Human Performance Improvement (HPI) Practices in Accelerator Operations

DOE Accelerator Safety Workshop

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SLAC NATIONAL ACCELERATOR LABORATORY

Stanford University | U.S. DEPARTMENT OF ENERGY

Agenda

Human Performance Improvement (HPI) Practices in Accelerator Operations

- Intro
- Background
- SLAC HPI:
  - Building on the Familiar
  - Making HPI part of culture
- Continuous improvement
- Wrap-up

Intro (who am I)

Lydia J. Young, Ph.D

SLAC

- 2023-present: Deputy ALD for Engineering, Accelerator Directorate (AD)
  - 4 Divisions: Mechanical, Electronics, Safety Systems Engineering, Cryogenics
- (2014-23) Division Director, AD Mechanical Engineering & Technical Services Division (METSD)
  - 5 departments (MechEng, Design, Technical Planning, Metrology, Manufacturing -175 FTEs at peak)
  - LCLSII design/fab/install; LSST fab; SuperCDMS fab; LCLS linac operations

Other

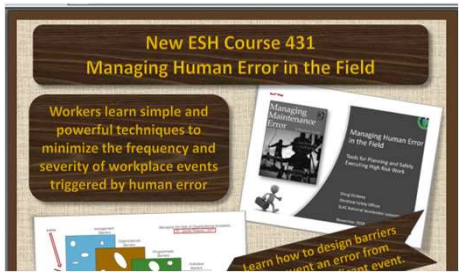
- LBNL Contractor Assurance, Requirements Management Program Manager
- Over 20 years in semiconductor capital equipment industry in roles VP Technology, CTO, General Manager, Technical Product Program Manager, Director of Engineering as well as individual contributor. Products: electron beam lithography, plasma chemical vapor deposition, wafer/LCD panel inspection and repair

Education:

- BA Physics, Mount Holyoke College
- MS Applied Physics; Ph.D. Nuclear Science and Engineering; both Cornell University
- US Patent Agent

Start of the Journey

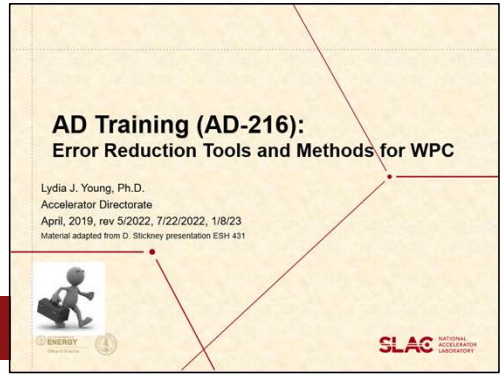
Human Performance Improvement (HPI) at SLAC



- Recognized as a needed best practice by D. Stickney (former SLAC Electrical Safety Officer) approximately 2018.
- Late 2018 recognition of need for “near perfection” in interconnection of LCLSII superconducting cryomodules (particle-free!)
- LCLSII long downtime started late 2018: installation of 2+ miles of beamline and equipment.

→ **PERFECT opportunity to introduce HPI and Enhanced Rigor WPC.**

- Course 431: electrical focused, very detailed, a bit long for the 60+ METSD staff installing LCLSII
- Created and implemented by early spring 2019:
  - A shorter AD216 class; renamed Error Reduction Tools and Methods
  - Enhanced Rigor WPC protocols
  - Both targeted for Field Teams



We’ve learned a lot along the way……

SLAC – view from above

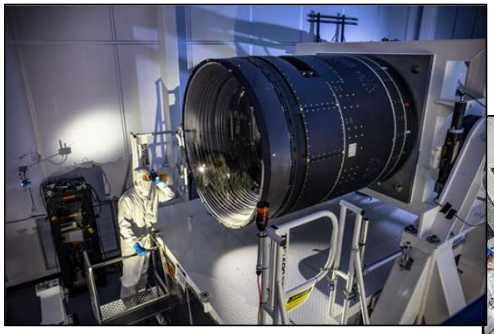
LCLS-superconducting linac: Field work from 2016 through 2022.

3.6km new/replaced beamline including srf cryomodules and two new undulator lines.
AD-METS Division: > 400,000 hrs (2017-2021) incl 11 DART (=0.08% lost time)

Opportunities for Application

Opportunities if managed → Habit in time

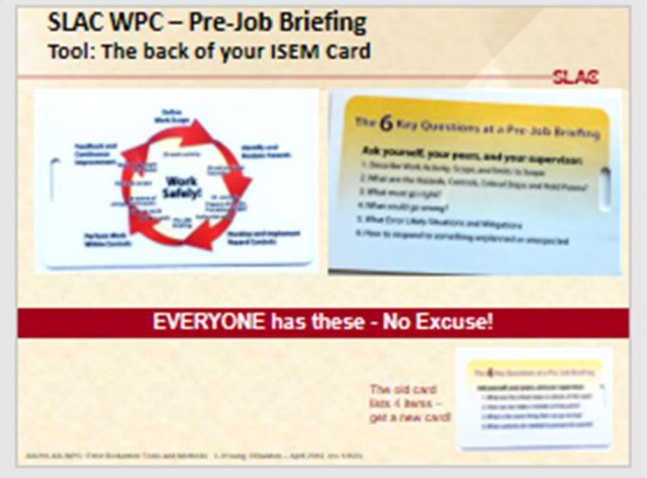
- LCLSII:
  - 2.5 miles of scientific equipment.
  - The needed perfection for superconducting beamline
  - Lots of people (several hundred)
  - Install time approx. late 2018, peak just before COVID, continuous vacuum achieved Dec 2021; commissioning still underway
- LSST camera:
  - The zillion dollar one-of-a-kind
  - Needed perfection in assembly, handling, shipping
  - Smallish team
  - 2019 to 2024 – SHIPPED to Chile!
- SLAC fabrication shops: Supporting multiple projects

