, or emotionally charged examples.
- Availability cascade – a self-reinforcing process in which a collective belief gains more and more plausibility through its increasing repetition in public discourse (or "repeat something long enough and it will become true").
- Base rate neglect or Base rate fallacy – the tendency to base judgments on specifics, ignoring general statistical information.
- Belief bias – an effect where someone's evaluation of the logical strength of an argument is biased by the believability of the conclusion.
- Clustering illusion – the tendency to see patterns where actually none exist.
- Conjunction fallacy – the tendency to assume that specific conditions are more probable than general ones.
- Forward Bias - the tendency to create models based on past data which are validated only against that past data.
- Gambler's fallacy – the tendency to think that future probabilities are altered by past events, when in reality they are unchanged. Results from an erroneous conceptualization of the Law of large numbers. For example, "I've flipped heads with this coin five times consecutively, so the chance of tails coming out on the sixth flip is much greater than heads."
- Hindsight bias – sometimes called the "I-knew-it-all-along" effect, the tendency to see past events as being predictable[31] at the time those events happened.
- Illusory correlation – inaccurately perceiving a relationship between two events, either because of prejudice or selective processing of information.
- Observer-expectancy effect – when a researcher expects a given result and therefore unconsciously manipulates an experiment or misinterprets data in order to find it (see also subject-expectancy effect).
- Optimism bias – the tendency to be over-optimistic about the outcome of planned actions.
- Ostrich effect – ignoring an obvious (negative) situation.
- Overconfidence effect – excessive confidence in one's own answers to questions. For example, for certain types of questions, answers that people rate as "99% certain" turn out to be wrong 40% of the time.
- Positive outcome bias – the tendency of one to overestimate the probability of a favorable outcome coming to pass in a given situation (see also wishful thinking, optimism bias, and valence effect).
- Pareidolia – a vague and random stimulus (often an image or sound) is perceived as significant, e.g., seeing images of animals or faces in clouds, the man in the moon, and hearing hidden messages on records played in reverse.
- Pessimism bias – the tendency for some people, especially those suffering from depression, to overestimate the likelihood of negative things happening to them.
- Primacy effect – the tendency to weigh initial events more than subsequent events.
- Recency effect – the tendency to weigh recent events more than earlier events (see also peak-end rule).
- Disregard of regression toward the mean – the tendency to expect extreme performance to continue.
- Stereotyping – expecting a member of a group to have certain characteristics without having actual information about that individual.
- Subadditivity effect – the tendency to judge probability of the whole to be less than the probabilities of the parts.
- Subjective validation – perception that something is true if a subject's belief demands it to be true. Also assigns perceived connections between coincidences.
- Well travelled road effect – underestimation of the duration taken to traverse oft-traveled routes and over-estimate the duration taken to traverse less familiar routes.

- Actor–observer bias – the tendency for explanations of other individuals' behaviors to overemphasize the influence of their personality and underemphasize the influence of their situation (see also Fundamental attribution error), and for explanations of one's own behaviors to do the opposite (that is, to overemphasize the influence of our situation and underemphasize the influence of our own personality).
- Dunning–Kruger effect – a twofold bias. On one hand the lack of metacognitive ability deludes people, who overrate their capabilities. On the other hand, skilled people underrate their abilities, as they assume the others have a similar understanding.
- Egocentric bias – occurs when people claim more responsibility for themselves for the results of a joint action than an outside observer would.
- Forer effect (aka Barnum effect) – the tendency to give high accuracy ratings to descriptions of their personality that supposedly are tailored specifically for them, but are in fact vague and general enough to apply to a wide range of people. For example, horoscopes.
- False consensus effect – the tendency for people to overestimate the degree to which others agree with them.
- Fundamental attribution error – the tendency for people to over-emphasize personality-based explanations for behaviors observed in others while under-emphasizing the role and power of situational influences on the same behavior (see also actor-observer bias, group attribution error, positivity effect, and negativity effect).
- Halo effect – the tendency for a person's positive or negative traits to "spill over" from one area of their personality to another in others' perceptions of them (see also physical attractiveness stereotype).
- Illusion of asymmetric insight – people perceive their knowledge of their peers to surpass their peers' knowledge of them.
- Illusion of transparency – people overestimate others' ability to know them, and they also overestimate their ability to know others.
- Illusory superiority – overestimating one's desirable qualities, and underestimating undesirable qualities, relative to other people. (Also known as "Lake Wobegon effect," "better-than-average effect," or "superiority bias").
- Ingroup bias – the tendency for people to give preferential treatment to others they perceive to be members of their own groups.
- Just-world phenomenon – the tendency for people to believe that the world is just and therefore people "get what they deserve."
- Moral luck – the tendency for people to ascribe greater or lesser moral standing based on the outcome of an event rather than the intention
- Outgroup homogeneity bias – individuals see members of their own group as being relatively more varied than members of other groups.
- Projection bias – the tendency to unconsciously assume that others (or one's future selves) share one's current emotional states, thoughts and values.
- Self-serving bias – the tendency to claim more responsibility for successes than failures. It may also manifest itself as a tendency for people to evaluate ambiguous information in a way beneficial to their interests (see also group-serving bias).
- System justification – the tendency to defend and bolster the status quo. Existing social, economic, and political arrangements tend to be preferred, and alternatives disparaged sometimes even at the expense of individual and collective self-interest. (See also status quo bias.)
- Trait ascription bias – the tendency for people to view themselves as relatively variable in terms of personality, behavior and mood while viewing others as much more predictable.
- Ultimate attribution error – similar to the fundamental attribution error, in this error a person is likely to make an internal attribution to an entire group instead of the individuals within the group.

