INCIDENT INVESTIGATIONS FROM AN HPI PERSPECTIVE - ONE COMPANY’S JOURNEY

PPSA ANNUAL CONFERENCE, JUNE 2016

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Senior Project Manager

June 2016
WHAT IF?

- What if paper machines could fly? Who would want to embark on a device with 95% efficiency? Even 99%?

- What if paper machines were nuclear power plants, could we tolerate the level of reliability we currently have?

- What do airplanes and nuclear plants have in common?

- Study of

Human Performance Improvement
WHAT ARE THE ODDS...

Odds of being killed on a single airline flight
Top 39 airlines (best accident rates)
1 in 19.8 million

Source: OAG Aviation & PlaneCrashInfo.com accident database, 20 years of data (1993 - 2012)

Odds of being injured in the pulp and paper industry
1 in 69,000

Odds of being injured in the nuclear industry
1 in 670,000
IS PRODUCTIVITY COMPATIBLE WITH SAFETY?

Sustained Reliability and Productivity

U.S. Nuclear Capacity Factor, Percent

90.9% in 2010
88.9% in 2011
86.4% in 2012
90.9% in 2013
91.7% in 2014

U.S. Nuclear Industrial Safety Accident Rate

One-Year Industry Values

Note: Starting in 2008, data includes supplemental personnel.
Source: World Association of Nuclear Operators
Updated: 5/15
CAN THIS BE USED IN OUR INDUSTRY?

- How complicated is this?
- Can we do this in with our limited resources?
What is HPI and where does it come from?
FRIDAY 8:30AM, CAN I PARK?
HPI TOOLS & DATA VISUALIZATION?

A visualization should be meaningful, should be build with a purpose; to answer a question

It's Friday morning 8:30 can I park here?

It's a simple question but sign on the left side does not answer the question!

It's a data dump and user is expected you to find out.

In the visualization, answer is easy to find: No I can’t park
HPI: THE REFERENCE MANUALS

DOE STANDARD
HUMAN PERFORMANCE IMPROVEMENT HANDBOOK
VOLUME 1: CONCEPTS AND PRINCIPLES

U.S. Department of Energy
Washington, D.C. 20585

DOE STANDARD
HUMAN PERFORMANCE IMPROVEMENT HANDBOOK
VOLUME 2: HUMAN PERFORMANCE TOOLS FOR INDIVIDUALS, WORK TEAMS, AND MANAGEMENT

U.S. Department of Energy
Washington, D.C. 20585
HPI: 5 KEY FUNDAMENTAL PRINCIPLES

1. People are fallible and even the best make mistakes.

2. Error-likely situations are predictable, manageable, and preventable.

3. Individual behavior is influenced by organizational processes and values.

4. People achieve high levels of performance because of encouragement and reinforcement received from leaders, PEERS, and subordinates.

5. Events can be avoided through an understanding of the reasons mistakes occur and application of the lessons learned from past events (or errors).
FROM DOMINOS TO SWISS CHEESE

<table>
<thead>
<tr>
<th>Re</th>
<th>+</th>
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<tbody>
<tr>
<td>Reduce errors</td>
<td>Manage Barriers</td>
<td>Zero Significant Events</td>
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BARRIERS OR CONTROLS TO PREVENT UNWANTED OUTCOMES

Unwanted Outcome

Latent error (weakens a barrier)

CULTURAL
ENGINNEERED
ADMINISTRATIVE
MANAGEMENT / OVERSIGHT

HPI TOOLBOX TO PREVENT ACTIVE AND LATENT ERRORS
HIGH RELIABILITY ORGANIZATION EXAMPLES

- Aircraft Carriers
- Air Traffic Controller
- Airplane Cockpit Crews
- Power Grid Dispatch Center
- Nuclear Submarine
- Nuclear Power Plants

Re + Mb → OE
HPI

Not limited to Safety
Quality / Reliability / Environment

Touches all Value Drivers
HPI

Moves away from relegating Human Error to a fault based system

Blaming people, training, procedures
HUMAN PERFORMANCE AND EVENTS

Human Errors

Unwanted outcomes

20% Equipment Failures

80% Human Error

70% Latent Organization Weaknesses

30% Individual mistakes
55/25/20% RULE OF HUMAN ERROR

20% Equipment Failures
- A1. Design/Engineering
- A2. Material/Equipment

25% Individual Mistakes
- A3. Human Performance

55% Latent Organization Weaknesses
- A4 Management Systems
- A5. Communication
- A6. Training