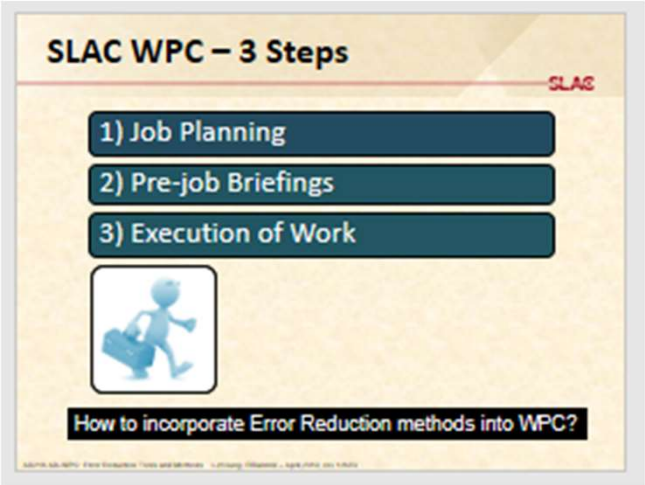


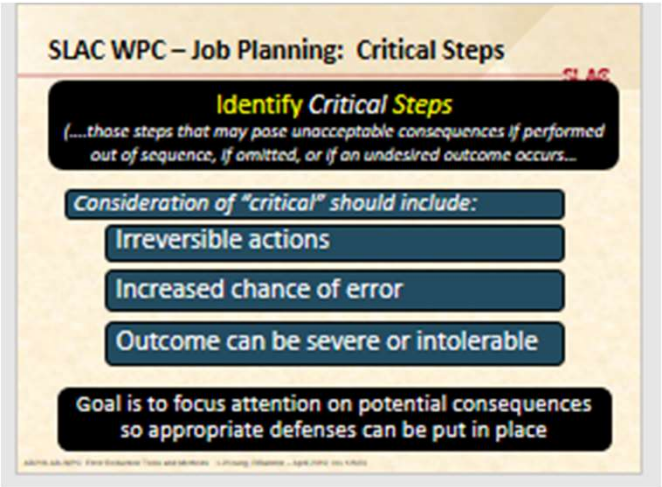
We've learned a lot in practice along the way…….

Approach: HPI Building on the Familiar

WPC Basics with empahsis on what can go wrong unless….





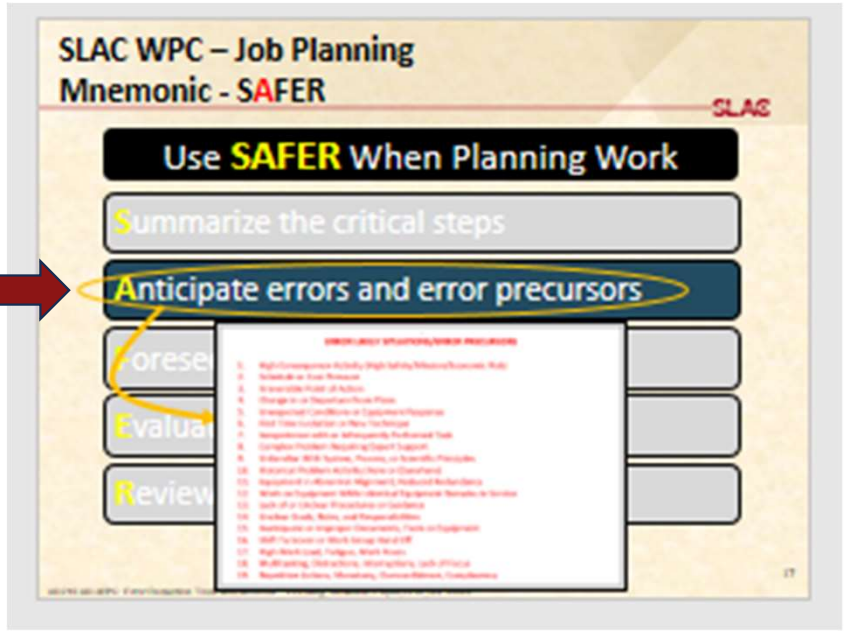


SLAC ESH Manual, Chapter 02

Course AD216 - approximately 300 trained since May 2019. Does not include the many repeats of messaging through All-Hands, Safety Forums, immediate feedback after events

Approach: HPI Building on the Familiar –

Introduce some tools, visuals – heighten awareness!



ERROR LIKELY SITUATIONS/ERROR PRECURSORS

1. High Consequence Activity (High Safety/Mission/Economic Risk)
2. Schedule or Cost Pressure
3. Irreversible Point of Action
4. Change in or Departure From Plans
5. Unexpected Conditions or Equipment Response
6. First Time Evolution or New Technique
7. Inexperience with or Infrequently Performed Task
8. Complex Problem Requiring Expert Support
9. Unfamiliar With System, Process, or Scientific Principles
10. Historical Problem Activity (Here or Elsewhere)
11. Equipment in Abnormal Alignment; Reduced Redundancy
12. Work on Equipment While Identical Equipment Remains in Service
13. Lack of or Unclear Procedures or Guidance
14. Unclear Goals, Roles, and Responsibilities
15. Inadequate or Improper Documents, Tools or Equipment
16. Shift Turnover or Work Group Hand Off
17. High Work Load, Fatigue, Work Hours
18. Multitasking, Distractions, Interruptions, Lack of Focus
19. Repetitive Actions, Monotony, Overconfidence, Complacency

Badge card!

ERROR PREVENTION/MITIGATION TOOLS

WORK PLANNING AND TAILGATE TOOLS

1. Plan (or Pause, Evaluate, Replan): Determine/Confirm Critical Steps, What-ifs, Error Barriers
2. Review Plan: Confirm Critical Steps, What-ifs and Adequacy of Error Barriers
3. Evaluate Short Term Benefit vs. Long Term Detriment (Future Risk or Cost)
4. Improve Focus: Control Urgency; Eliminate Short Cuts, Distractions and Multitasking
5. Verify (or Re-verify) Adequacy of Work Plans and Procedures
6. Review Historical Problem Solutions; Incorporate into Work Plan
7. Challenge Assumptions; Appoint Devil's Advocate; Avoid Group Think
8. Ensure Adequate Skills, Knowledge, Tools, PPE and Equipment
9. Reinforce Work Plans, Procedures, Communication Protocols, Roles & Responsibilities

WORKER TOOLS [USE DURING EXECUTION OF WORK]

10. DISTRACTED? Increase Attention
    a. Self Check: STAR (Stop, Think, Act, Review)
    b. Peer Check
11. UNCOMFORTABLE? Increase Verification
    a. Ask Questions, Validate, Verify; Peer Check; Review Work Plan and Procedures
12. CONFUSED? Increase Knowledge
    a. Speak Up; Get Help or Expert Advice