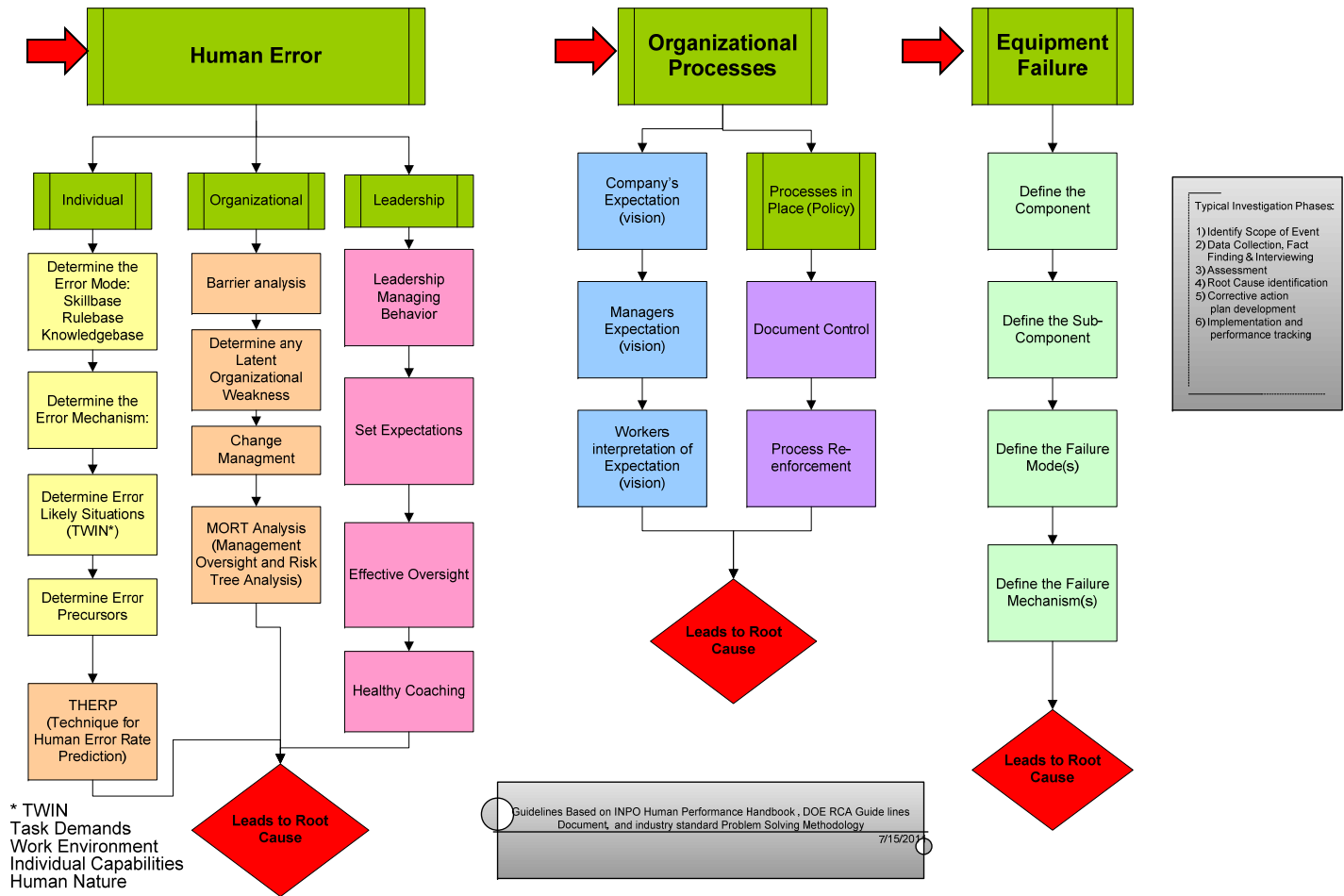
- Cryptomnesia – a form of misattribution where a memory is mistaken for imagination.
 - Egocentric bias – recalling the past in a self-serving manner, e.g. remembering one's exam grades as being better than they were, or remembering a caught fish as being bigger than it was.
 - False memory – confusion of imagination with memory, or the confusion of true memories with false memories.
 - Hindsight bias – filtering memory of past events through present knowledge, so that those events look more predictable than they actually were; also known as the "I-knew-it-all-along effect."
 - Positivity effect – older adults remember relatively more positive than negative things, compared with younger adults[46]
 - Reminiscence bump – the effect that people tend to recall more personal events from adolescence and early adulthood than from other lifetime periods.
 - Rosy retrospection – the tendency to rate past events more positively than they had actually rated them when the event occurred.
 - Self-serving bias – perceiving oneself responsible for desirable outcomes but not responsible for undesirable ones.
 - Suggestibility – a form of misattribution where ideas suggested by a questioner are mistaken for memory.
 - Telescoping effect – the effect that recent events appear to have occurred more remotely and remote events appear to have occurred more recently.
 - Von Restorff effect – the tendency for an item that "stands out like a sore thumb" to be more likely to be remembered than other items.
-
- Bounded rationality – limits on optimization and rationality
 - Attribute substitution – making a complex, difficult judgment by unconsciously substituting an easier judgment
 - Attribution theory, especially:
 - Salience
 - Cognitive dissonance, and related:
 - Impression management
 - Self-perception theory
 - Heuristics, including:
 - Availability heuristic – estimating what is more likely by what is more available in memory, which is biased toward vivid, unusual, or emotionally charged examples
 - Representativeness heuristic – judging probabilities on the basis of resemblance
 - Affect heuristic – basing a decision on an emotional reaction rather than a calculation of risks and benefits
 - Introspection illusion
 - Adaptive bias
 - Misinterpretations or misuse of statistics.

