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Improving Human Performance: Building a Culture of High Reliability

James Merlo, PhD, Associate Director of Human Performance

March 26, 2013

RELIABILITY | ACCOUNTABILITY

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Which Direction?

RRM Direction

- **Reliability – addressing real problems to improve the reliability of the grid.**
- **Assurance – being accountable to customers, the industry and government for the performance of the grid.**
- **Learning – enabling the industry to learn from experience to improve future reliability performance.**
- **Risk-based model – focusing actions and programs on issues most important to grid reliability.**

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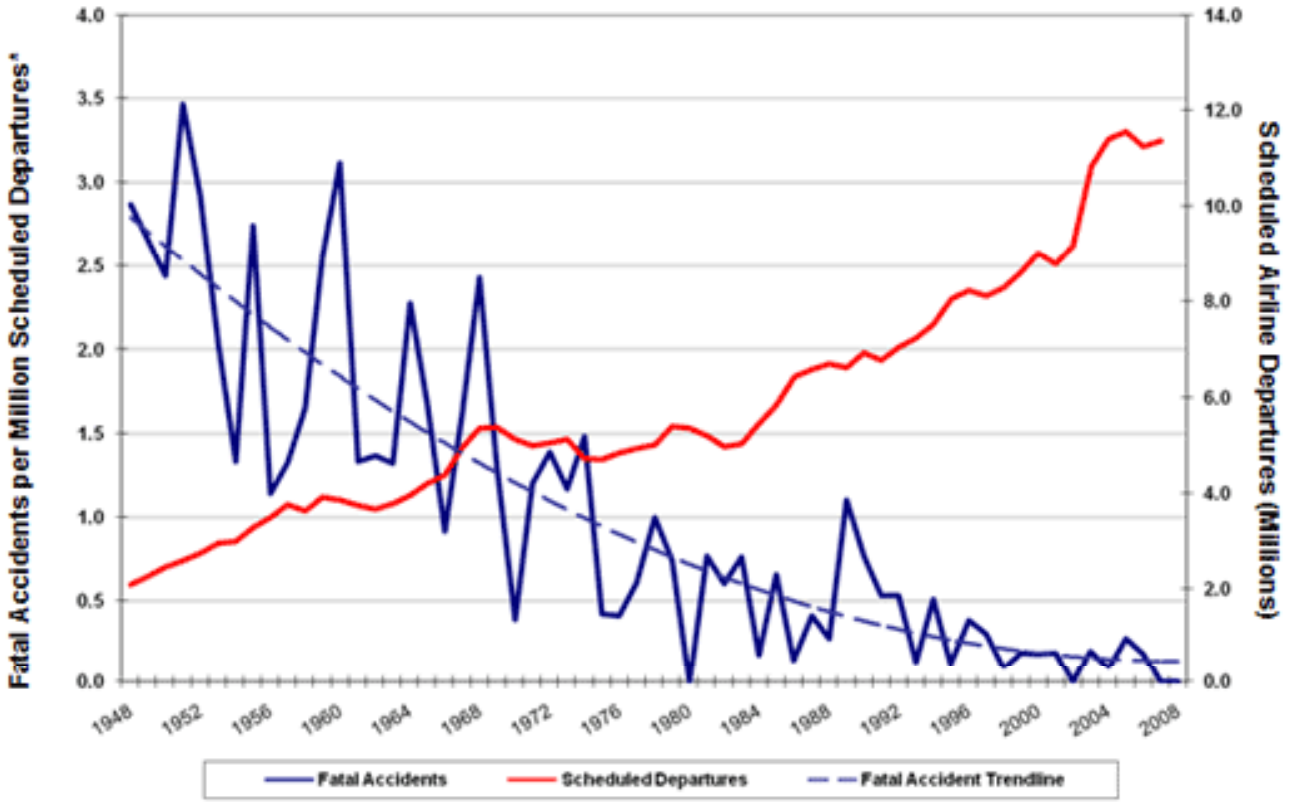
Challenge

With Each Decade, U.S. Airline Safety Has Improved



* Scheduled passenger and cargo operations of U.S. air carriers operating under 14 CFR 121; NTSB accident rates exclude incidents resulting from illegal acts

Source: National Transportation Safety Board (NTSB)

Too Hard?

"Complicated Industry"
"Come along way"
"Can't get to zero"
"Automate, technology reduces the need for human operator"

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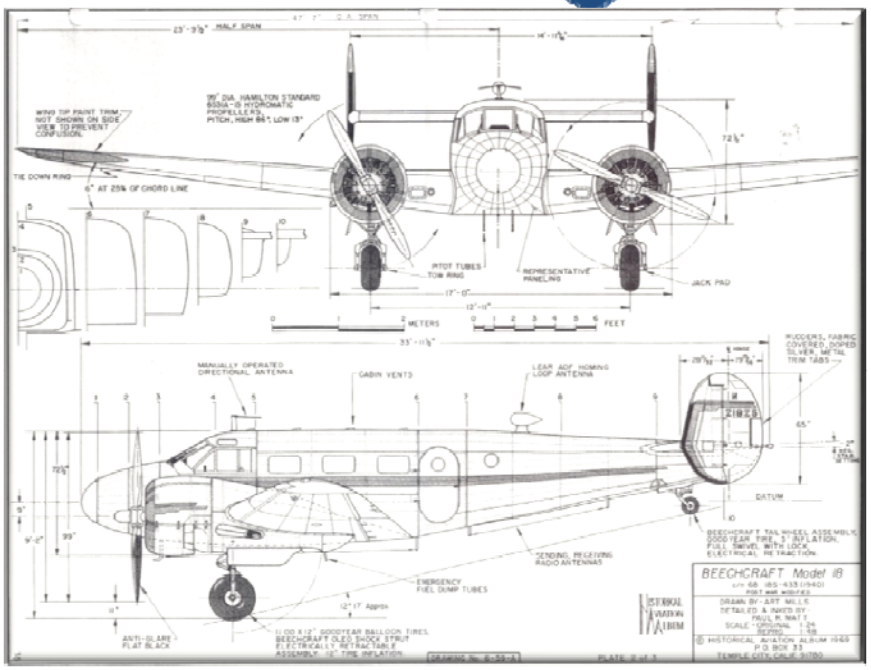

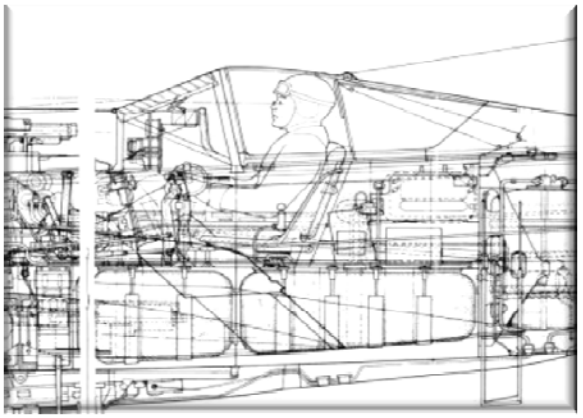

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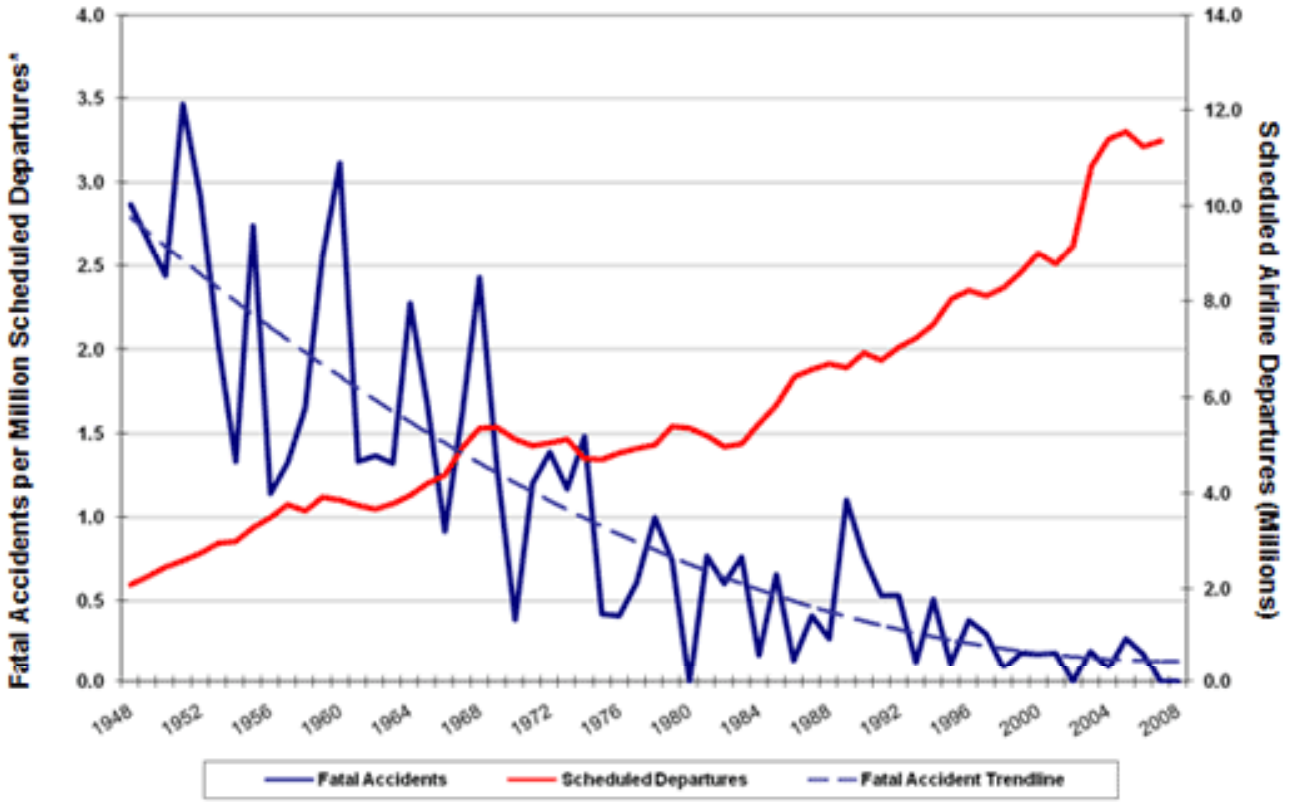