Mar 2019

Emphasis on remaining attentive and aware always – especially for ROUTINE work

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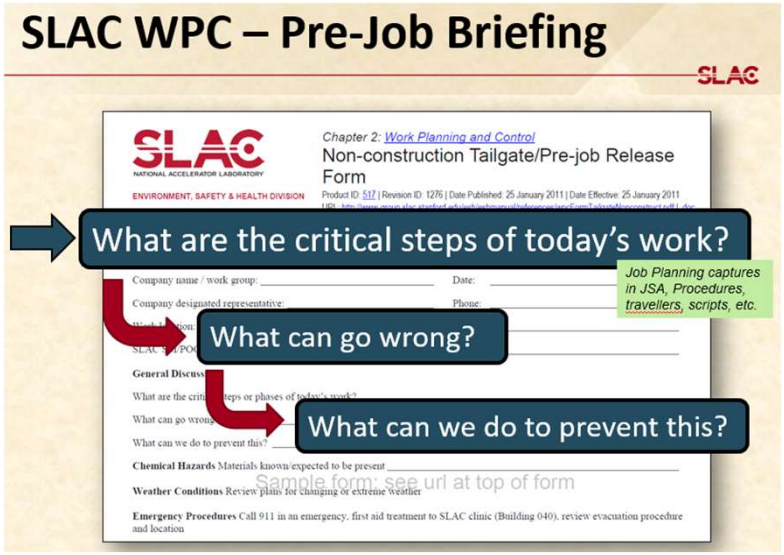

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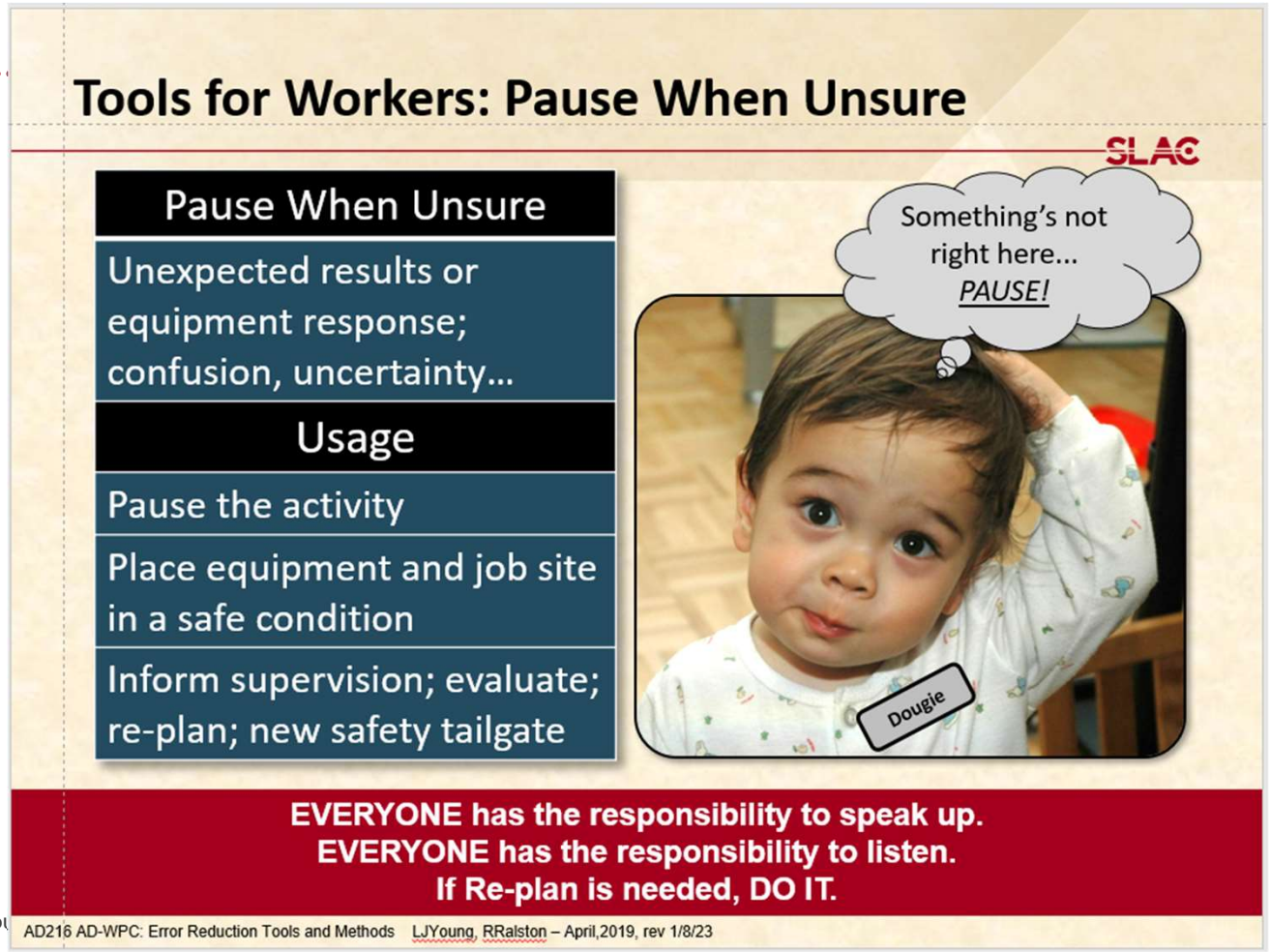
Mar 2019