Uwanted outcome
CAUSAL FACTORS

FROM D.O.E. STANDARD

A1 Design / Engineering Problem
B1 Design input data not clear
B2 Design input data graphics not clear
B3 Design input data plots not clear
B4 Design input data not available

B2 Design output
C1 Design output data not clear
C2 Design output data not consistent
C3 Design output data not available

B3 Human performance LTA
A1 Human Performance LTA
A2 Human Performance LTA
A3 Human Performance LTA
A4 Human Performance LTA

A4 Management Problem
B1 Skill-based Error LTA
B2 Skilled-based Error LTA
B3 Skilled-based Error LTA
B4 Skilled-based Error LTA

A5 Communication LTA
B1 Written Communication LTA
B2 Written Communication LTA
B3 Written Communication LTA
B4 Written Communication LTA

A6 Training Deficiency
C1 Training deficiency
C2 Training deficiency
C3 Training deficiency
C4 Training deficiency

DOE STANDARD

OCCURRENCE REPORTING CAUSAL ANALYSIS

U.S. Department of Energy
Washington, D.C. 20585

AREA SAFT

NOT MEASUREMENT SENSITIVE

DOMINANTntag-05-1911

SEPTEMBER 2011

DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited.
## Error Precursors

Conditions that are known to increase error rate

<table>
<thead>
<tr>
<th>Task Demands (TD)</th>
<th>Individual Capabilities (IC)</th>
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</thead>
<tbody>
<tr>
<td>TD1. Time pressure <em>(in a hurry)</em></td>
<td>IC1. Unfamiliarity with task / First time</td>
</tr>
<tr>
<td>TD2. High workload <em>(memory requirements)</em></td>
<td>IC2. Lack of knowledge <em>(mental model)</em></td>
</tr>
<tr>
<td>TD3. Simultaneous, multiple tasks</td>
<td>IC3. New technique not used before</td>
</tr>
<tr>
<td>TD4. Repetitive actions / Monotony</td>
<td>IC4. Imprecise communication habits</td>
</tr>
<tr>
<td>TD5. Irreversible actions *</td>
<td>IC5. Lack of proficiency / Inexperience</td>
</tr>
<tr>
<td>TD6. Interpretation requirements</td>
<td>IC6. Unsystematic problem-solving skills</td>
</tr>
<tr>
<td>TD7. Unclear goals, roles, or responsibilities</td>
<td>IC7. “Can do” attitude for crucial task</td>
</tr>
<tr>
<td>TD8. Lack of or unclear standards</td>
<td>IC8. Illness or Fatigue</td>
</tr>
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<tr>
<th>Work Environment (WE)</th>
<th>Human Nature (HN)</th>
</tr>
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<tr>
<td>WE1. Distractions / Interruptions</td>
<td>HN1. Stress</td>
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<td>WE2. Changes / Departure from routine</td>
<td>HN2. Habit patterns</td>
</tr>
<tr>
<td>WE3. Confusing procedure / Vague guidance</td>
<td>HN3. Assumptions</td>
</tr>
<tr>
<td>WE5. Work-around / OOS instrumentation</td>
<td>HN5. Mind set <em>(intention)</em></td>
</tr>
<tr>
<td>WE6. Hidden system response</td>
<td>HN6. Inaccurate risk perception</td>
</tr>
<tr>
<td>WE7. Unexpected equipment conditions</td>
<td>HN7. Mental shortcuts <em>(biases)</em></td>
</tr>
<tr>
<td>WE8. Lack of alternative indication</td>
<td>HN8. Limited short-term memory</td>
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HUMAN PERFORMANCE MODES
IMPACT OF PERFORMANCE MODE ON ERROR RATE

- **Knowledge-Based Patterns**: Chance for error is high – 1 in 2
- **Rule-Based If-Then**: Chance for error is 1 in 1,000
- **Skill-Based Auto**: Chance for error is 1 in 10,000

**Inattention** (Slip – Trips – Lapse)
- **Misinterpretation**: Chance for error is 1 in 1,000
- **Mistake**: I know what to do
- **Inaccurate Mental Picture**: Chance for error is high – 1 in 2

3 HPI TOOLS – WHAT’S THE LINK WITH INVESTIGATIONS?
4 STEPS OF AN EVENT INVESTIGATION

WHAT?  WHY?  CAUSAL FACTORS  CORRECTIVE ACTIONS

INVESTIGATION PROCESS
FINDING OUT WHAT HAPPENED

- Collecting evidence
- The 4 P’s – material evidence
  - Position
  - Parts
  - Paper
  - Process
- The 5th « P » - people evidence
  - Conducting **interviews**

« Ahhh… Just one more thing… »
WE WANT TO UNDERSTAND WHAT?