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Five Questions

- Know thy user
- Elegant simplicity
- Actions not words
- The rat is never wrong
- You can’t afford not to know the truth

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Know thy user

- Know thy user
  - Context Matters
  - Human Ingenuity
  - Only two hands, two eyes, see the pattern?
  - If you only have a minute, it only takes a minute…
  - Set me up for success…please…
  - Human nature


2300
7A


2300
7B
2300
7C
2300
7A

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PG&E


DANGER

Signs

Darnell, M. J. (2006). Bad Human Factors Designs. Baddesigns.Com

Human Performance Tenets

- People are fallible, and all 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 near misses

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Sometimes it is a Human

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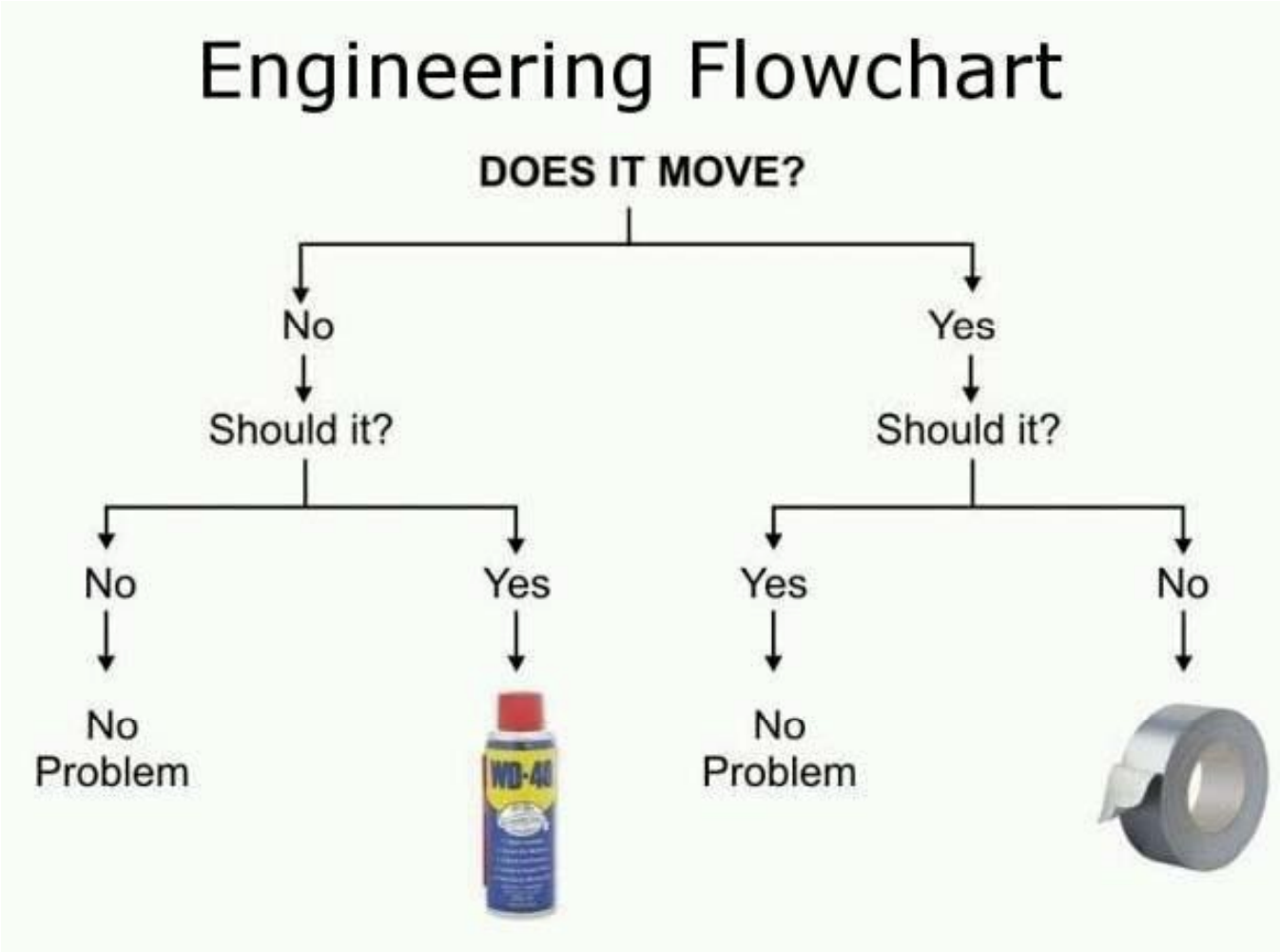
Elegant simplicity

- Elegant simplicity
  - Russians and the US Space Program
  - How many tools in the box?
  - The tool shouldn't be harder than the task.
  - Surround the truth…it is out there somewhere…

Flowchart for Human Performance



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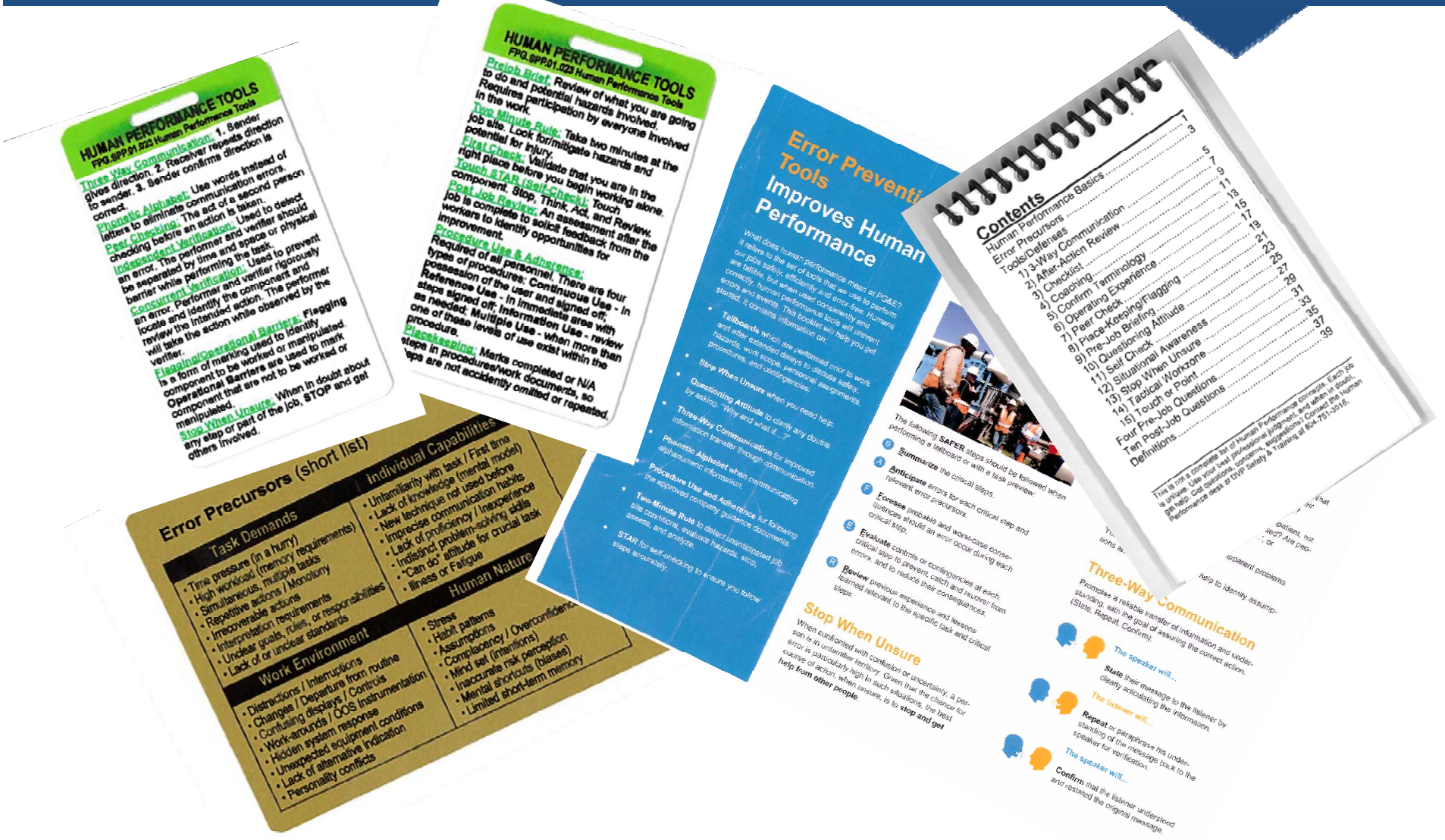
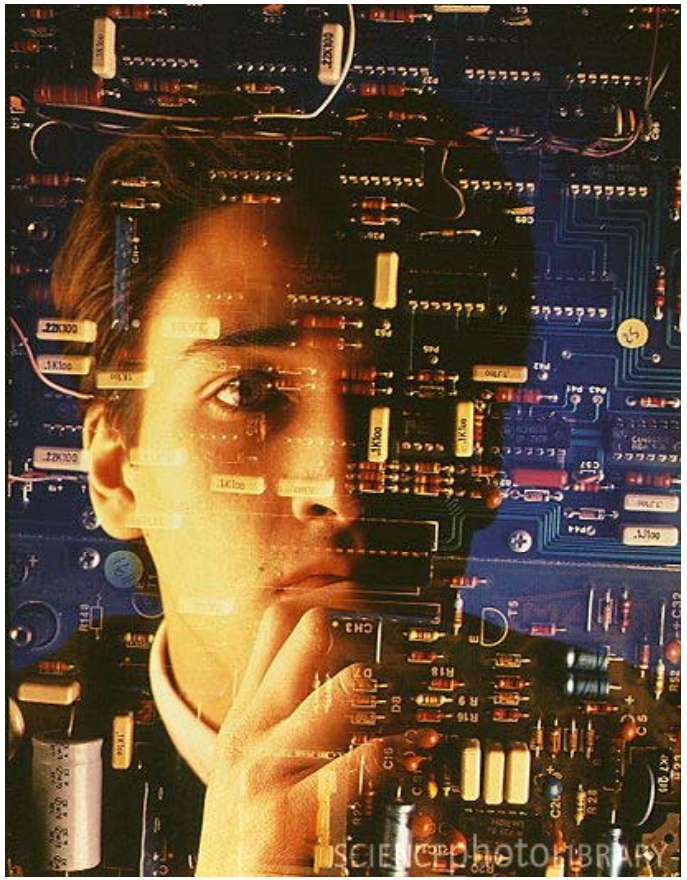
Human Performance Tools