Emphasis on remaining attentive and aware always – especially for ROUTINE work

Approach: HPI Building on the Familiar

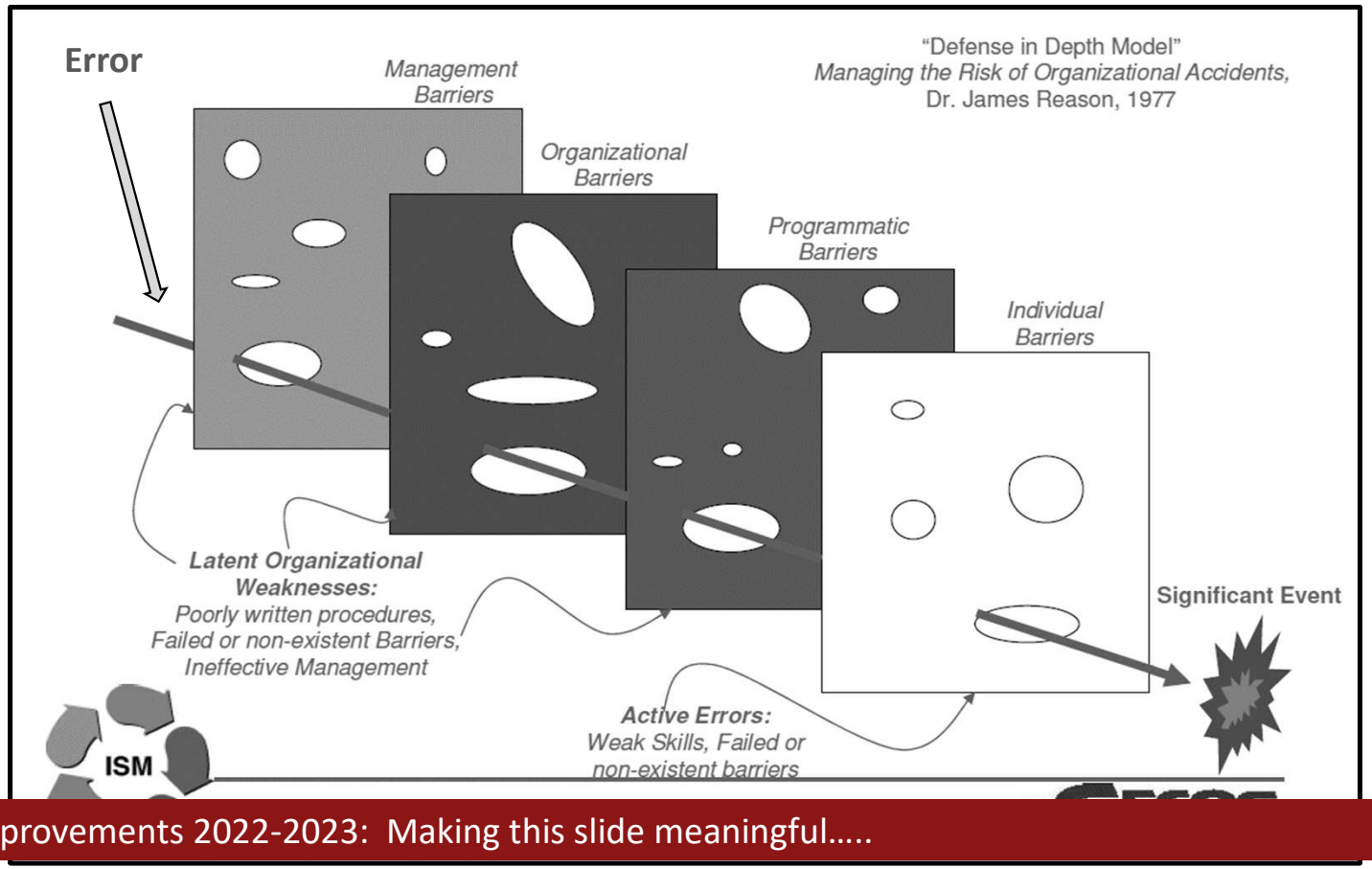
And expanding the practices…

- **Culture adjustments:**
  - Team = Everyone has a say
  - Even if it means Re-plan
  - “Are we ready?”
  - “Am I ready?”



Approach: Building on the Familiar –

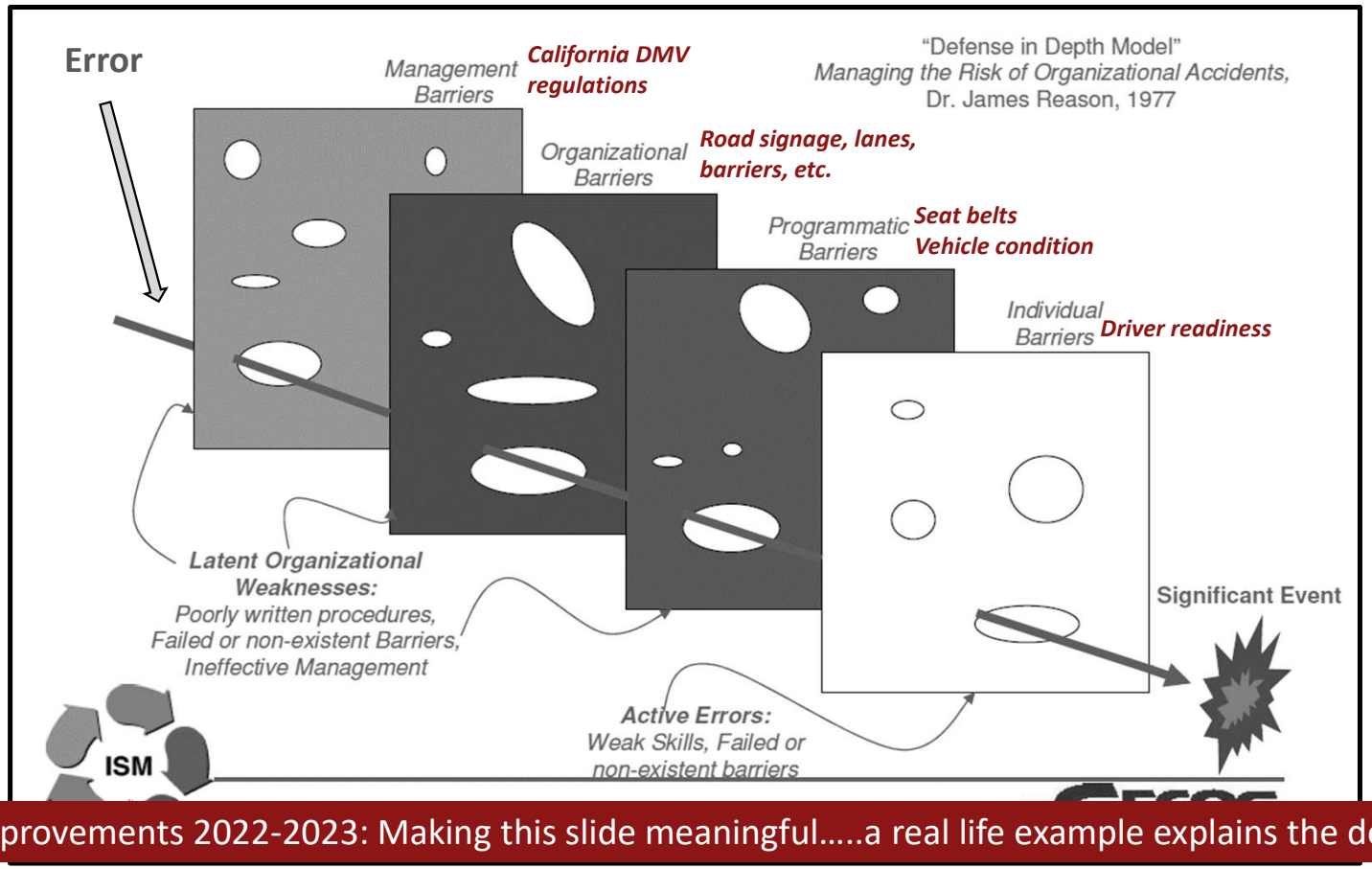
Defense in Depth: Error Mitigation



Training improvements 2022-2023: Making this slide meaningful…..