Context!
Context does not justify behavior. It explains it!
**INTERVIEWS: OPEN VS LEADING QUESTIONS**

- **Open questions**: encourages a full, meaningful answer
  - Considers the subject's own knowledge and/or feelings.

- **Closed questions**: encourages a short or single-word answer.
  - Tends to restrict people from articulating themselves.

- **What** was supposed to happen?
- **How** is the task normally performed?
- **What** was different this time compared to other times, that deviated from “normal”?
- **What** factors existed at the time that influenced your decisions and actions?
- **What** advice do you have for the organization to help minimize the likelihood of a reoccurrence?
- Do you have other comments?
HUMAN ERROR: PATTERNS OF FAILURE

To drift is human

A behavior may have become the new Norm across an entire operation or organization

Illustration from: The Field Guide to Human Error Investigations
INVESTIGATION SEQUENCE

WHAT?
- MATERIAL EVIDENCE
- INTERVIEWS

WHY?

CAUSAL FACTORS

CORRECTIVE ACTIONS

[PPSA 2016 – INVESTIGATIONS WITH HPI]
EVENT CAUSAL FACTOR CHARTING
BUILDING THE SEQUENCE OF EVENTS
EVENT CAUSAL FACTOR CHARTING
BUILDING THE SEQUENCE OF EVENTS

WORKER INJURED WHEN CHANGING A VALVE

Worker A holds up the valve while worker B undoes the bolts. They lower the valve to the floor

Worker B asks worker A if he needs help carrying the valve. Worker A says "no, it's not that bad"

Worker A carries the valve to his buggy

When setting down the valve on the buggy, Worker A crushed a finger between the valve and the side of the dolly

Open fracture at tip of finger

ACTION
DECISION
ACTION
EVENT
UNWANTED OUTCOME
WORKER INJURED WHEN CHANGING A VALVE

1. **CONDITIONS**
   - Tight space, no anchor points for rigging
   - Long catwalk from point of work then down a flight of stairs to the basement
   - A dolly was located just next to the buggy

2. **ACTION**
   - Worker A holds up the valve while worker B undoes the bolts. They lower the valve to the floor

3. **DECISION**
   - Worker B asks worker A if he needs help carrying the valve. Worker A says "no, it's not that bad"

4. **ACTION**
   - Worker A carries the valve to his buggy

5. **EVENT**
   - When setting down the valve on the buggy, Worker A crushed a finger between the valve and the side of the dolly

6. **UNWANTED OUTCOME**
   - Open fracture at tip of finger
**CONTEXT**
- True weight of the valve is 100 lbs. Worker A thought it was in fact 60-70 lbs. Site recommendation is max. 50 lbs.

**CONDITIONS**
- Tight space, no anchor points for rigging
- Long catwalk from point of work then down a flight of stairs to the basement
- A dolly was located just next to the buggy

**ACTION**
- Worker A holds up the valve while worker B undoes the bolts. They lower the valve to the floor
- Worker B asks worker A if he needs help carrying the valve. Worker A says "no, it's not that bad"
- Worker A carries the valve to his buggy

**DECISION**

**EVENT**
- When setting down the valve on the buggy, Worker A crushed a finger between the valve and the side of the dolly

**OUTCOME**
- Open fracture at tip of finger
BARRIER ANALYSIS

- **CULTURAL**: Agreed-upon rules of the road unique to a location. C
  - Color of the traffic signals. **Green** means go. **Red** is stop. But a **yellow** traffic light means "prepare to stop".

- **ENGINEERED**: seat belts, airbags, anti-lock brakes, back up warning systems, rear view mirrors, etc.
  - Can be passive or active (need to be defeated)

- **ADMINISTRATIVE**: Driver education, insurance, qualification and testing, speed limits and rules of the road.

- **OVERSIGHT / MANAGEMENT**: Police, speed control radar, cameras at intersections, etc... Other drivers can act as an oversight defense.
BARRIER ANALYSIS

What were the barriers?
How did they perform?
Why did the barriers fail?
How did the barrier affect the event?
Context
Error precursors?

Bars
Resilient Process

CULTURAL
ENGINEERED
ADMINISTRATIVE
MANAGEMENT / OVERSIGHT

Active error

Unwanted Outcome

Feed the ECFC
(Event causal factor chart)
WORKER INJURED WHEN CHANGING A VALVE

- True weight of the valve is 100 lbs. Worker A thought it was in fact 60-70 lbs. Site recommendation is max. 50 lbs.