Human Performance Tools

- Two Minute rule
- Stop when unsure
- Self checking (also called STAR and touch STAR)
- Procedure use and adherence
- Three way communication
- Phonetic alphabet
- Pre-job brief
- Peer check
- Concurrent verification
- Independent verification
- Flagging operational barriers
- Place keeping
- Post job interview
- First Check



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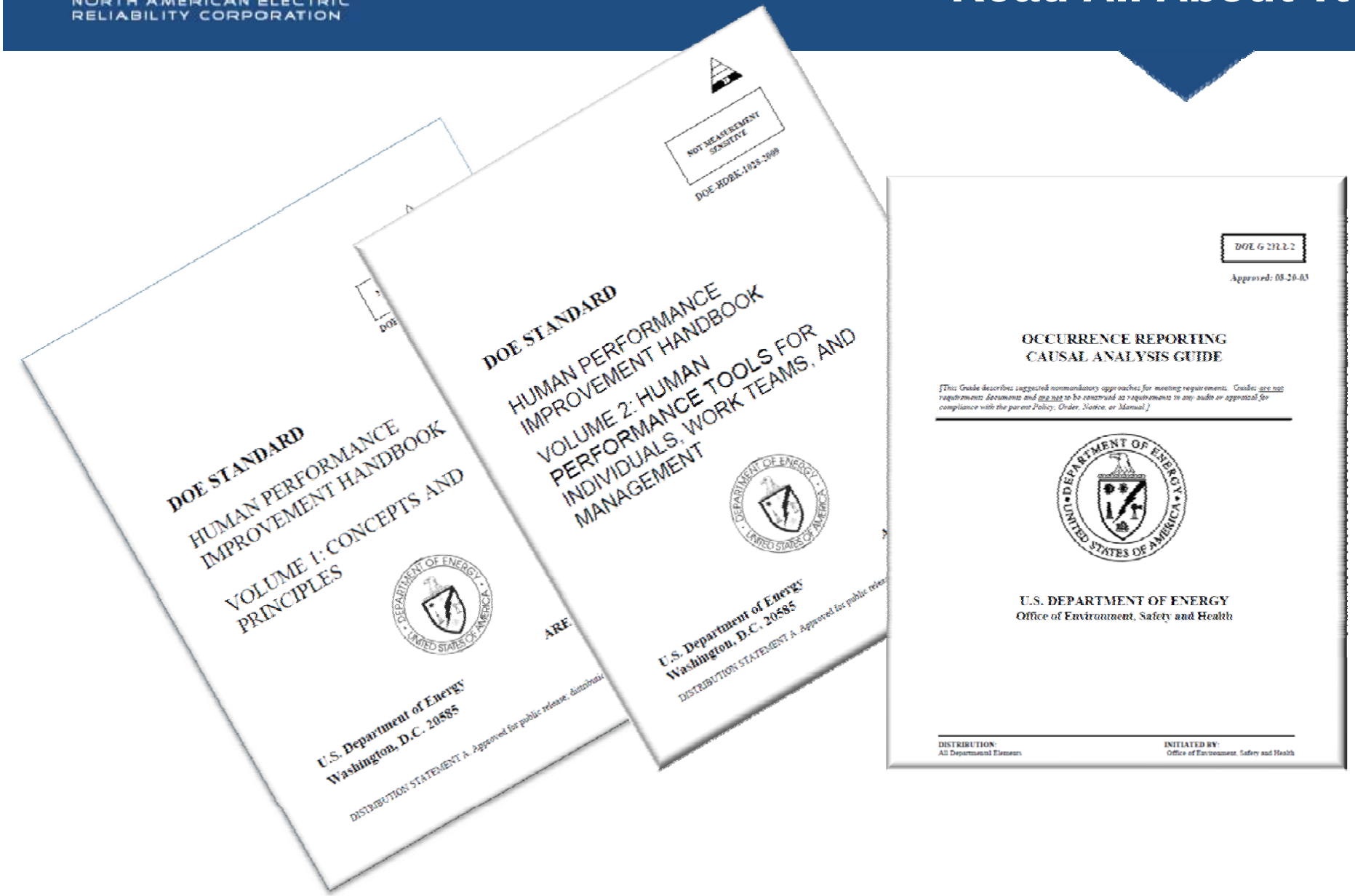
Read All About It



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Actions not words

- Actions not words
  - It is not important unless it is checked.
  - What is your story?
  - Are you telling your story up or down?

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Tell your story…

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Five Questions

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The rat is never wrong

- The rat is never wrong
  - Behaviorism
  - Not enforcing a policy is like not having a policy at all
  - Don’t have a rule that you aren’t going to enforce

The rat is never wrong

Human behavior is shaped by interaction in the world…

- Punishment stops behavior
- Reinforcement shapes and sustains behavior

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Silence is Consent

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truth

- You can't afford not to know the truth
  - Root cause
  - Just Culture
  - Near misses

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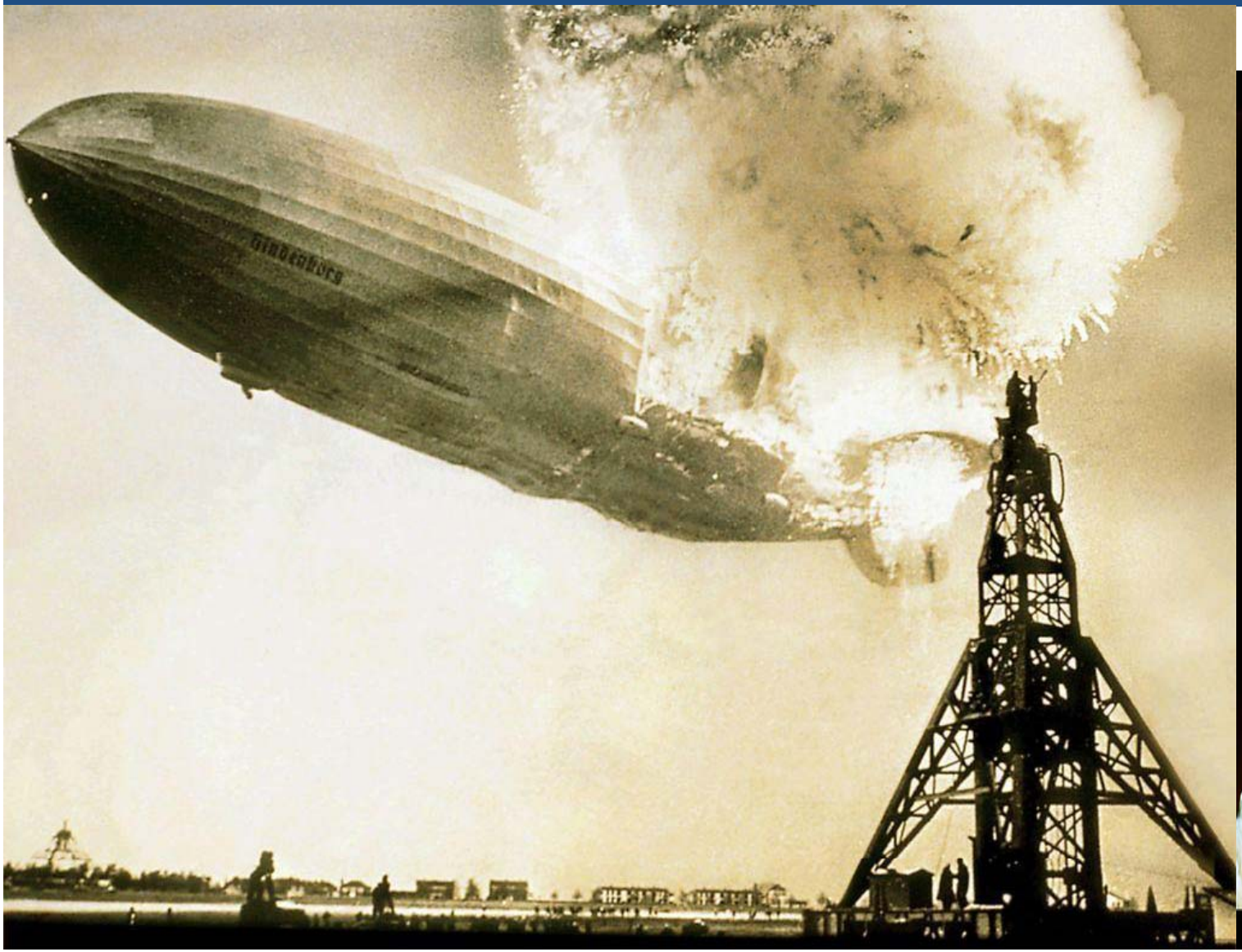
Stuff Happens



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A Tale of Two Cylinders

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Or…When Good Pistons go Bad!

Why Root Cause Versus Apparent Cause?

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

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The rest of the story…

- Mechanic noticed some scalding on other pistons
- No history of ever over heating…
- Jeep was hit on right side, at 70k miles….
- Right fender was replaced, radiator and fan blade..no damage to engine block
- New Fan blade was installed backwards!!!!
- Jeep was running hotter than it should…just slightly…not enough to notice…and there was a new owner so there was no baseline…

Can Your Organization Handle the Truth?

"Before you tell the "truth" to the patient, be sure you know the "truth," and that the patient wants to hear it."