Approach: Building on the Familiar –

Defense in Depth: Error Mitigation – Driving a Vehicle



Training improvements 2022-2023: Making this slide meaningful…..a real life example explains the definitions…

Approach: Building on the Familiar –

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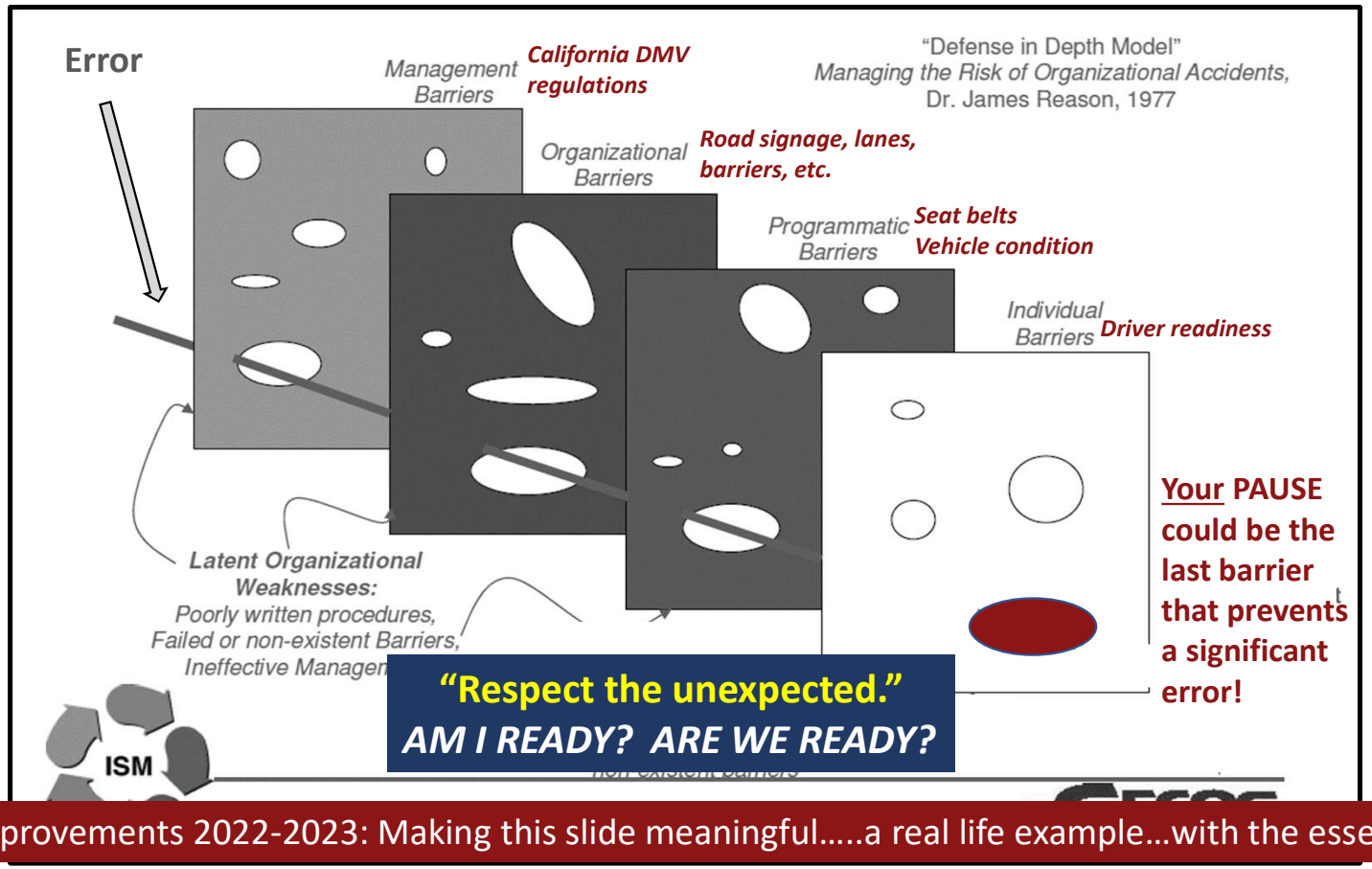
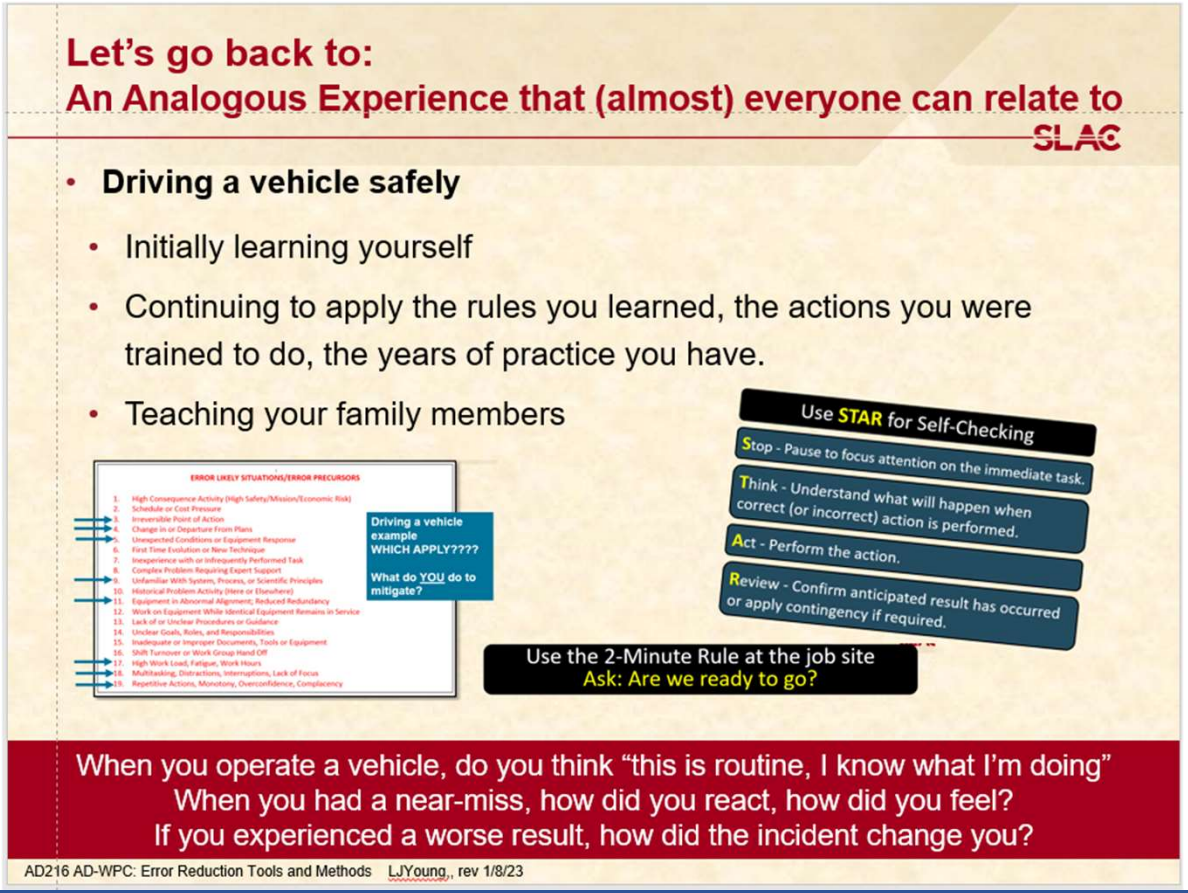