- Organizational “blind spots”
 - Little contact between people performing one task and people performing another task (“fiefdoms”)
- Organizational bias
 - Congregating of like-minded (or like-background) people, not passing information to others “outside their group”
 - “homophily” – the tendency of similar individuals to migrate to each other
- Diffusion of responsibility
 - “Someone else will do it”
 - AKA - “bystander effect”



Overview of Event Analysis

Event Analysis Methodology Tree



- Many Tools
 - Techniques go together – one may feed another
 - Example: Barrier Analysis feeds EC&F or Cause & Effect Charting
 - Example: Change analysis feeds Kepner-Tregoe
- Select what is right for you AND for the situations
- Use multiple tools and methodologies if you need to do so.

- **Only assigned AFTER the analysis is completed**
 - Too early leads to “Categorical Thinking” (putting blinders on to anything not in that category – Confirmation Bias or Selective Perception)
- **Used to help analyze separate events over time**
 - to “Trend” or locate similar problems separated by time or distance
- **Must be standardized to be effectively used**

- CCAP video

DOE G 231.1-2

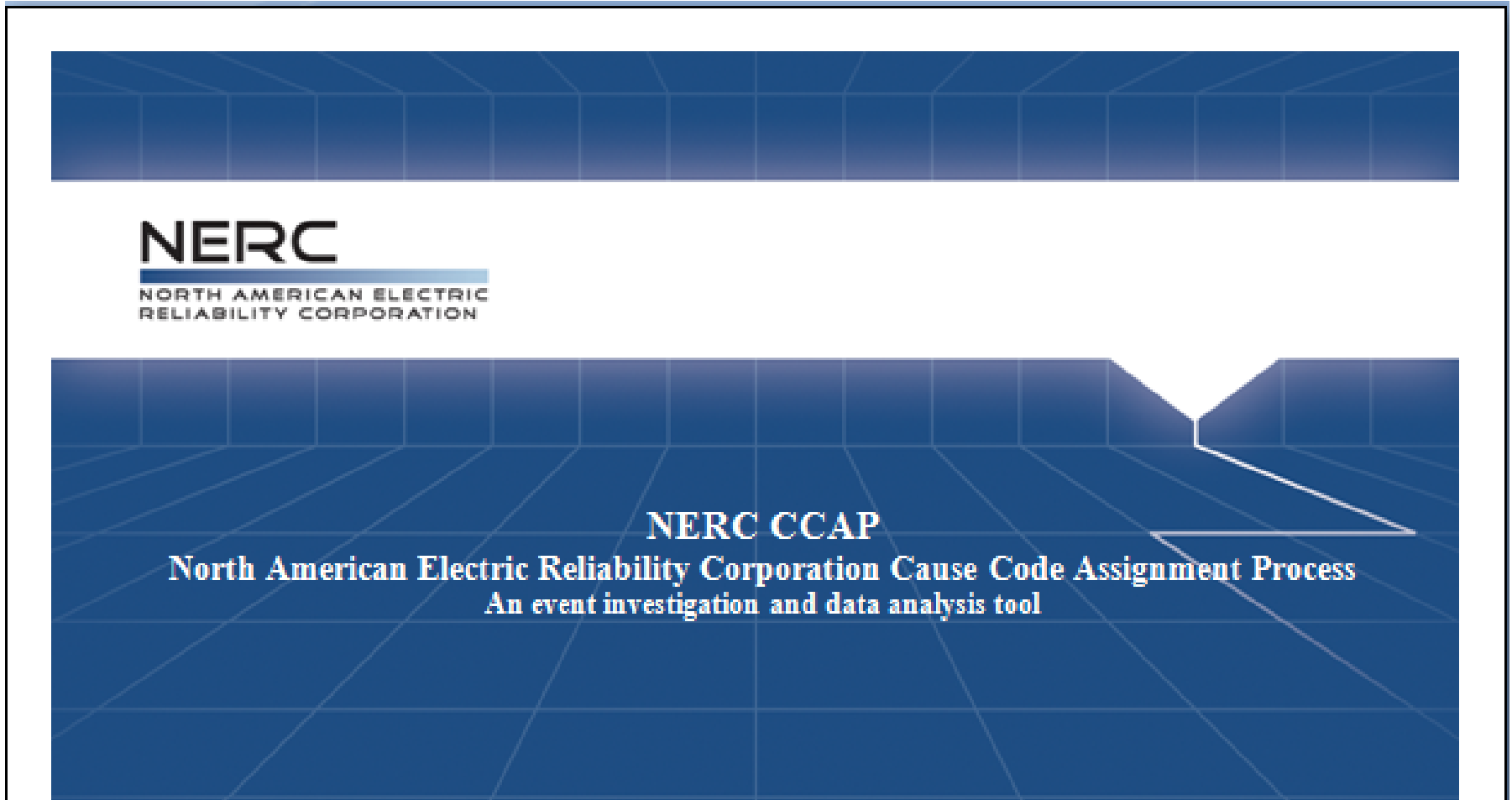
Approved: 08-20-03

OCCURRENCE REPORTING CAUSAL ANALYSIS GUIDE

[This Guide describes suggested nonmandatory approaches for meeting requirements. Guides are not requirements documents and are not to be construed as requirements in any audit or appraisal for compliance with the parent Policy, Order, Notice, or Manual.]



- As adopted (and tailored) by NERC



- Level 1 Codes – 2-characters, format of Bold Text, underlined (A-level) **Level A nodes are underlined**
 - Level 2 Codes – 2-characters, format ALL CAPS (B-level) **Level B nodes are in ALLCAPS.**
 - Level 3 Codes – 3-characters, format normal text (C-level) **Level C nodes are in “sentence case.”**
 - Level 4 Codes – 3-characters, format not defined (D-level)
-
- **LTA = Less than adequate**

- **A1 Design/Engineering**
- **A2 Equipment/Material**
- **A3 Individual Human Performance**
- **A4 Management/Organization**
- **A5 Communication**
- **A6 Training**
- **A7 Other**
- **AX Overall Configuration**
- **AZ Information to determine cause LTA**

- **A1 Design/Engineering**