Journal of Chronic Diseases (1963)

Dr. Richard Clarke Cabot

(1868-1939)

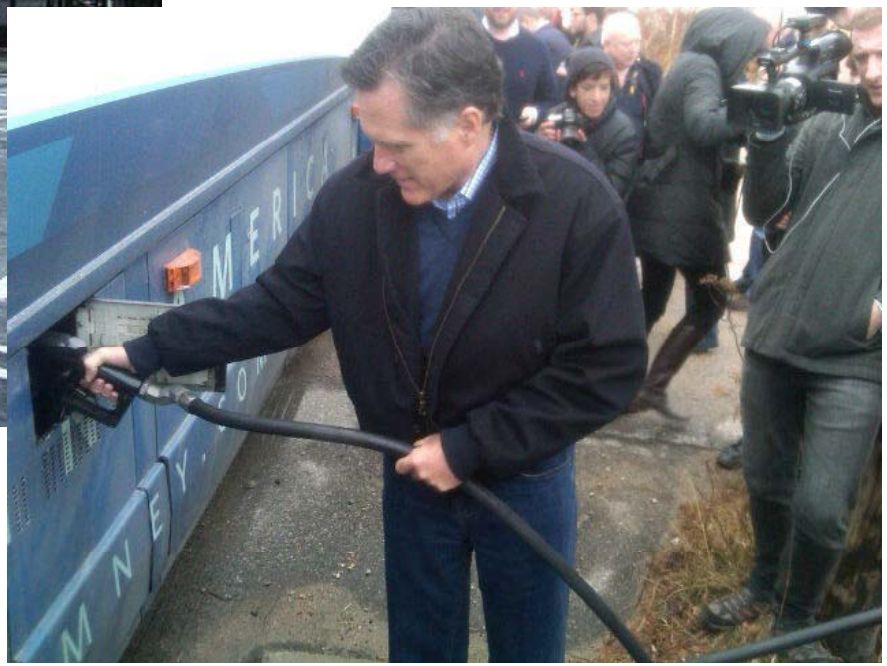
Human Performance Analysis

- We have not fully understood an event if we don't see the actors' actions as reasonable.

- The point of a human error investigation is to understand why people did what they did, not to judge them for what they did not do.

- The difference between an accident and a serious incident lies only in the result.

Can Your Organization Handle the Truth?



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  - Root Cause

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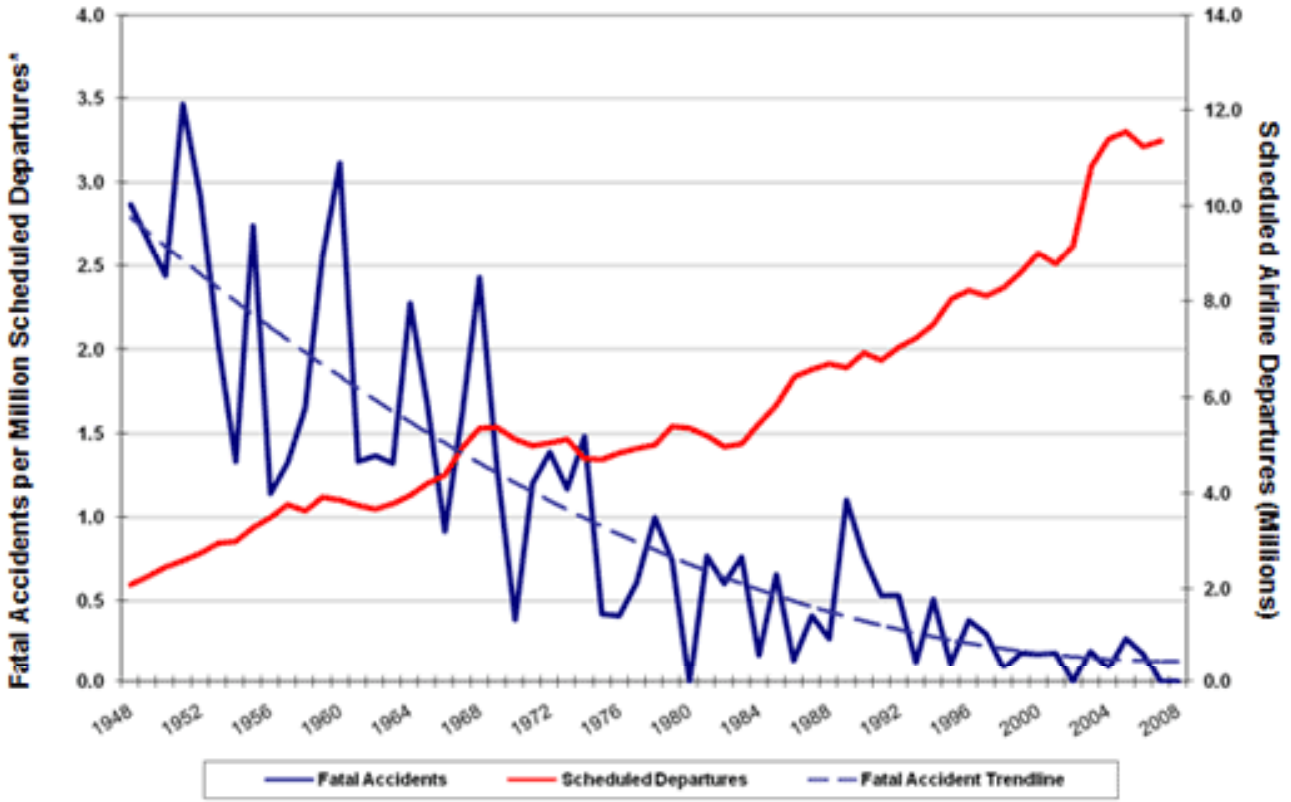

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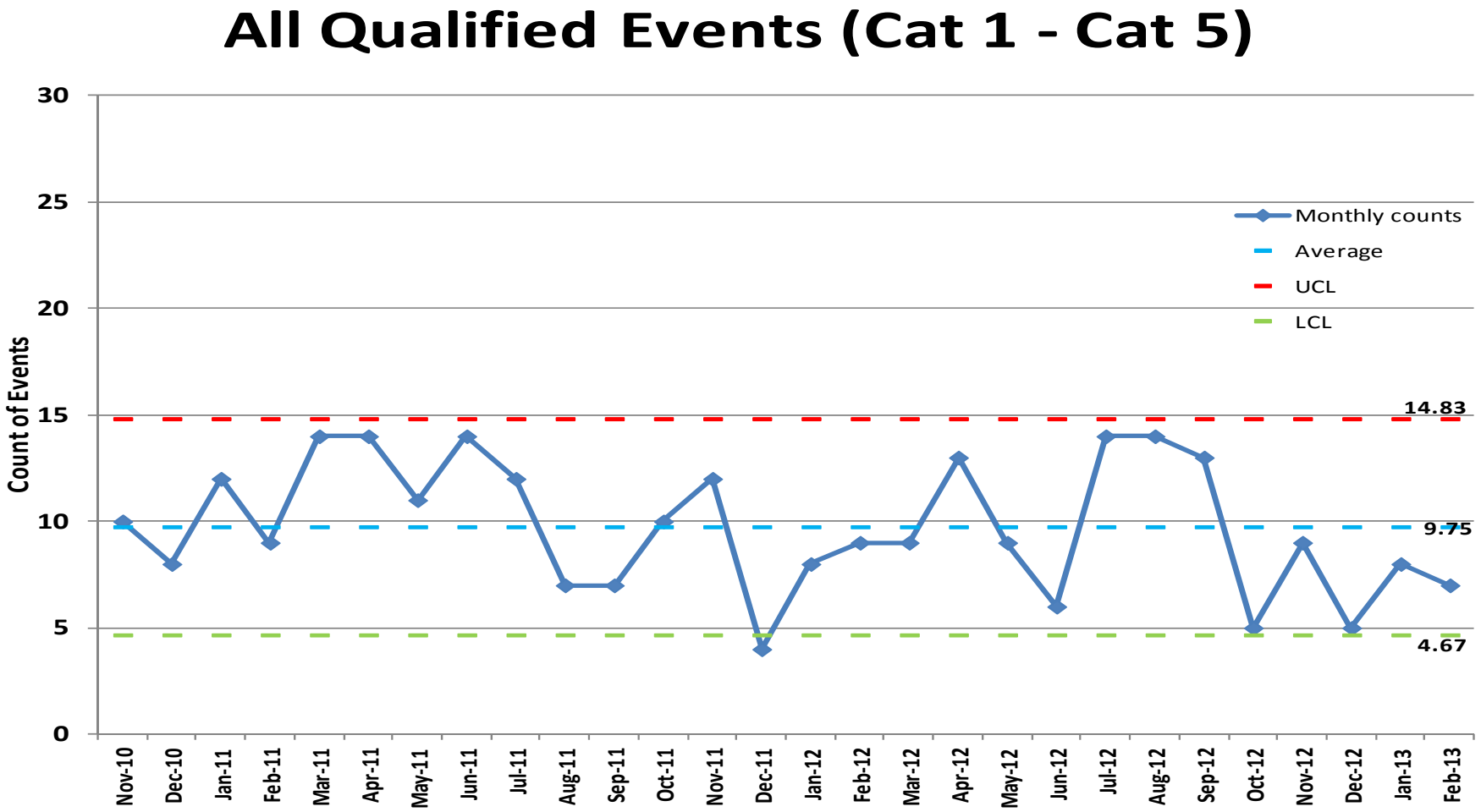
Event Counts

Event Category	Summary Definition	Count (Total)
CAT 1	3 or more generators (500 -1,999 MW); Failure or misoperation of BPS SPS/RAS; Unintended BPS system separation that results in an island of 100 to 999 MW	178
CAT 2	Complete loss of SCADA, control or monitoring for ≥ 30 minutes; LOOP; Unintended loss of 300 MW or more of firm load for ≥ 15 minutes	96
CAT 3	loss of load or generation of ≥ 2,000 MW or ≥ 1,400 MW or more in the ERCOT Interconnection. Unintended system separation that results in an island of 5,000 to 10,000 MW	9
CAT 4	loss of load or generation from 5,001 to 9,999 MW	3
CAT 5	loss of load or generation of ≥ 10,000 MW	1
Total Events		**288**
Other occurrences reported	**Not meeting the above mentioned EA categories.**	**1544 +**

Control Chart of Qualified Events



NERC CCAP

North American Electric Reliability Corporation Causal Code Assignment Process

An event and data analysis tool

The Reliability Risk Management Group (RRM) has designed, developed, and implemented the North American Energy Reliability Corporation (NERC) Causal Code Assignment Process to allow accurate, efficient trending and subsequent analysis of events for sharing and providing a cooperative forum focused on improving the reliability of the Bulk Power System (BPS).

