Human Factors
in Accident Prevention

People / Environment / Work
Force / Frequency / Posture

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Human Reliability and Information Transfer

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Objectives

- Understand different ways to assess the potential for human error (human reliability)
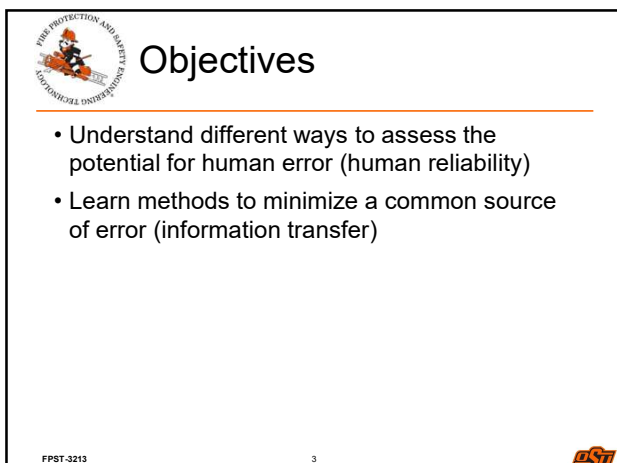- Learn methods to minimize a common source of error (information transfer)

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Reduction of Error

- Human centered
  - Use Macroergonomics
  - Reduce fatigue, stress, MSD
  - Increase safety, productivity, quality

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Definitions

- **Reliability:** the probability that any item will perform a specified function for a given time under specific conditions
- **Human reliability:** the probability of successful human performance on a task in any stage of system operation(s) under a given time parameter
- **Human performance reliability:** the probability that the human will fulfill a given job under specified conditions

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Reduction of Error

- Reliability analyses in 1950s only focused on equipment

- Humans are not perfect
  - Must account for failings of human operators
  - Information transfer common source of error

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Human Reliability Analysis

- Evolved because of catastrophic disasters
  - Causes of major catastrophic accidents were compilation of

?

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Human Reliability Analysis (HRA)

- Human reliability…as an activity…
  - The analysis, prediction and evaluation of work-oriented human performance
  - Attempts to quantify
    - Error likelihood
    - Probability of task accomplishment
    - Response time

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Goals of HRA

- Predict human performance outcomes related to specific tasks
- Identify the effects on the system and undesired outcomes
- Isolate factors most likely to cause human error
- Identify potential areas of risk
- Quantify the overall risk
- Indicate systemic improvements

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HRA Techniques

- Human Error Probability
  - The number of actual errors / number of opportunities for error to occur

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HRA Techniques

- THERP - Technique for Human Error Rate Prediction
  - Analyzes success or failure of an operator actions as they were part of the system

- Steps
  - Identify system functions that may be affected by human error
  - Analyze jobs performed by human operators
  - Estimate probability of human error and undetected error on each task
  - Evaluate and estimate consequences of the error

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HRA Techniques

- HEART - Human Error Assessment and Reduction Technique
  - Identify a specific task
  - Assign a nominal human error probability
  - Result is quantified risk

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HRA Techniques

- SLIM - Success Likelihood Index Method
  - Link human error probabilities of a specific situation to performance-shaping factors
  - Involves a weighting and rating scale to quantify risk

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HRA Techniques

TESEO - T*ecnica empirica stima errori operatori*

- Evaluates the probability of a human error occurring throughout the completion of a specific task
  - The time available to the operator to complete the task
  - The operator's level of experience/characteristics
  - The operator's state of mind
  - The environmental and ergonomic conditions prevalent

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Limitations of HRAs

- Estimations are based on subjective (biased) judgements of the analysts
- Do not account for all human interactions throughout all aspects of system operations (installation, management maintenance, etc.)
- Relies on probability estimations where no data exists
- Estimations may not be transferable from on event to another

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Error Tolerance

- The best way to protect the system is to make it more error-tolerant
  - 30 minute rule
    - Allow the human operator time to think after initiating an action before an automated system takes over
  - Safety Factors
    - Backup systems or redundancies

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Human error is unpredictable and thus, inevitable

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Examples

- King's Cross Fire
- Avenida Suba Tragedy
- Explosions
- Three Mile Island

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King's Cross Fire

The King's Cross fire.

On 18 November 1987, the worst fire in the history of the London Underground began when a match was dropped on the escalators.