 - B1 = DESIGN INPUT LTA
 - B2 = DESIGN OUTPUT LTA
 - B3 = DESIGN/DOCUMENTATION LTA
 - B4 = DESIGN/INSTALLATION VERIFICATION LTA
 - B5 = OPERABILITY OF DESIGN/ENVIRONMENT LTA

- **A2 Equipment/Material**
 - B1 = CALIBRATION FOR INSTRUMENTS LTA
 - B2 = PERIODIC/CORRECTIVE MAINTENANCE LTA
 - B3 = INSPECTION/TESTING LTA
 - B4 = MATERIAL CONTROL LTA
 - B5 = PROCUREMENT CONTROL LTA
 - B6 = DEFECTIVE, FAILED, OR CONTAMINATED
 - B7 = EQUIPMENT INTERACTIONS LTA

- **A3 Individual Human Performance**
 - B1 = SKILL BASED ERROR
 - B2 = RULE BASED ERROR
 - B3 = KNOWLEDGE BASED ERROR
 - B4 = WORK PRACTICES LTA

- **A4 Management / Organization**
 - B1 = MANAGEMENT METHODS LTA
 - B2 = RESOURCE MANAGEMENT LTA
 - B3 = WORK ORGANIZATION & PLANNING LTA
 - B4 = SUPERVISORY METHODS LTA
 - B5 = CHANGE MANAGEMENT LTA

DOE-G 231.1-2 (2003)

- **A5 Communications**

- B1 = WRITTEN COMMUNICATIONS METHOD OF PRESENTATION LTA
- B2 = WRITTEN COMMUNICATION CONTENT LTA
- B3 = WRITTEN COMMUNICATION NOT USED
- B4 = VERBAL COMMUNICATION LTA

- **A6 Training**

- B1 = NO TRAINING PROVIDED
- B2 = TRAINING METHODS LTA
- B3 = TRAINING MATERIAL LTA

- **A7 Other**

- B1 = EXTERNAL PHENOMENA
- B2 = RADIOLOGICAL / HAZARDOUS MATERIAL PROBLEM
- B3 = VENDOR OR SUPPLIER PROBLEM

DOE-G 231.1-2 (2003)

- **AX Overall Configuration**
 - B1 = INSTALLATION/DESIGN CONFIGURATION LTA
 - B2 = MAINTENANCE/MODIFICATION CONFIGURATION LTA

- **AZ Information to determine cause LTA**
 - B1 = UNABLE TO IDENTIFY SPECIFIC ROOT CAUSE
 - B2 = REPORT STOPS AT FAILURE/ERRO MODE
 - B3 = INFORMATION CITES OTHER PARTY INVOLVEMENT
 - B4 = CROSS-REFERENCE REQUIRED FOR OTHER SOURCES OF INFORMATION

- **Example:**
 - Step was omitted due to distraction would be: A3B1C02
 - A3 = Individual Human Performance
 - B1 = Skill-Based Errors
 - C02 = Step was omitted due to distraction
- **By definition (provided)**
 - Attention was diverted to another issue during performance of the task and the individual committed an error in performance due to the distraction.

- Does the investigation go deep enough?
- Does the report of the investigation answer the questions?
- The Measure: can you develop cause codes from the report?

Cause Coding of events

The event happened on (date) and was a result of real fault on one of the feeder circuit.