- Tight space, no anchor points for rigging

- Engineerered barrier (missing)

- Worker A holds up the valve while worker B undoes the bolts. They lower the valve to the floor

- Worker B asks worker A if he needs help carrying the valve. Worker A says "no, it's not that bad"

- Worker A carries the valve to his buggy

- When setting down the valve on the buggy, Worker A crushed a finger between the valve and the side of the dolly

- A dolly was located just next to the buggy

- Open fracture at tip of finger

- Event treatment
ERROR PRECURSOR & PERFORMANCE MODE

Worker A

TD7 – Unclear goals, roles or responsibilities?
IC6 – « Can-do » attitude?
HN3 – Assumptions?

Misinterpretation
Rule-based error
INVESTIGATION SEQUENCE

WHAT?
- MATERIAL EVIDENCE
- INTERVIEWS

WHY?
- BARRIER ANALYSIS

CAUSAL FACTORS

CORRECTIVE ACTIONS
IDENTIFYING CAUSAL FACTORS

- 7 Causal factor families in 3 categories (equipment, human performance, organisation)
- 32 sub-families (B nodes)
- 166 individual causal factors (C nodes)
**Process Can Be Automated**

### Causal Factors

#### Background
- **Error Precurors**
  - Task Demands (TD) vs. Individual Capabilities (IC)

#### Work Environment (WE)
- WE1. Distractions / Interruptions
- WE2. Changes / Departure from routine
- WE3. Confusing procedure / Vague guidance
- WE4. Confusing displays / Controls
- WE5. Work-around / OBS Instrumentation
- WE6. Hidden system response
- WE7. Unexpected equipment conditions
- WE8. Lack of alternative instruction

#### Human Nature (HN)
- HN1. Stress
- HN2. Habit patterns
- HN3. Assumptions
- HN4. Complicity / Overconfidence
- HN5. Mind-set (channeling)
- HN6. Inaccurate risk perception
- HN7. Mental shortcuts (guesstimates)
- HN8. Limited short-term memory

### Task Demands (TD) and Description

<table>
<thead>
<tr>
<th>TD.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Urgency or excessive pace required to perform action or task.</td>
</tr>
<tr>
<td></td>
<td>Manifested by shortcuts, being in a hurry, and an unwillingness to accept additional work or to help others.</td>
</tr>
<tr>
<td></td>
<td>No spare time.</td>
</tr>
</tbody>
</table>
PROOF IS IN THE PUDDING

- Choosing a causal factor is not trivial
- Support the choice with evidence
- In DOE language:
  - A3.B2.C01 - Strong rule incorrectly chosen over other rule
  - A4.B1.C01 - Management policy guidance/expectations not well-defined, understood or enforced
INVESTIGATION SEQUENCE

WHAT?

MATERIAL EVIDENCE

INTERVIEWS

WHY?

BARRIER ANALYSIS

ECFC

CAUSAL FACTORS

CORRECTIVE ACTIONS
S.M.A.R.T+ER CORRECTIVE ACTIONS

1. **Specific**
   - Is it detailed & understandable?

2. **Measurable**
   - Is it easily evaluated?

3. **Action Based**
   - Does it include desired end result?

4. **Realistic**
   - Is expected outcome reasonable?

5. **Timely**
   - Is deadline reachable?

6. **E.R.**
   - Effectiveness Reviews
INVESTIGATION SEQUENCE

WHAT?
- MATERIAL EVIDENCE
- INTERVIEWS

WHY?
- BARRIER ANALYSIS

CAUSAL FACTORS
- ECFC

CORRECTIVE ACTIONS
- SMART
  - SPECIFIC: IS IT DETAILED & UNDERSTANDABLE?
  - MEASURABLE: IS IT EASILY EVALUATED?
  - ACTION BASED: DOES IT INCLUDE DESIRED END RESULT?
  - REALISTIC: IS EXPECTED OUTCOME REASONABLE?
  - TIMELY: IS DEADLINE REACHABLE?

ER
- EFFECTIVENESS REVIEWS
SUMMARY

- **Human Performance Improvement**
  - Used by some of the safest industries
  - Human error in the context of an organization
  - Human error is not necessarily the cause, it becomes the symptom
  - Error precursors, performance mode, causal factor tree

- **An HPI investigation**
  - Attempts to see the incident in the eyes of the worker
    - Why did the worker do what he did knowing what he knew
    - Context does not justify the behavior, it explains it
  - Systematic approach to root cause analysis
  - Uproots organizationnal weaknesses
« The only real mistake is the one from which we learn nothing »