Cause Code Assignment Process (CCAP)

- A1 - Design/Engineering (23 sub codes)
- A2 - Equipment/Material (27 sub codes)
- A3 - Individual Human Performance (20 sub codes)
- A4 – Management / Organization (46 sub codes)
- A5 - Communication (25 sub codes)
- A6 - Training (11 sub codes)
- A7 - Other (8 sub codes)
- AZ - Information to determine cause LTA

A3 - Human Performance

- A1 Design/Engineering
- A2 Equipment/Material
- A3 Individual Human Performance
  - B1 SKILL BASED ERROR
  - B2 RULE BASED ERROR
  - B3 KNOWLEDGE BASED ERROR
  - B4 WORK PRACTICES
- A4 Management / Organization
- A5 Communication
- A6 Training
- A7 Other

A3 - Human Performance

- A3 Individual Human Performance
  - B1 SKILL BASED ERROR
    - C01 Check of work LTA
    - C02 Step was omitted due to distraction
    - C03 Incorrect performance due to mental lapse
    - C04 Infrequently performed steps were performed incorrectly
    - C05 Delay in time caused LTA actions
    - C06 Wrong action selected based on similarity with other actions
    - C07 Omission / repeating of steps due to assumptions for completion
  - B2 RULE BASED ERROR
  - B3 KNOWLEDGE BASED ERROR
  - B4 WORK PRACTICES

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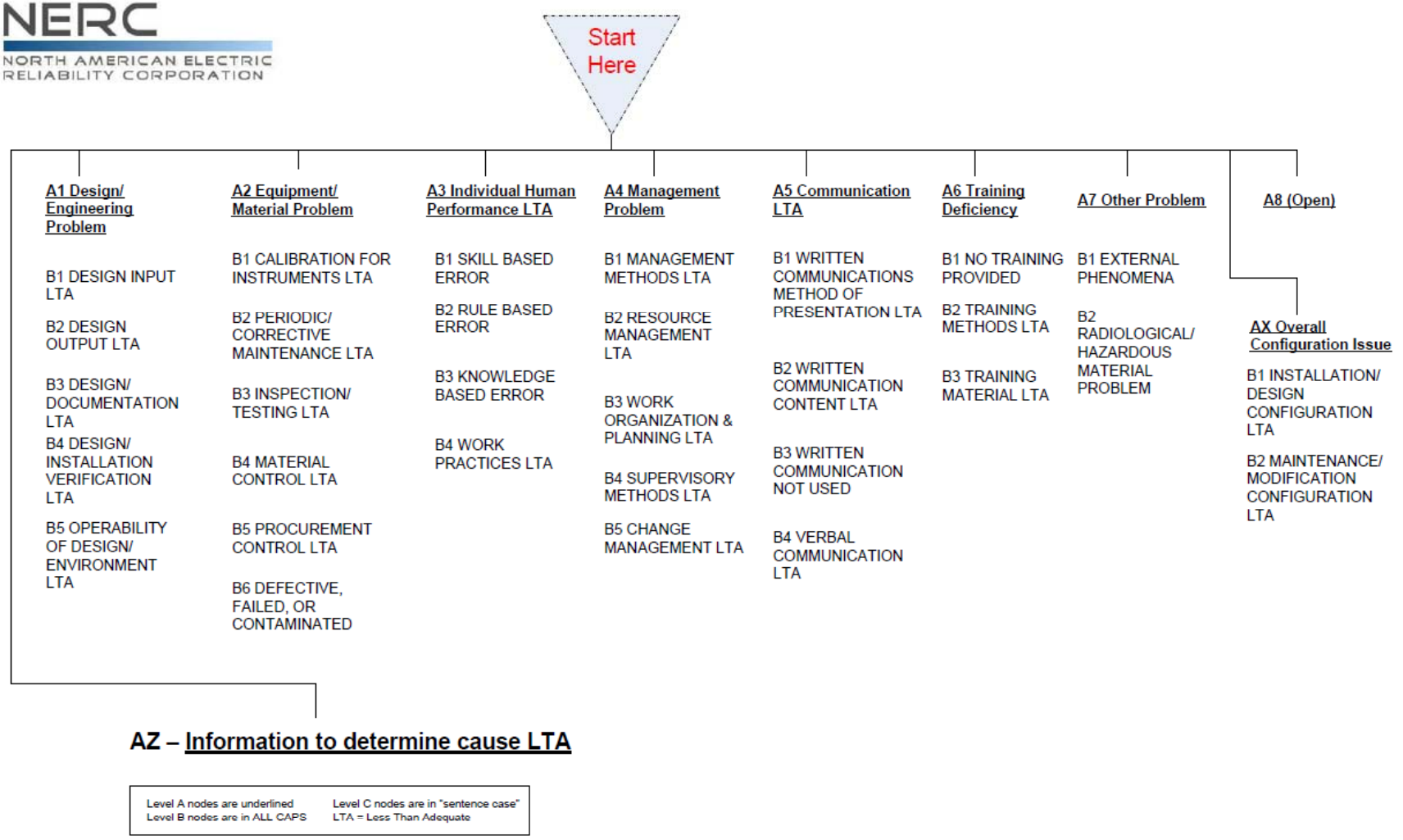

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Start Here

NERC CCAP
Cause Code Quick Reference

nerc.lessonslearned@nerc.net www.nerc.com

A1 Design/Engineering

B1 DESIGN INPUT LTA
- C01 Design input cannot be met
- C02 Design input obsolete
- C03 Design input not correct
- C04 Necessary design input not available

B2 DESIGN OUTPUT LTA
- C01 Design output scope LTA
- C02 Design output not clear
- C03 Design output not correct
- C04 Inconsistent design output
- C05 Design input not addressed in design output
- C06 Drawing, specification, or data error
- C07 Error in equipment or material selection
- C08 Errors not detectable
- C09 Errors not recoverable

B3 DESIGN/DOCUMENTATION LTA
- C01 Design / documentation not complete
- C02 Design /documentation not up-to-date
- C03 Design/documentation not controlled

B4 DESIGN/INSTALLATION VERIFICATION LTA
- C01 Independent review of design / documentation LTA
- C02 Testing of design / installation LTA
- C03 Independent inspection of design / installation LTA
- C04 Acceptance of design / installation LTA

B5 OPERABILITY OF DESIGN/ ENVIRONMENT LTA
- C01 Ergonomics LTA
- C02 Physical environment LTA
- C03 Natural environment LTA

AN – No causes found

AZ – Information to determine cause LTA

B1 UNABLE TO IDENTIFY SPECIFIC ROOT CAUSE

B2 REPORT STOPS AT FAILURE/ERROR MODE
- C01 Apparent Cause Analysis only
- C02 No causal sequence established or identified
- C03 Attributed to weather beyond initiating cause

B3 OTHER PARTIES INVOLVED IN EVENT
- C01 Other entity cited as involved in event
- C02 Vendor or contractor cited as involved in event

B4 CROSS-REFERENCE REQUIRED FOR OTHER SOURCES OF INFORMATION
- C01 Requires secondary review once appropriate reports are received
- C02 Requires secondary review once additional outside investigative report is received

A2 Equipment/Material

B1 CALIBRATION FOR INSTRUMENTS LTA
- C01 Calibration LTA
- C02 Equipment found outside acceptance criteria

B2 PERIODIC/ CORRECTIVE MAINTENANCE LTA
- C01 Preventive maintenance for equipment LTA
- C02 Predictive maintenance LTA
- C03 Corrective maintenance LTA
- C04 Equipment history LTA

B3 INSPECTION/ TESTING LTA
- C01 Start-up testing LTA
- C02 Inspection / testing LTA
- C03 Post-maintenance / Post-modification testing LTA

B4 MATERIAL CONTROL LTA
- C01 Material handling LTA
- C02 Material storage LTA
- C03 Material packaging LTA
- C04 Material shipping LTA
- C05 Shelf life exceeded
- C06 Unauthorized material substitution
- C07 Marking / labeling LTA

B5 PROCUREMENT CONTROL LTA
- C01 Control of changes to procurement specifications / purchase order LTA
- C02 Fabricated item did not meet requirements
- C03 Incorrect item received
- C04 Product acceptance requirements LTA

B6 DEFECTIVE, FAILED, OR CONTAMINATED
- C01 Defective or failed part
- C02 Defective or failed material
- C03 Defective weld, braze, solder joint, crimp, hinge, or other connection
- C04 End-of-life failure
- C05 Electrical or instrument noise
- C06 Contaminant
- C07 Software failure

B7 EQUIPMENT INTERACTIONS LTA
- C01 Physical communications path LTA
- C02 Data quality LTA
- C03 Supporting power system LTA
- C04 Undesirable operation of Coordinated Systems

A3 Individual Human Performance

B1 SKILL BASED ERROR
- C01 Check of work LTA
- C02 Step was omitted due to distraction
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- C04 Infrequently performed steps were performed incorrectly
- C05 Delay in time caused LTA actions
- C06 Wrong action selected based on similarity with other actions
- C07 Omission / repeating of steps due to assumptions for completion

B2 RULE BASED ERROR
- C01 Strong rule incorrectly chosen over other rules
- C02 Signs to stop were ignored and steps performed incorrectly
- C03 Too much activity was occurring and error made in problem solving
- C04 Previous success in use of rule reinforced continued use of rule
- C05 Situation incorrectly identified or represented resulting in wrong rule used

B3 KNOWLEDGE BASED ERROR
- C01 Attention was given to wrong issues
- C02 LTA conclusion based on sequencing or facts
- C03 Individual justified action by focusing on biased evidence
- C04 LTA review based on assumption that process will not change
- C05 Incorrect assumption that a correlation existed between two or more facts
- C06 Individual underestimated the problem by using past events as basis

B4 WORK PRACTICES LTA
- C01 Individual's capability to perform work LTA [Examples include: Sensory /perceptual capabilities LTA; Motor / physical capabilities LTA; and Attitude / psychological profile LTA]
- C02 Deliberate violation

A4 Management / Organization

B1 MANAGEMENT METHODS LTA
- C01 Management policy guidance / expectations are not well-defined, understood, or enforced
- C02 Job performance standards not adequately defined
- C03 Management direction created insufficient awareness of impact of actions on safety / reliability
- C04 Management follow-up or monitoring of activities did not identify problems
- C05 Management assessment did not determine causes of previous event or known problem
- C06 Previous industry or in-house experience was not effectively used to prevent recurrence
- C07 Responsibility of personnel not well-defined or personnel not held accountable
- C08 Corrective action responses to a known or repetitive problem was untimely
- C09 Corrective action for previously identified problem or event was not adequate to prevent recurrence