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King's Cross Fire

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Avenida Suba Tragedy - Colombia

On 24 April 2004, Bogota Colombia experience the worst "traffic" accident when an asphalt recycler land over a school bus.

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Avenida Suba Tragedy - Colombia

FPST-3213 22 EL TIEMPO

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Avenida Suba Tragedy

Newspaper EL TIEMPO

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Avenida Suba Tragedy

EL TIEMPO REUTERS

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Avenida Suba Tragedy

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Avenida Suba Tragedy

Memorial

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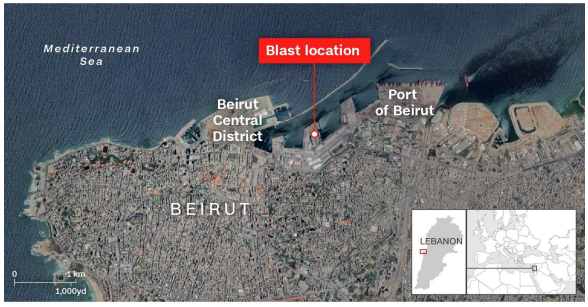
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Beirut explosion

On 4 August 2020, a **large amount of ammonium nitrate stored at the port of the city of Beirut**, the capital of Lebanon, exploded, causing at least 200 deaths, 3 reported missing, 6,500 injuries, US$ 10–15 billion in property damage, and leaving an estimated 300,000 people homeless.

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Beirut explosion

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Beirut explosion

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Beirut explosion

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Beirut explosion

BLAST SITE

WIDESPREAD DESTRUCTION

WINDOWS BLOWN OUT UP TO 15 MILES AWAY

Beirut

HEAVY DAMAGE

DAMAGE REPORTED

Imagen: https://www.eurixe.com/

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Beirut explosion

Satellite images show damage at Beirut blast site

25 Jan 2020

5 Aug 2020

Grain silos

Location of blast

Source: Cnes 2020, Distribution Airbus DS

BBC

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Beirut explosion

GETTY IMAGES

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Beirut explosion

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Beirut explosion

HASSAN AMMAR / AP
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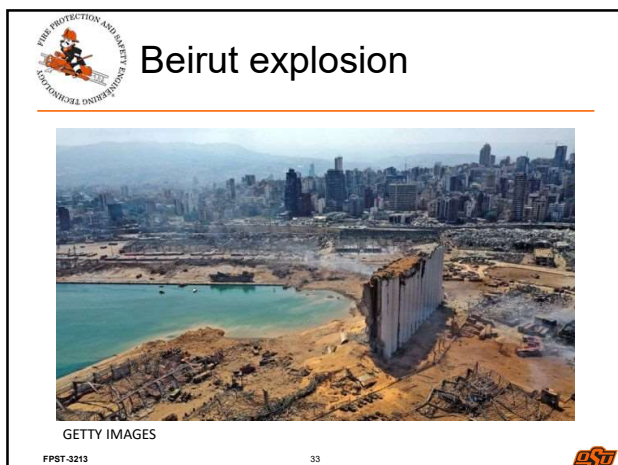
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Beirut explosion

REUTERS

GETTY IMAGES

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Mexico Explosion

On 18 January 2019, a pipeline transporting gasoline exploded in the town of Tlahuelilpan, in the Mexican state of Hidalgo. The blast killed at least 137 people and injured dozens more. Mexican authorities blamed fuel thieves, who had illegally tapped the pipeline.

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Mexico Explosion

Foto: Coordinación Social del Gobierno de México

Imagen: TV Azteca

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Mexico Explosion

Imagen: CNN en español

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Mexico Explosion

Imágenes: CNN en español

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Three Mile Island

https://www.youtube.com/watch?v=eGI7VymjSho

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Information Transfer

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Information Transfer

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Information Transfer

- Common Information Transfer Errors
  - Not complying with a warning
  - Misinterpretation of instructions
  - Information overload from too many codes
  - Entering information in the wrong location on a form
  - Transposing numbers
  - Correct signal might not be sent
  - Label and function not synchronized
  - Behavioral stereotypes
  - ???