The event happened because the ___kV Bus Differential Relay circuit was not connected correctly and the relay saw the fault on the feeder circuit as a ___kV bus and not just a normal feeder fault. The relay opened all of the ___kV breakers and the ___ transformer main breakers. This caused the city wide outage of ___ MW.

What was the real cause of the problem?

What was the reason for the “not connected correctly” condition?

Cause Code Selection

1	1. Select the appropriate grouping of the Level A Descriptions					
2	2. After selecting a Level A description, you then pick the appropriate Level B description. <i>IF NOT selected, the block will show any previous select</i>					
3	3. Once Level A and Level B selections are made, select the appropriate Level C description. <i>IF NOT selected, the block will show any previous sele</i>					
4	Pick the Level A Code Description	Level A Code selected is	Pick the Level B Code Description	Level B Code Selected is	Pick the Level C Code Description	Level C Code Selected is
5	Management Problem	A4				
	<ul style="list-style-type: none"> Design/Engineering Problem Equipment/Material Problem Individual Human Performance LTA Management Problem Communications LTA Training Deficiency Other Problem (Open) 					
		Defined as:		Defined as:		
	<p>An event or condition that could be directly traced to managerial actions, or methodology (or lack thereof). A "management" problem attributed to management methods (directions, monitoring, assessment, accountability, and corrective action), inadequate resource allocation, work organization and planning, supervisory methods and/or change management practices. Note: Apparent Cause Corrective Actions for this branch in particular easily slip into correcting the program as opposed to the implementation. Fixing the program is the realm of Root Cause[s]. The analyst is cautioned to gauge Corrective Actions appropriately.</p>					

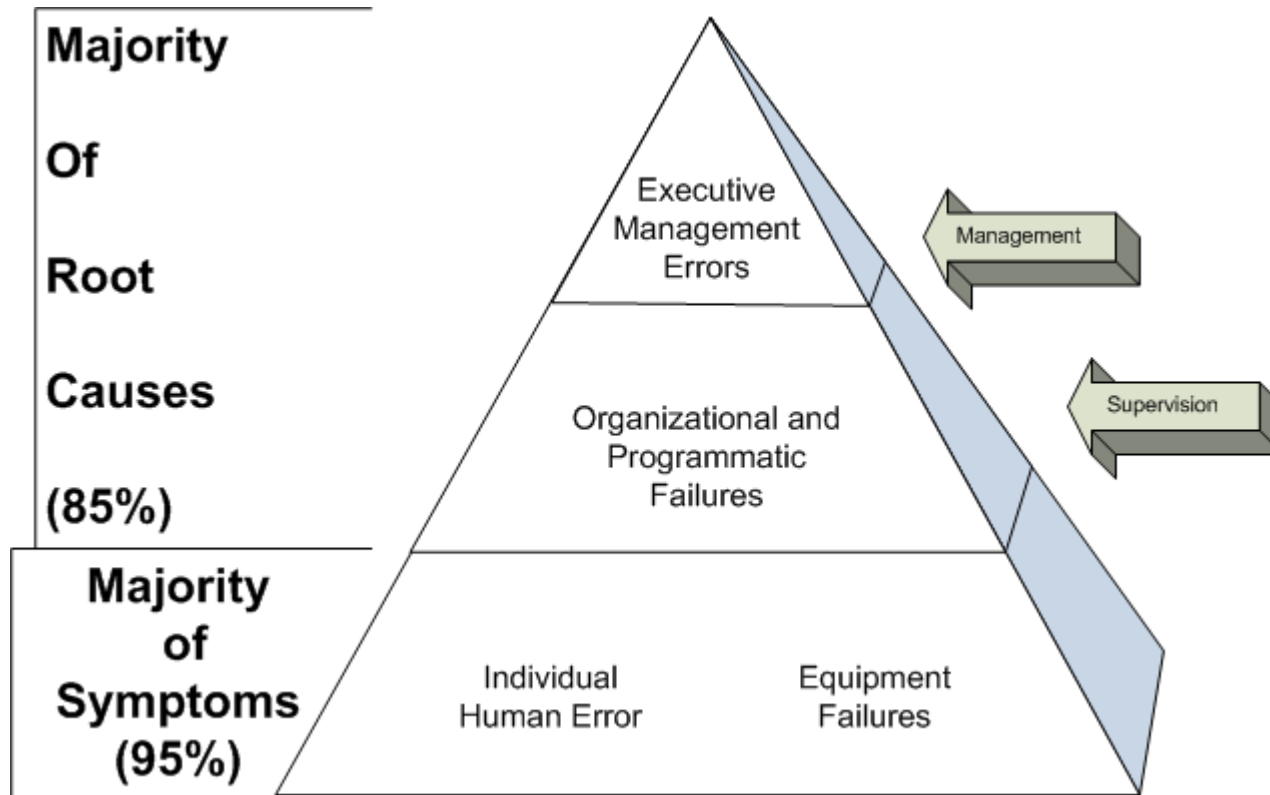
Cause Code Selection

1. Select the appropriate grouping of the Level A Descriptions
2. After selecting a Level A description, you then pick the appropriate Level B description. *IF NOT selected, the block will show any previous selections, which*
3. Once Level A and Level B selections are made, select the appropriate Level C description. *IF NOT selected, the block will show any previous selections, which*