B2 RESOURCE MANAGEMENT LTA
- C01 Too many administrative duties assigned to immediate supervisor
- C02 Insufficient supervisory resources to provide necessary supervision
- C03 Insufficient manpower to support identified goal/ objective
- C04 Resources not provided to assure adequate training was provided / maintained
- C05 Needed resource changes not approved / funded
- C06 Means not provided to assure procedures / documents / records were of adequate quality and up-to-date
- C07 Means not provided for assuring adequate availability of appropriate materials / tools
- C08 Means not provided for assuring adequate equipment quality, reliability, or operability
- C09 Personnel selection did not assure match of worker motivations/job descriptions
- C10 Means/method not provided for assuring adequate quality of contract services

B3 WORK ORGANIZATION & PLANNING LTA
- C01 Insufficient time for worker to prepare task
- C02 Insufficient time allotted for task
- C03 Dates not well-distributed among personnel
- C04 Too few workers assigned to task
- C05 Insufficient number of trained or experienced workers assigned to task
- C06 Planning not coordinated with inputs from Walk downs/Task analysis
- C07 Job scoping did not identify potential task interruptions &/or environmental stress
- C08 Job scoping did not identify special circumstances &/or conditions
- C09 Work planning not coordinated with all departments involved in task
- C10 Problem performing repetitive tasks &/or sub-tasks
- C11 Inadequate work package preparation

B4 SUPERVISORY METHODS LTA
- C01 Tasks and individual accountability not made clear to worker
- C02 Progress / status of task not adequately tracked
- C03 Appropriate level of in-task supervision not determined prior to task
- C04 Direct supervisory involvement in task interfered with overview role
- C05 Emphasis on schedule exceeded emphasis on methods / doing a good job
- C06 Job performance and self-checking standards not properly communicated
- C07 Too many concurrent tasks assigned to worker
- C08 Frequent job or task "shuffling"
- C09 Assignment did not consider worker's need to use higher-order skills
- C10 Assignment did not consider worker's previous task
- C11 Assignment did not consider worker's ingrained work patterns
- C12 Contact with personnel too infrequent to detect work habit / attitude changes
- C13 Provided feedback on negative performance but not on positive performance

B5 CHANGE MANAGEMENT LTA
- C01 Problem identification did not identify need for change
- C02 Change not implemented in timely manner
- C03 Inadequate vendor support of change
- C04 Risks / consequences associated with change not adequately reviewed / assessed
- C05 System interactions not considered
- C06 Personnel / department interactions not considered
- C07 Effects of change on schedules not adequately addressed
- C08 Change-related training / retraining not performed or not adequate
- C09 Change-related documents not developed or revised
- C10 Change-related equipment not provided or not revised
- C11 Changes not adequately communicated
- C12 Change not identifiable during task
- C13 Accuracy / effectiveness of change not verified or not validated

A5 Communication

B1 WRITTEN COMMUNICATIONS METHOD OF PRESENTATION LTA
- C01 Format deficiencies
- C02 Improper referencing or branching
- C03 Checklist LTA
- C04 Deficiencies in user aids (charts, etc.)
- C05 Recent changes not made apparent to user
- C06 Instruction step / information in wrong sequence
- C07 Unclear / complex wording or grammar

B2 WRITTEN COMMUNICATION CONTENT LTA
- C01 Limit inaccuracies
- C02 Difficult to implement
- C03 Data / computations wrong / incomplete
- C04 Equipment identification LTA
- C05 Ambiguous instructions / requirements
- C06 Typographical error
- C07 Facts wrong / requirements not current
- C08 Incomplete / situation not covered
- C09 Wrong revision used

B3 WRITTEN COMMUNICATION NOT USED
- C01 Lack of written communication
- C02 Not available or inconvenient for use

B4 VERBAL COMMUNICATION LTA
- C01 Communication between work groups LTA
- C02 Shift communications LTA
- C03 Correct terminology not used
- C04 Verification / repeat back not used
- C05 Information sent but not understood
- C06 Suspected problems not communicated to supervision
- C07 No communication method available

A6 Training

B1 NO TRAINING PROVIDED
- C01 Decision not to train
- C02 Training requirements not identified
- C03 Work incorrectly considered "skill of the craft"

B2 TRAINING METHODS LTA
- C01 Practice or hands-on experience LTA
- C02 Testing LTA
- C03 Refresher training LTA
- C04 Inadequate presentation

B3 TRAINING MATERIAL LTA
- C01 Training objectives LTA
- C02 Inadequate content
- C03 Training on new work methods LTA
- C04 Performance standards LTA

A7 Other

B1 EXTERNAL PHENOMENA
- C01 Weather or ambient conditions LTA
- C02 Power failure or transient
- C03 External fire or explosion
- C04 Other natural phenomena LTA
- C05 Copper Theft
- C06 Vandalism

B2 RADIOLOGICAL/HAZARDOUS MATERIAL PROBLEM
- C01 Legacy contamination
- C02 Source unknown

A8 (Open)

AX Overall Configuration

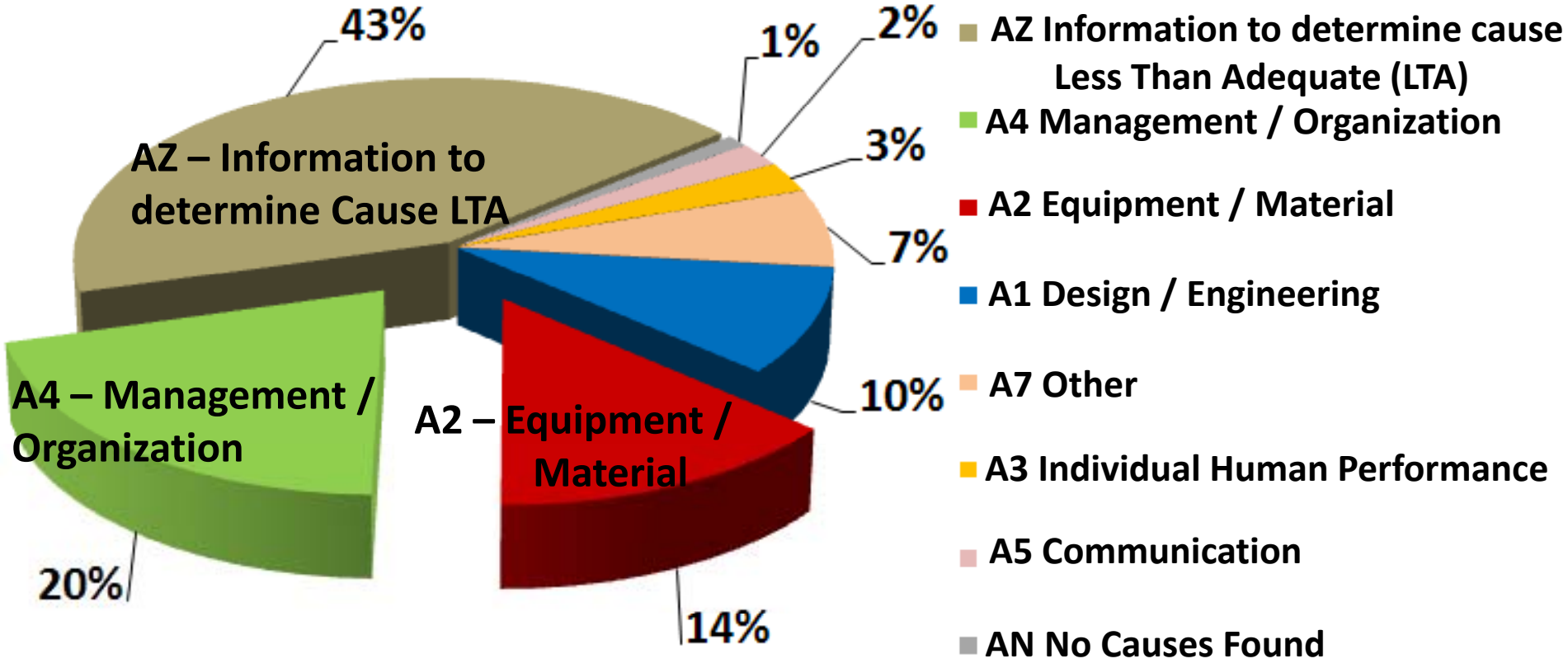
B1 INSTALLATION/DESIGN CONFIGURATION LTA