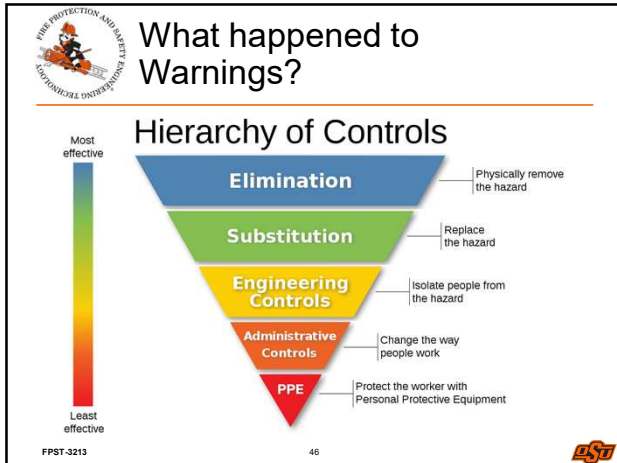FPST-3213   44

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Warnings

To provide individuals with information regarding

_____

WARNING
THIS SIGN IS ONLY A DISTRACTION

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What happened to Warnings?

Hierarchy of Controls

Most effective

- **Elimination** — Physically remove the hazard
- **Substitution** — Replace the hazard
- **Engineering Controls** — Isolate people from the hazard
- **Administrative Controls** — Change the way people work
- **PPE** — Protect the worker with Personal Protective Equipment

Least effective

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What Makes an Effective Warning?

- Easily Identifiable
- Distinguishable from the background noise
- Interpretable
- Understood by the user population

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CAUTION THIS SIGN HAS SHARP EDGES DO NOT TOUCH THE EDGES OF THIS SIGN — ALSO, THE BRIDGE IS OUT AHEAD

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Audible Alarms

- Incidental
  - Warn after problem has started
- Intentional
  - Engineering sounds specifically designed to warn
- Different types
  - Speech
  - Non- speech
  - Auditory icons

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Speech Signals

- Recognition
  - Preceded by signal
  - Change in voice
  - Distinct from ambient
  - Repetition

- Urgency
  - Female voice
  - Short word duration
  - Emotional voice

- Process 3 messages in emergencies
  - 7 under normal conditions

- Preferred
  - Best response
  - Easy to learn / remember

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Speech Signals

- High workload conditions

- The perceived urgency depends
  - Pitch, intensity, duration

- Use the words
  - Danger, caution, warning

- Example: _____
- Evacuation/Emergency: Voice Sample from Matthew Kelly (Highcroft.com) - Bing video

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Speech Signals

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Non-speech Signals

- 10 dB above ambient
- Standardized within facility
- Use stereotypes
  - Urgency
    - Speed: faster
    - Pulse level: high
    - Interval: short

- Example: _____Evacuate alarm sound - Bing video

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Audibility vs. Intelligibility

- Audibility

- Intelligibility

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Requirements

- In areas greater than 85 dB, meeting intelligibility requirements may not be possible and other means of communication might be required

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Requirements

- According to NFPA 72:
  - Male voice provides for better intelligibility outdoors
    - Lower frequency travels better
  - Female voice better for indoor messages
    - More distinct from typical ambient noises

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Visual Signals

- Signal word
- Hazard
- Consequences
- Instructions

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Visual Signals

- Signal word

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Visual Signals

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Legibility of Color Combinations

Very Good	O	O		
Good	O	O	O	O
Fair	O	O		
Poor	O	O	O	O
Very Poor	O	O		

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Coding

- Color Coding
- Shape Coding
- Alpha Coding
- Symbol Coding

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Coding

- Detectable
- Meaningful
- Stereotypes
- Standardized

Blue Medical Emergency	Grey Threatening Behaviour
Red Fire / Smoke	Black Serious Aggression
Orange Evacuation	Brown External Emergency
Yellow Internal Emergency	Purple Bomb Threat

Australian Standard 4083-2010 Planning for Emergencies – Health care facilities

firewize

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Labels and Signs

- Comprehensibility
- Legibility
- Readability

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Too many signs….

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Too many signs….

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Too many signs….

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Written Instructions

- Not paragraphs
- Diagrams and text (inexperienced)
- Diagrams only (experienced)
- Warnings in instructions
  - Reading level 7 or 8 (average population)

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1. Calculate the average sentence length:

   L = Number of words + Number of sentence

2. Calculate the average number of syllables per word:

   N = Number of syllables + Number of words

3. Determine grade level:

   Reading level = (L x 0.39) + (N x 11.8) – 15.59

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Example

Prior to entry, the entry supervisor must ensure that the authorized entrants are fully informed of hazardous materials or conditions they are likely to encounter by conducting a safety preparation briefing.