Training improvements 2022-2023: Making this slide meaningful…..a real life example…with the essential messages

Approach: Building on the Familiar –

- Choice of this example of driving really "hits home."
- ***"Approach each task every day as if it were new."***

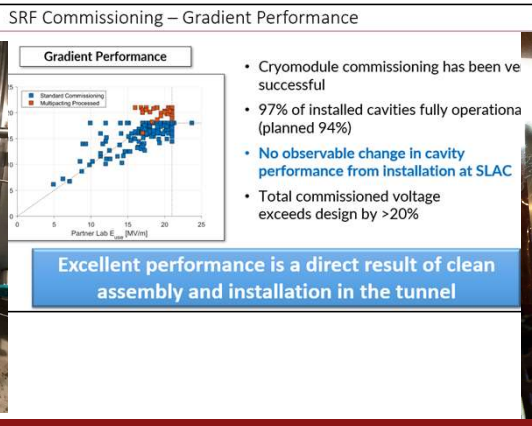


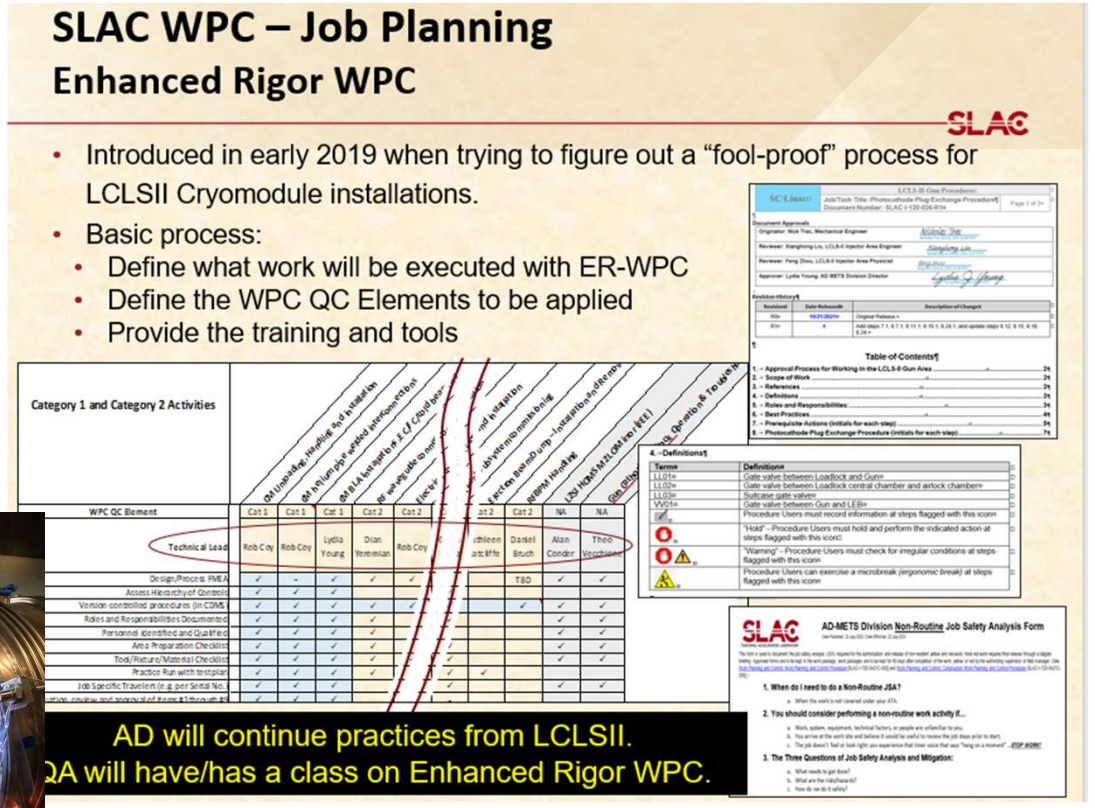
Training improvements 2022-2023: Making this slide meaningful…..a real life example…with the essential messages

Approach: Expanding the Familiar –

Enhanced Rigor WPC

- Team members selected and trained. Plenty of practice.
- For Cryomodule installs, it “worked”!!
- First turn on of Cryomodules (2023): NO evidence of added field emission compared to before ship/immediately after receipt.