B2 MAINTENANCE/ MODIFICATION CONFIGURATION LTA

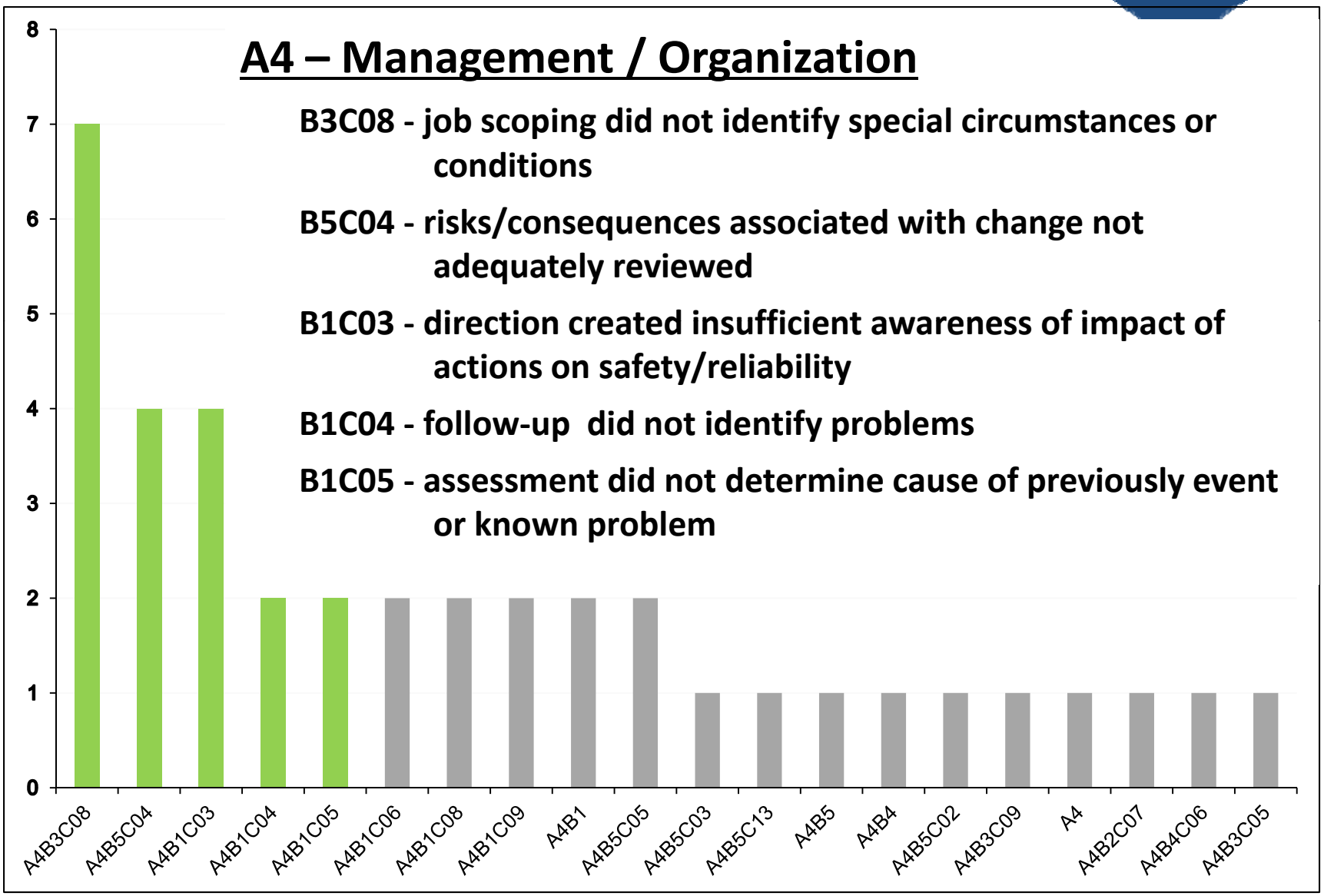
Level A nodes are underlined	Level C nodes are in "sentence case"
Level B nodes are in ALL CAPS	LTA = Less Than Adequate

Cause Coding - How to start (Rev 8 2-22-2013)-11 x 17 page format.vsd

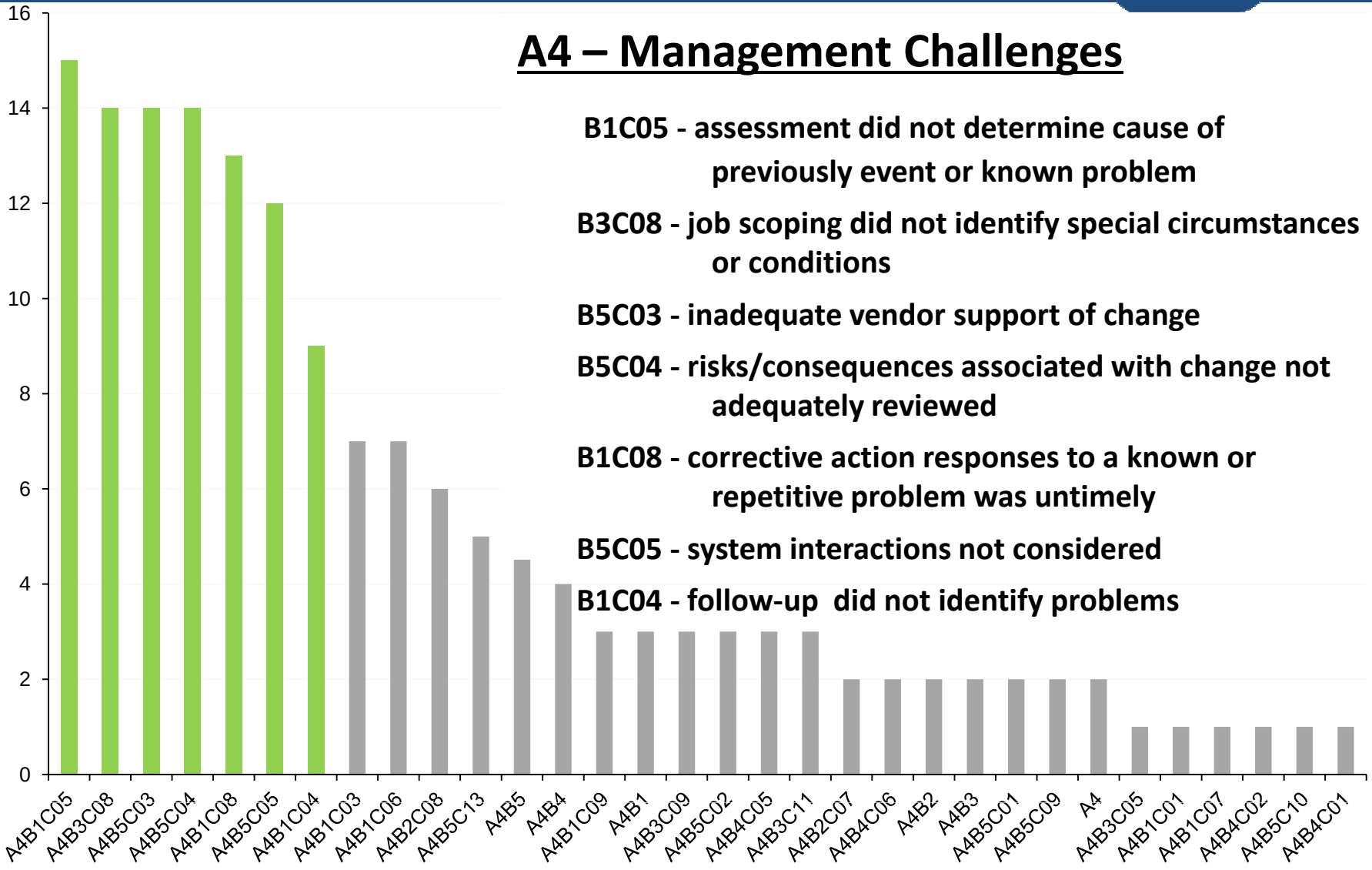
Root Cause Determinations



Deeper Dive into Management / Organization (Based on Root Cause)



All Causes for Management / Organization



A4 – Management Challenges

B1C05 - assessment did not determine cause of previously event or known problem

B3C08 - job scoping did not identify special circumstances or conditions

B5C03 - inadequate vendor support of change

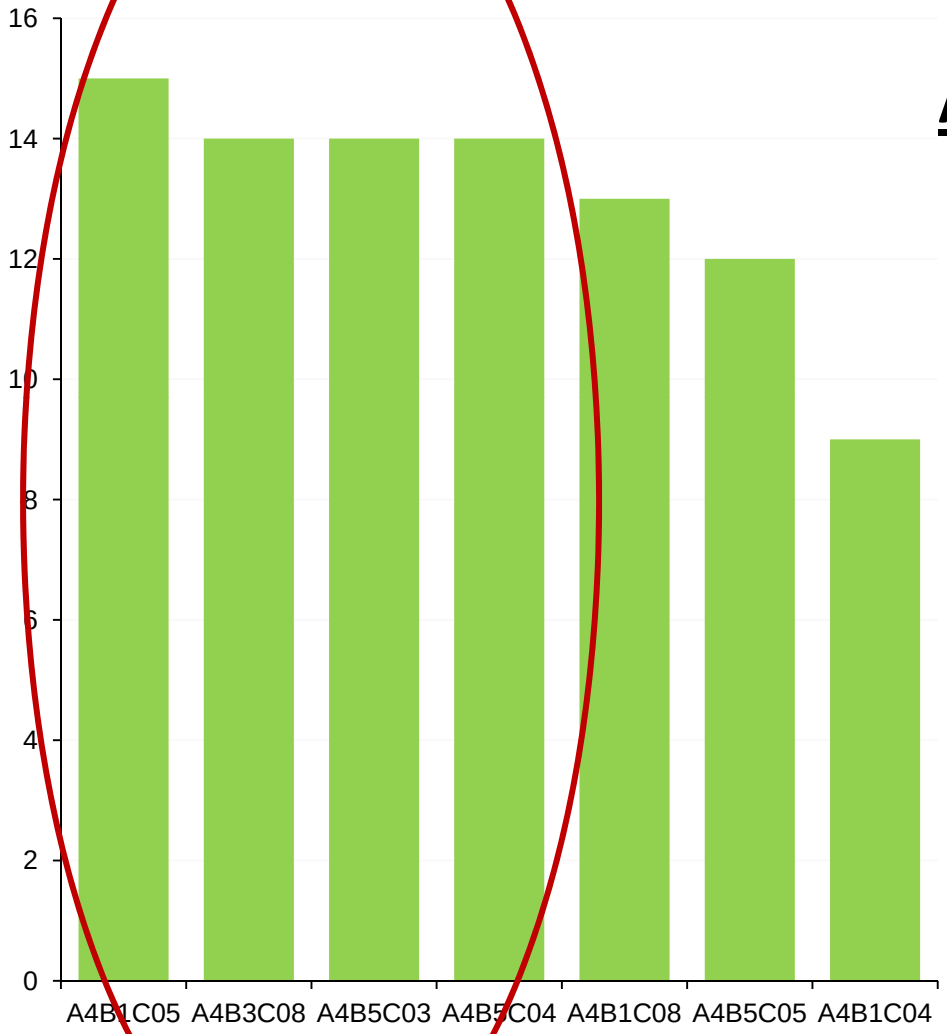
B5C04 - risks/consequences associated with change not adequately reviewed

B1C08 - corrective action responses to a known or repetitive problem was untimely

B5C05 - system interactions not considered

B1C04 - follow-up did not identify problems

Top Causes for Management / Organization



A4 – Management Challenges

B1C05 - assessment did not determine cause of previous event or known problem

B3C08 - job scoping did not identify special circumstances or conditions

B5C03 - inadequate vendor support of change

B5C04 - risks/consequences associated with change not adequately reviewed

B1C08 - corrective action responses to a known or repetitive problem was untimely

B5C05 - system interactions not considered

B1C04 - follow-up did not identify problems

A4 – Management / Organization

B1 – Management Methods

C05 - Assessment did not determine cause of previous event or known problem

Definition: Analysis methods failed to uncover the causal factors of consequential or non-consequential events.