- 31 words
- 1 sentence
- 58 syllables

- Reading level = (31/1*0.39) + (58/31*11.8) – 15.59
- Reading Level = 18.6

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Wacky Warning Labels

Warning:
Never use while sleeping.

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Wacky Warning Labels

Warning:
Never use this product while driving.

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Written Instruction

- Passive vs. Active voice

Five hamburgers must have been eaten by the man.

Hamburgers (subject) *are being **eaten*** (verb).

The letter was mailed by Marilyn.

The **letter** (subject) *was being **mailed*** (verb).

The man must have eaten five hamburgers

The **man** *(subject)* is doing the **eating** (verb).

Marilyn mailed the letter.

Marilyn (subject) is doing the **mailing** (verb).

Colorful parrots live in the rainforests.

Parrots (subject) are doing the **living** (verb).

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Written Instruction

- Safe
- Adequate
- Appropriate
- Sufficient
- Correct
- Suitable
- Applicable
- Acceptable
- "Be Careful"

What's wrong with these words?
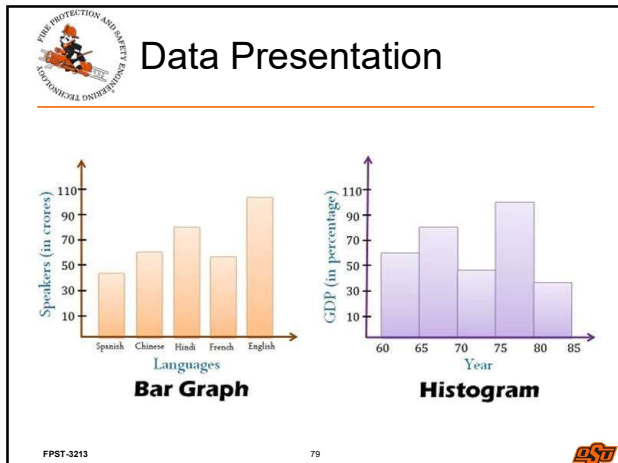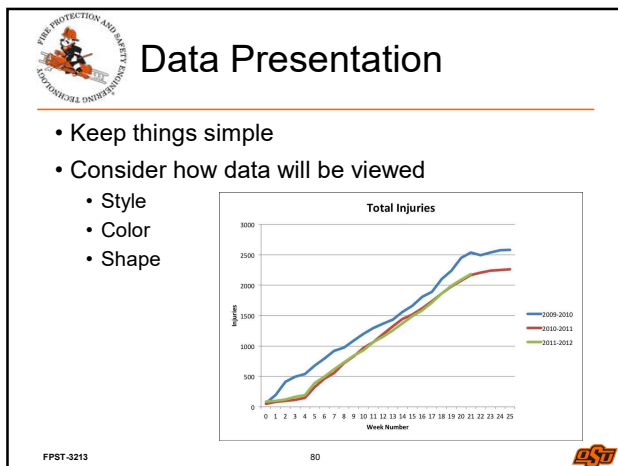
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Written Instruction

- What's wrong with this sentence?