Pick the Level A Code Description	Level A Code selected is	Pick the Level B Code Description	Level B Code Selected is	Pick the Level C Code Description	Level C Code Selected is
Management Problem	A4	RESOURCE MANAGEMENT LTA	A4B2	- Insufficient manpower to support identified goal / objective	A4B2C03
Defined as: An event or condition that could be directly traced to managerial actions, or methodology (or lack thereof). A "management" problem attributed to management methods (directions, monitoring, assessment, accountability, and corrective action), inadequate resource allocation, work organization and planning, supervisory methods and/or change management practices. Note: Apparent Cause Corrective Actions for this branch in particular easily slip into correcting the program as opposed to the implementation. Fixing the program is the realm of Root Cause[s]. The analyst is cautioned to gauge Corrective Actions appropriately.		Defined as: Evaluation of the processes whereby manpower and material were allocated to successfully perform assigned tasks. Note: A4B2 serves as an expansion to A4B1, Management Methods, since both A4B1 and A4B2 are important inter-related factors. A4B2 provides more in-depth causal nodes for evaluating manpower and material issues impacting performance of work-related activities.		Defined as: Personnel were not available as required by task analysis of goal/objective.	

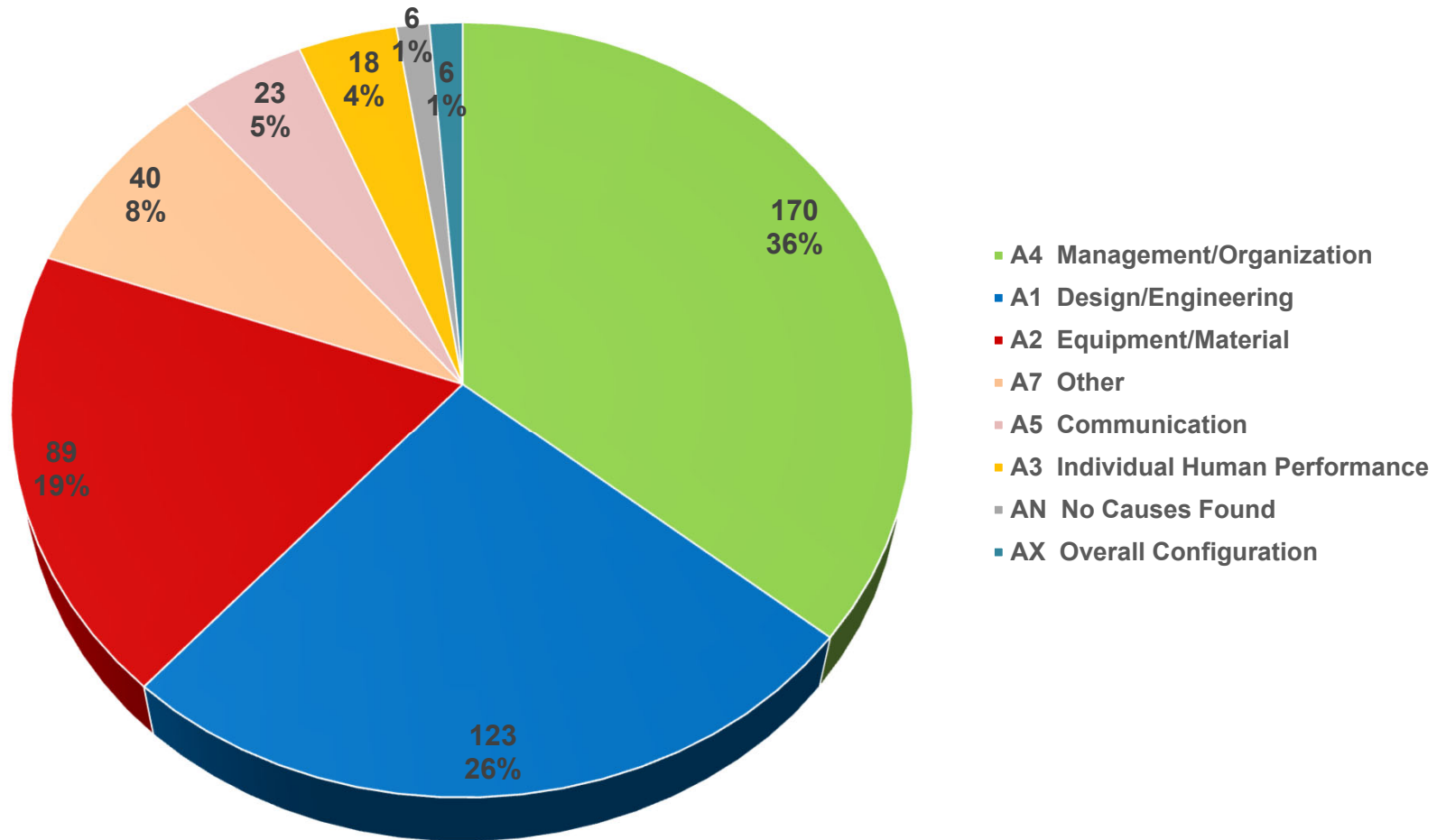
Data Selection
Select from the list the most correct description of the source of the problem

- **EMS Alert Advisory Analysis-** During the Event Analysis (EA) field trial, 28 Category 2b events have occurred where a complete loss of SCADA/EMS lasted for more than 30 minutes. Analysis is currently being conducted to provide emerging trends for the industry
- Current analysis of these events has shown:
 - **Software failure** is a major contributing factor in 50 percent of the events
 - **Testing of the equipment** has been shown to be a factor in over 40 percent of the failures:
 - Test environment did not match the production environment
 - Product design (less than adequate)
 - **Change Management** has had an impact in over 50 percent of the failures:
 - Risk and consequences associated with change not properly managed
 - Identified changes not implemented in a timely manner
 - **Individual operator skill-based error** was involved in 15 percent of the events...