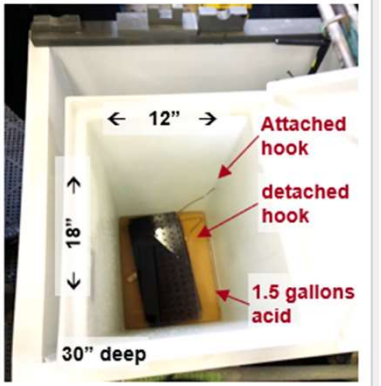


Feedback took 3 years to arrive to prove the value of Enhanced Rigor WPC with HPI…and now we have (some) believers

Application of the Messages for Emphasis

Review and repeat the Messages especially after Incidents towards making these HABIT.

Event 1: Lift of 2x 115lb plates – Not properly bolted together before lifting.
Causes: Change of plan without team replan
Followup #1 – within 2 days: Work team discussion
Followup #2 – within 2 weeks: Multi-dept mini-workshop – planning, replanning, pause if unsure!

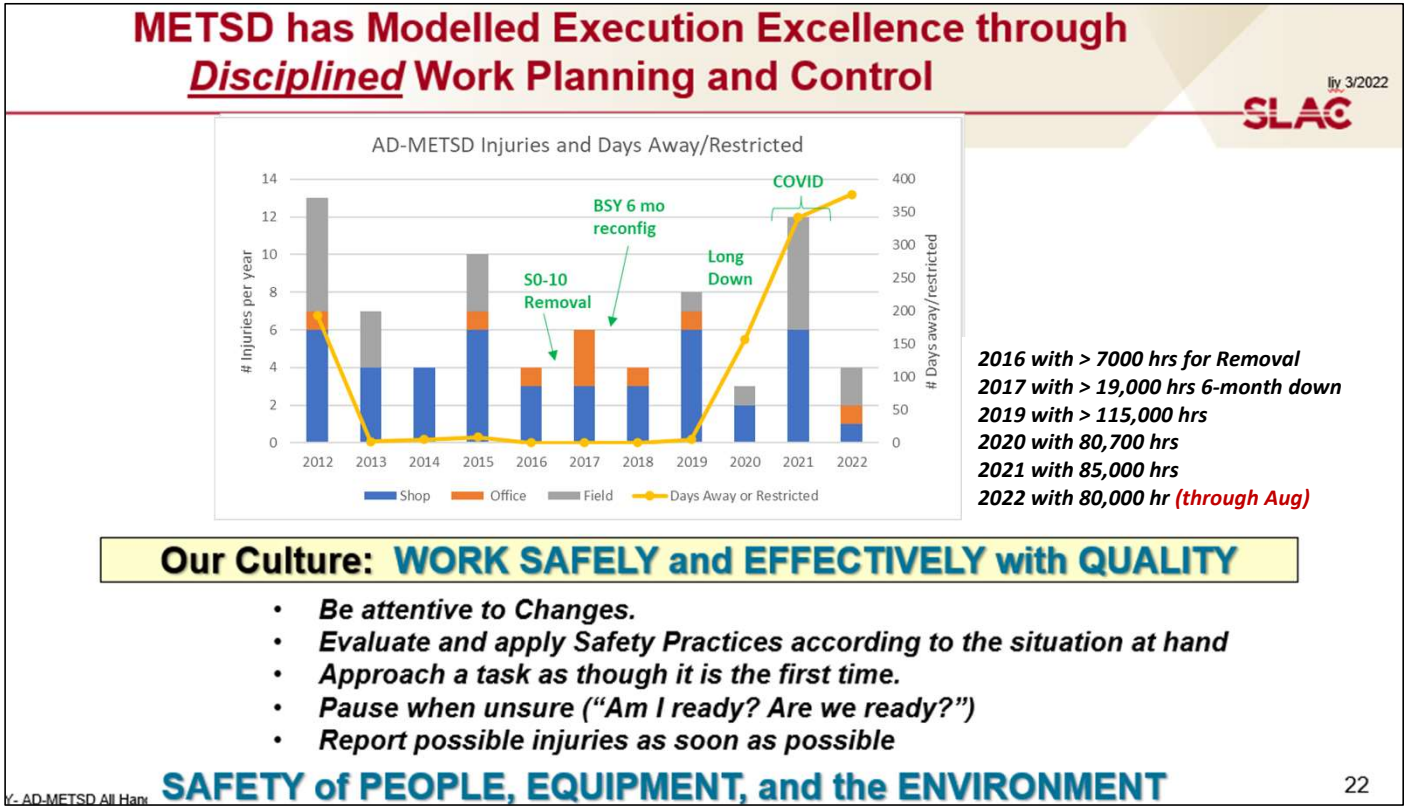


Event 2: While lowering 5lb plate, plate slipped cause chemical splashing.
Causes: Mis-sizing of part/tank; worker assumptions; plan not reviewed.
Followup – same day: Work team discussion

Immediate Feedback to Teams is an effective Best Practice to adjust culture.

Signs of Success?

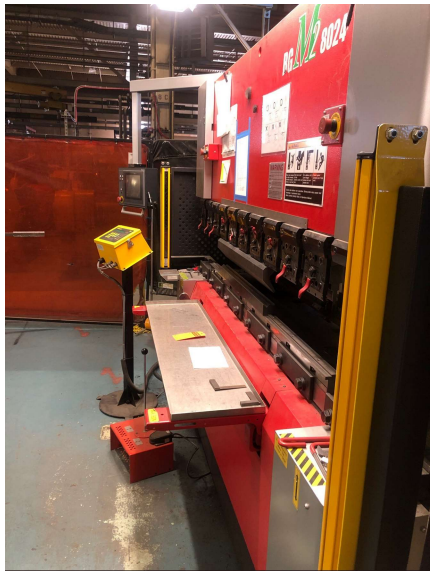
We watched Field Work very carefully……



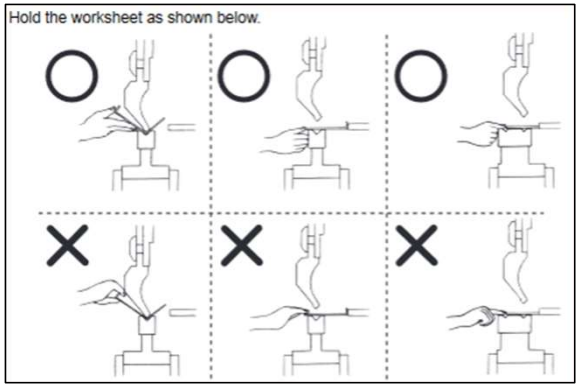
…and thought we were doing well……UNTIL……

….The Shops

A 2022 Event made all in the Division stop and think again.