- Review internal event analysis procedure and ensure that it includes a consideration of not just what happened but also why it happened.
- Determine why cause analysis was not implemented in former cases. Implement appropriate corrective actions. Establish a corrective action tracking process to close out and document the corrective actions.
- Where redundant systems are in use (production or primary and disaster recovery) troubleshooting and correct of problems on one system should be applied to all systems as required.

A4 – Management / Organization

B3 – Work Organization and Planning

C08 - Job scoping did not identify special circumstances or conditions

Definition: The work scoping process was not effective in detecting work process elements having a dependency upon other circumstances or conditions.

- Review implementation of work planning processes, examining program-to-program interface requirements (configuration management, work planning, operations, engineering, maintenance).
- Company Generation will consider, as part of its initial maintenance procedures/plan development, the identification of a “single-point of failure” being created due to maintenance activities (e.g., electrical, fuel, water, mechanical, etc).

A4 – Management / Organization

B5 – Work Organization and Planning

C03 - Inadequate vendor support of change

Definition: Management failed to adequately assess the ability of vendors to supply products or services in support of changing expectations for a particular objective.

- Review vendor program and self-verification process, examining inspection and testing activities, sampling plans, technology-based review and verification processes, and oversight methodologies.
- Work with peers to see if issues are unique to your organization or exist with others.
- Work closely with vendors to share expectations and involve them in problem solving.

A4 – Management / Organization

B5 – Work Organization and Planning

C04 - Risks/consequences associated with change not adequately reviewed

Definition: Elements of the process or physical or cyber (to include software) systems changes were not recognized as having adverse impact or increased risk of adverse impact prior to implementing the changes.

- Include whether second and third-order changes to systems and procedures affect the way they are used in production.
- Before making changes to systems and procedures, conduct a pilot test to ensure that the new system or procedure does not have unintended consequences.

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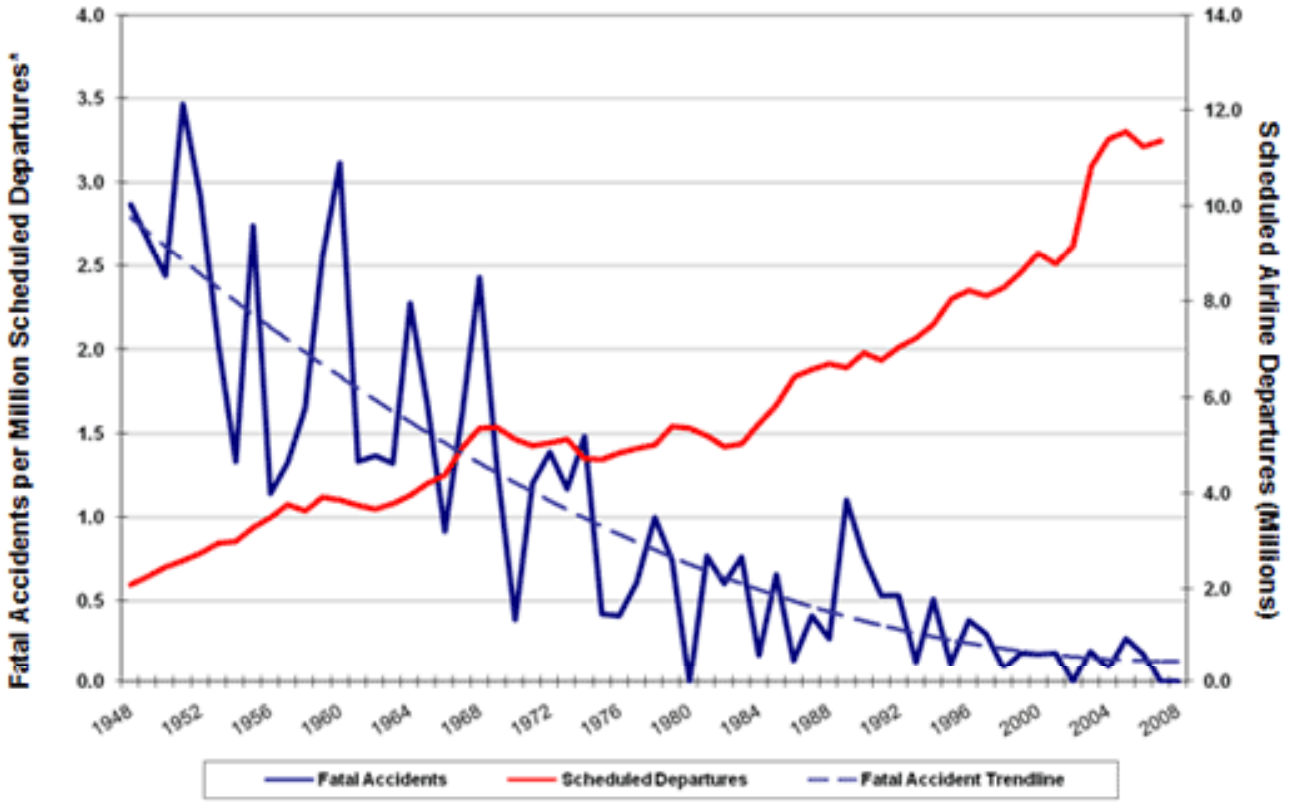
Summary

- Entity event analysis is critical to the identification and subsequent remediation of reliability threats
- Management and Organization challenges overshadow individual human error
  - Less than adequate job scoping is a threat to reliability
- Technical conferences and coordinated feedback to vendors will help drive solutions

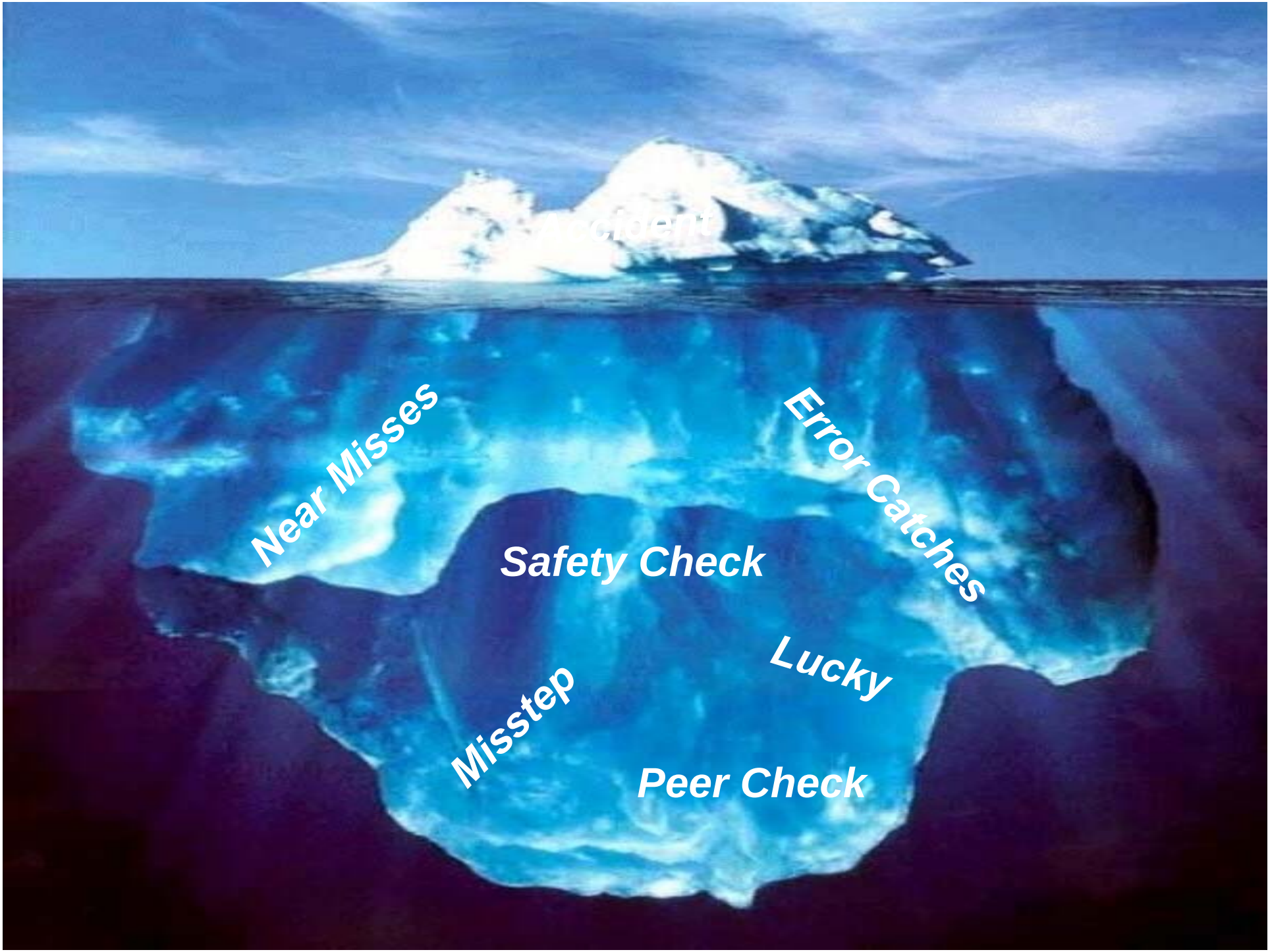
Challenge

With Each Decade, U.S. Airline Safety Has Improved



* Scheduled passenger and cargo operations of U.S. air carriers operating under 14 CFR 121; NTSB accident rates exclude incidents resulting from illegal acts

Source: National Transportation Safety Board (NTSB)


Near Misses
Error Catches
Safety Check
Lucky
Misstep
Peer Check

NERC – Event Analysis
http://www.nerc.com/page.php?cid=5

Event Analysis Process
http://www.nerc.com/page.php?cid=5|365

Questions and Answers

James Merlo, PhD
Associate Director, Human Performance, RRM
404-446-2560 office | 404-387-5249 cell
James.Merlo@nerc.net