The PII Performance Pyramid™

A-Level Root Causes (1000 events cause coded; removing AZ) As of 7/1/2017



Five phases:

I. Data Collection

II. Assessment

III. Corrective Actions

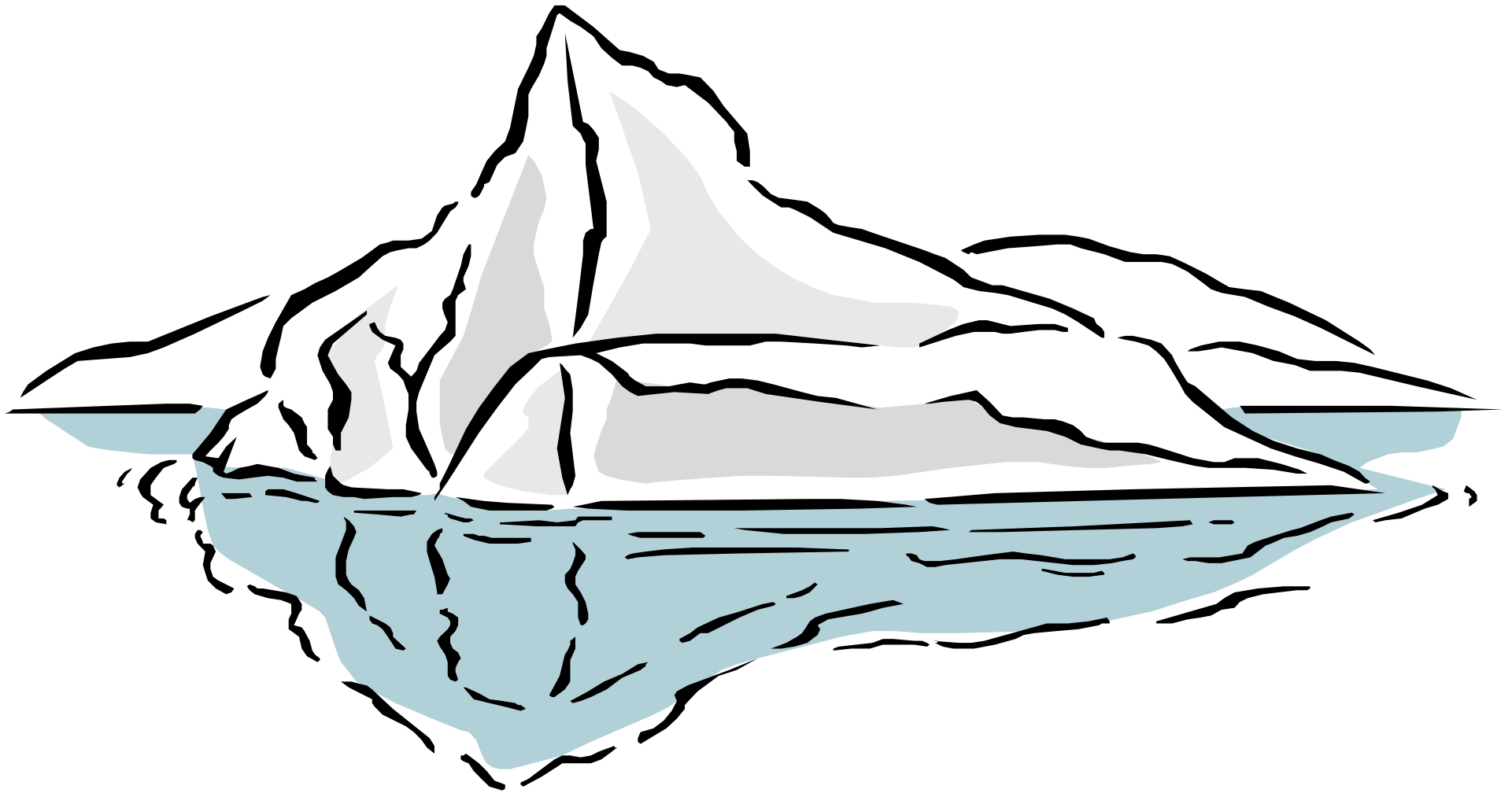
IV. Inform

V. Follow-up

Ref: DOE-NE-STD-1004-92

- Implementing effective corrective actions (solutions) for each cause reduces the probability that a problem will recur and improves reliability and safety.
- Evaluate the potential of “Extent of Cause” situations
- Evaluate the need for an “Extent of Condition (EOC) Evaluations”

- Remember: it is not the cause we are searching for, it is a SOLUTION.
- Characteristics of a solution
 - Prevent recurrence
 - Within your control
 - Consistent with your goals and objectives
 - Does not create other problems (that you are aware of)



a.k.a. How big is this problem?