- Ensure the permit is complete

  - It's active voice
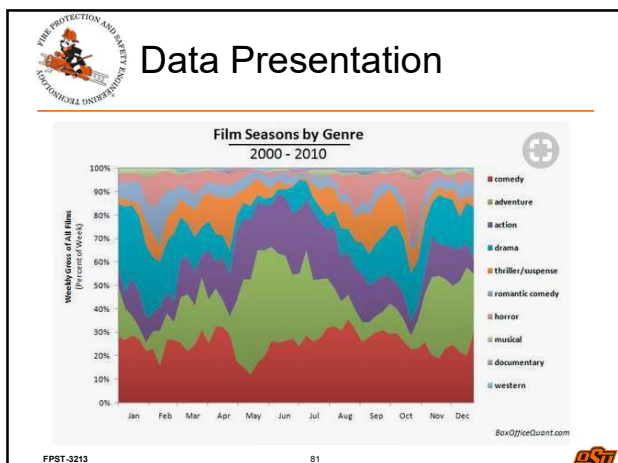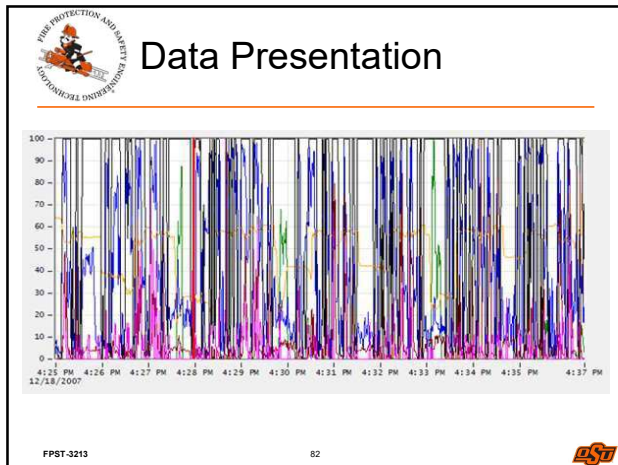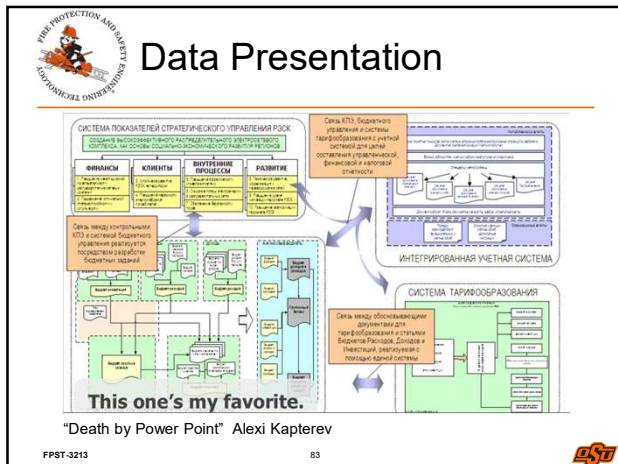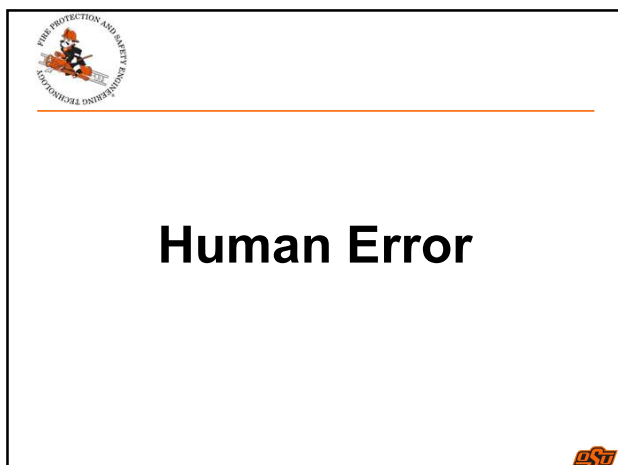 - It does not who must ensure

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Data Presentation

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Data Presentation

This one's my favorite.

"Death by Power Point" Alexi Kapterev

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Human Error

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To Err is Human…

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How Can Human Error Prevention Help Safety?

https://www.youtube.com/watch?v=ILmJ1Mm13IQ

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Is 99.9% Good Enough?

- 870 unsafe landings per day in US

- 105 dropped babies per day

- 56 lost pieces of mail per second

- 123,287 incorrect drug prescriptions per day

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Stats

- About 80% of all workplace incidents are attributed to human error
  - Closer to 90% in some industries

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Stats

- When broken down further…

  - Majority of errors stem from latent organizational weaknesses

  - About 30% are caused by the individual worker touching the equipment and systems
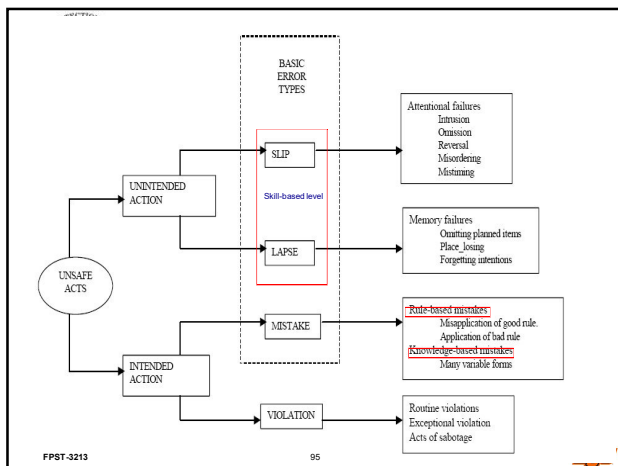
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Human Error

- Not all of errors lead to a disaster or loss:

- What are these events called?