Event 3: Brake Press (bend metal) - Mispositioned thumbs.
Cause: Skill of craft judgment, situational awareness.



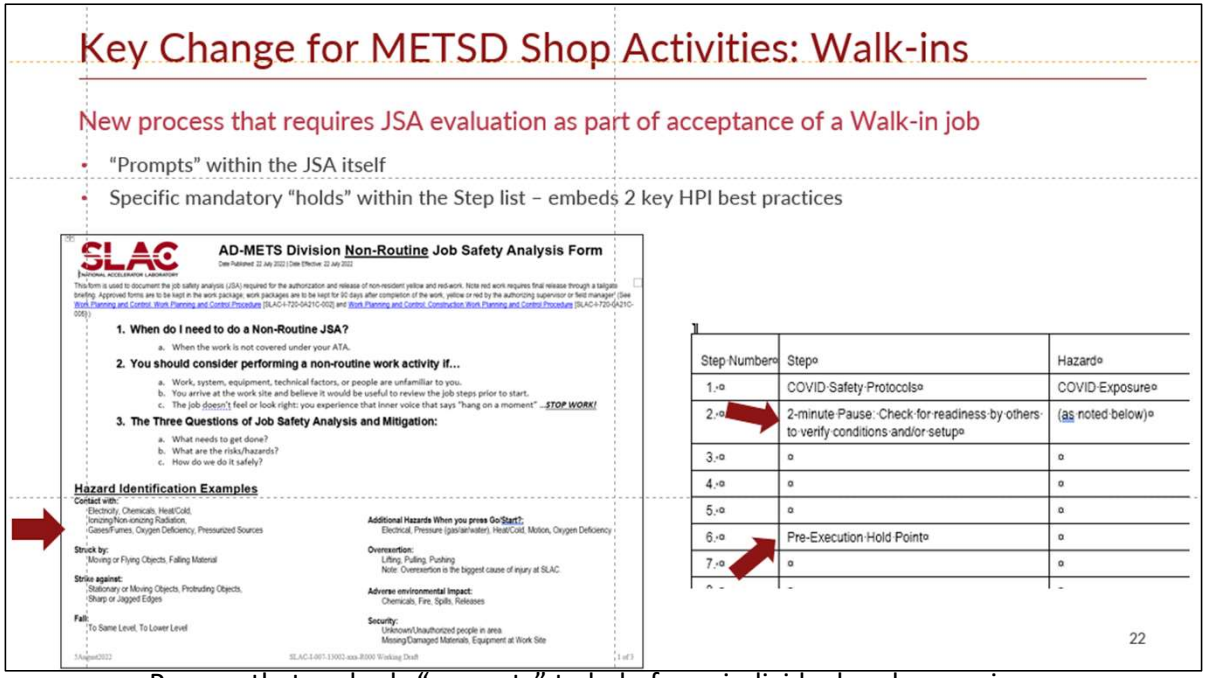
- Followup meeting with Division Leads. Key realization:
  - METSD Shop Activities vs Field Activities: *Differences require different emphases in WPC*
    - Shop work: Individuals
    - Skill of craft judgment
    - No habit of asking for others to check "Readiness"

The Lesson: A field job has more constant eyes and more levels of experience – more people to call for Pause
What error mitigation practices can we develop and apply to the shop environment?

Amended thinking to address the Shops, too

Work still in progress – Ideas include:

- Culture: One that is open to questions and to be questioned. This is a culture where we teach each other and learn from each other. We seek to be collaborative.
- Review and update and apply(!) the training modules of 8-10 years ago;
- Create a Skill Set matrix/database: Use to evaluate current staff, to develop training.
- Determine how to assess someone is "ready" (judgment!)
- Cross-train across shops
- Devise and apply deliberate methods to capture/share/teach Tribal Knowledge



Process that embeds "prompts" to help focus individual and supervisor

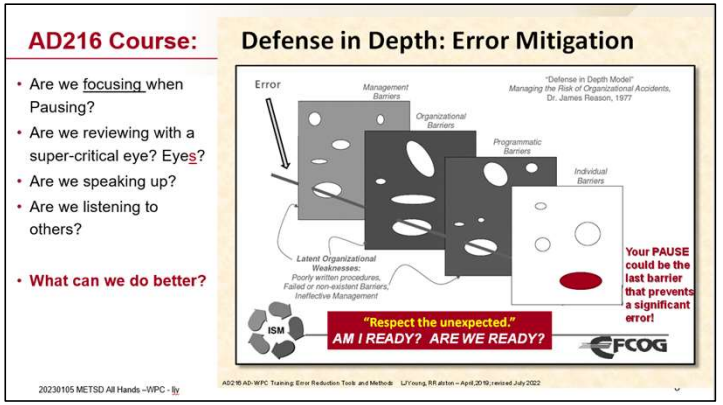
"Experience comes from good judgment. Good judgment comes from bad experience."

Realization → …but!!!…we managers cannot "permit" bad experiences…so, how to train to develop good judgment?

HPI, WPC: the Journey continues

Learnings continue to drive messaging, training, and methods to adjust culture

- For Staff:
  - Apply 2 Minute Rule prior to start of work.
  - **Ask: *Am I ready? Are we ready?***
  - **Pause if unsure**. Do not hesitate to ask for help
  - Practice asking "what if's".
  - During planning, participate and encourage others to join in.
  - Assess Lessons Learned from a task/job; feed forward to next work
    - At daily tailgates, reflect on what went well, what didn't.



- For Managers/Supervisors:
  - **Making HPI/WPC habit takes effort and will always be a continuing challenge.**
  - *Experience comes from good judgment. Good judgment comes from bad experience. BUT…we SLAC managers cannot "permit" bad experiences.* How can we improve our training program to help people develop good judgment?

Error is pervasive. The unexpected is pervasive… What is not pervasive are well-developed skills to detect and contain these errors at their early stages. - Dr. Karl Edward Weick @ University of Michigan

Thank you! Questions?

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