An iceberg floating in the ocean. The tip of the iceberg is above the water line and is labeled 'Accident'. The much larger, submerged part of the iceberg is labeled with several safety-related terms: 'Near Misses', 'Error Catches', 'Safety Check', 'Lucky', 'Misstep', and 'Peer Check'. The water is a deep blue, and the sky is a lighter blue with some clouds.

Accident

Near Misses

Error Catches

Safety Check

Lucky

Misstep

Peer Check

Transportability of condition:

Determines whether the same problem / condition exists elsewhere.

Determines the extent to which the condition may exist in other system equipment, organizations, processes or human performance.

Transportability of cause:

Determines whether the same root or underlying causes of the problem/condition may be affecting performance elsewhere (other equipment, processes, or human performance).

To identify *ALL* effects from the condition.

To identify possible event initiators and correct them to preclude additional events.

Corrective Actions (cont'd)

EFFECTIVENESS RANKING	ACTION TYPE	CHARACTERISTIC	EXAMPLES	
<p>Most Effective</p> <p>↑</p> <p>Least Effective</p>	1	Preventive Design Changes	Automatically prevents the undesirable situation with no human action required	<ul style="list-style-type: none"> - auto-start circuitry on low system pressure - permanent handrails around fall hazard
	2	Mitigating Devices	Automatically limits the adverse effects of the undesirable situation with no human action required	<ul style="list-style-type: none"> - Fire sprinkler systems - automatic shutoffs/trip circuitry
	3	Warning Devices	No human action is required to activate, but success is dependent upon human action to recognize and understand the warning and respond properly	<ul style="list-style-type: none"> - radiological boundaries and postings - low level alarms
	4	Administrative Controls	Long-term in nature; provides a consistent and reproducible result if utilized, but human action is required to implement, and respond properly	<ul style="list-style-type: none"> - new/revised procedures - new/revised preventive maintenance tasks - formal training and qualification requirements
	5	Active Stop-Gap Measures	Limited, short-term actions involving direct face-to-face communication; human action is required to remember, implement, and respond appropriately	<ul style="list-style-type: none"> - counseling - lessons learned training session
	6	Passive Stop-Gap Measures	Limited, short-term actions involving written communication; human action is required to locate the source document, remember, implement, and respond appropriately	<ul style="list-style-type: none"> - required reading - training bulletins

- **Extent of Condition (EOC) Evaluations**
 - **Actual or potential applicability for an event or condition to exist elsewhere**
 - **Performed for “significant issues” (as defined by entities Corrective Action Program)**
 - **Seriousness**
 - **Importance**
 - **Considerations**
 - **Causal Factors**
 - **Uniqueness**
 - **Recurrence**
 - **Consequences (potential or actual)**

Five phases:

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

Ref: DOE-NE-STD-1004-92

- Discussing and explaining the results of the analysis, including corrective actions, with management and personnel involved in the occurrence (properly written Event Analysis Report (***EAR***) and Brief Reports).
- In addition, consideration should be given to providing information of interest to other facilities (***Lessons Learned***).
- Report the occurrence via applicable communication channels.

Note: Some events may require initial notification prior to this phase

Ref: DOE-NE-STD-1004-92



Each step depends on (and reflects) the Quality of the previous step

** The term “investigation” as used here does not reflect or imply any “compliance determination”*

Five phases:

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

V. Follow-up

Ref: DOE-NE-STD-1004-92

- Follow-up includes determining if corrective actions are effective in resolving the issue.

An effective follow-up process is essential to ensure that corrective actions have been implemented as intended, and that the issue does not recur.
























- No “unintended consequences”

Ref: DOE-NE-STD-1004-92



- Found at: <http://www.nerc.com/pa/rrm/ea/Pages/Cause-Analysis-Training-Reference-Materials.aspx>

-  Barrier Analysis Form (Blank)
-  Cause Analysis Methods for NERC, Regional Entities, and Registered Entities_09202011_rev1
-  CCAP_Manual_January_2017
-  Change Analysis Form (blank)
-  Department of Defense Human Factors Analysis and Classification System
-  DOE - Vol 1 Human Performance Handbook
-  DOE - Vol 2 Tools for Individuals Work Teams and Management
-  DOE causal codes g2311-2 2003
-  DOE Occurrence Reporting and Performance Analysis Guide g2311-1[1]
-  DOE Occurrence Reporting m2311-2[1]
-  DOE_5000.3B
-  DOEGuidelinesforRootCause
-  E&CF Charting
-  eBook_4_Simple_Steps_to_a_5-Star_Cause_and_Effect_Chart_V5
-  Fault Tree Handbook (downloaded copy)
-  hazard and barrier analysis guide
-  MORT Bill Johnson for AEC 1973 SAN8212
-  MORT_Chart
-  MORT_Users_Manual (2nd Edition)
-  Selecting the Cause Code (3-17-2017)
-  Visio-Cause Coding - How to start (Rev 12 1-31-2017)-11 x 17 page format

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Questions ??? and Answers !!!

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