- Errors of **omission**
- Errors of **commission**

- **There are only two reasons why someone does something unsafe.**

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Human Factors

- Population
- Environment
- Situation

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Views of Human Error

- Old view

  - System is fine except for the people
  - Human error causes potential for failure

  - Human error is a conclusion of incident investigations

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Views of Human Error

- New view

  - Human error…a symptom of deeper trouble
  - …the starting point to determining failure

  - System is not inherently safe…people create safety, efficiency, productivity

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Why Error Occurs

- Old view
  - Says what people failed to do
  - States what people should have do to prevent the incident
  - Single out poor performers
  - Find evidence of bad behavior
  - Unreliable people weaken a safe system

- Corrective actions
  - Replace people
    - …with new people or technology
  - More procedures…more training

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Why Error Occurs

- New view
  - Not the cause of incidents
  - Not random
  - Understand <u>why</u> people did what they did
    - Why did their decision make sense to them at the time of the incident?
    - What conditions produced the behavior?
  - Nobody comes to work to do a bad job
  - Corrective Actions?

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100

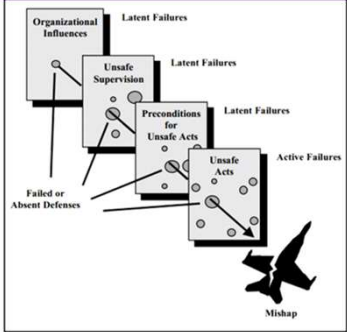## Reactions to Failure

- Looking back on the event sequence knowing the outcome
- Focused on what people should have done knowing the outcome

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Two Kinds of Error: Active and Latent

Model of Human Error causation (Reason, 1990).
Adapted from Shappel (2000)

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Latent Organizational Weaknesses (sources)

- Processes (structure)
  - Work controls
  - Accountability policies
  - Reviews & approval processes
  - Equipment design
  - Procedure development
  - Human resources
  - Training
- Values (relationships)
  - Measures & controls
  - Critical incidents
  - Coaching & teamwork
  - Rewards & sanctions
  - Reinforcement
  - Promotions & terminations

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Risk Perception/Tolerance
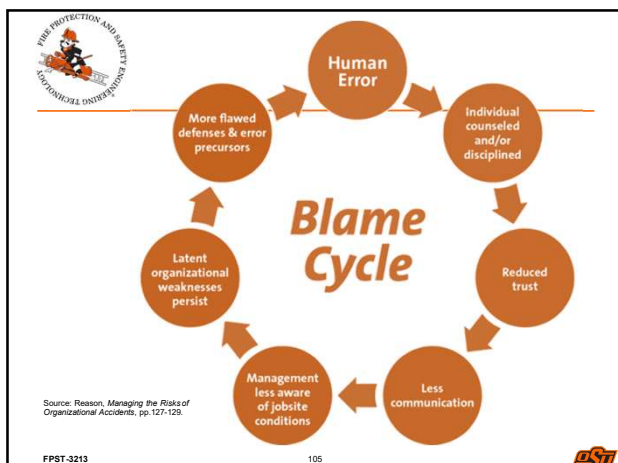
Factors that affect Risk Tolerance
- Pride
- Heroism
- Fatalistic
- Invulnerability
- Pollyanna
- Bald Tire

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Source: Reason, *Managing the Risks of Organizational Accidents*, pp.127-129.

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Human Error

- 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 due largely on the encouragement and reinforcement received from leaders, peers, and subordinates.
- Events can be avoided by understanding the reasons mistakes occur and applying the lessons learned from past events (or errors).

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Do you believe a facility can be operated indefinitely without events?

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Human Error

Story seems so simple
- Somebody did not pay enough attention
- If only somebody had recognized the significance of this indication, of that piece of data, then nothing would have happened
- Somebody should have put in a little more effort
- Somebody thought that making a shortcut was not a big deal

https://youtu.be/Fw3SwEXc3PU

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