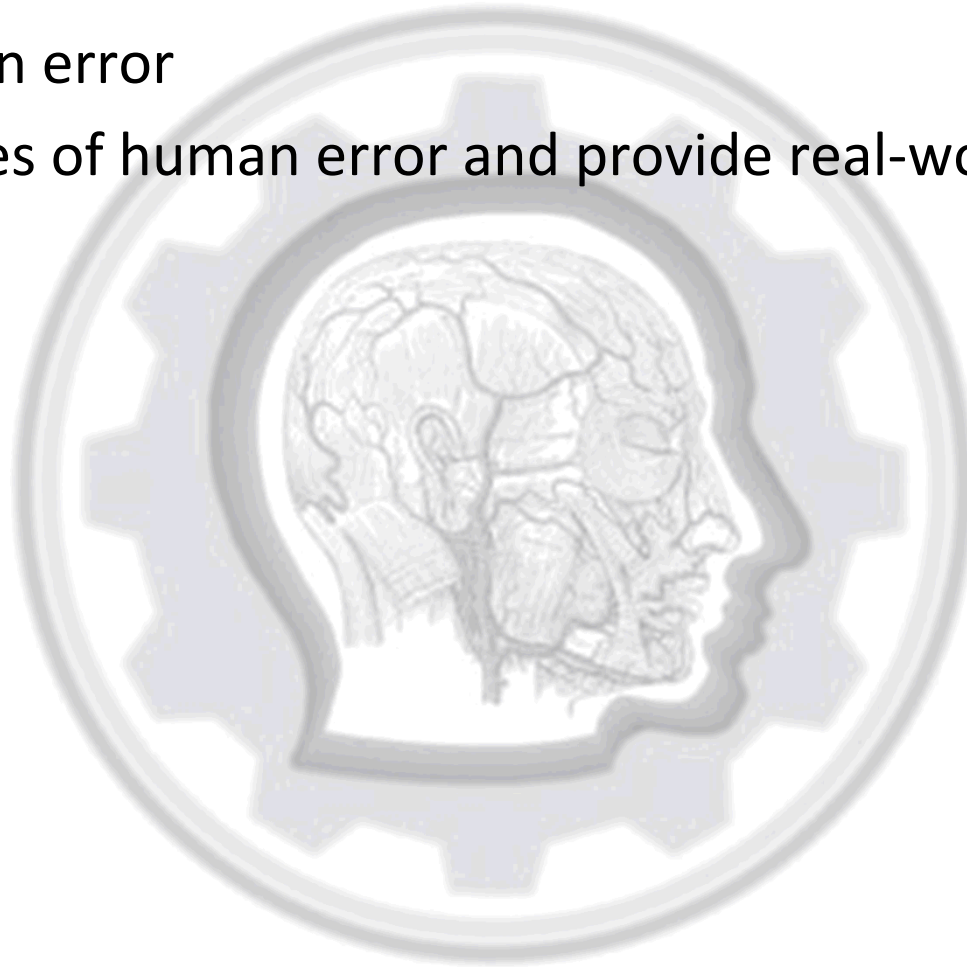


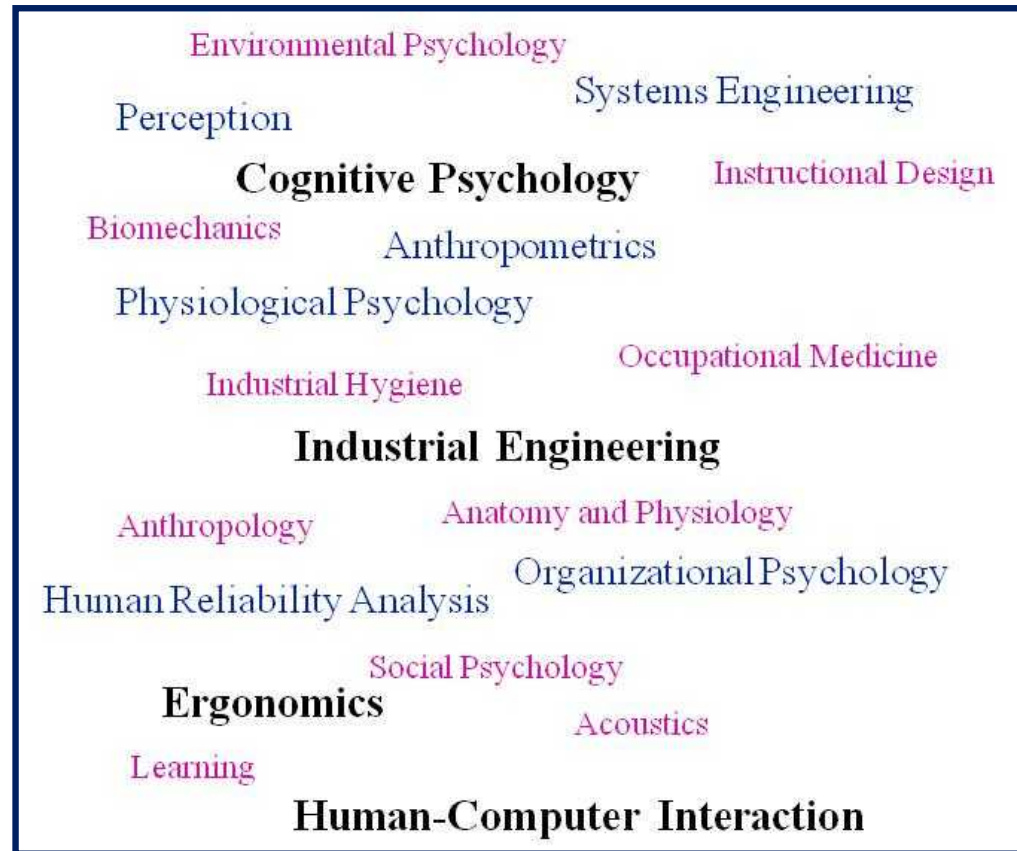
Purpose

- Describe human factors
- Define human error
- Discuss causes of human error and provide real-world examples



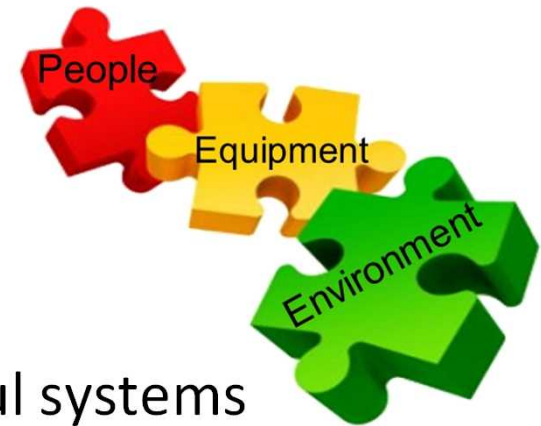
What is human factors?

- Scientific discipline that applies knowledge about human abilities, characteristics, and limitations to design jobs, equipment, and environments
- A.k.a ergonomics and human-centered design
- Human factors education
 - Advanced Master's and Doctoral degrees
 - Industrial Engineering or Psychology Departments
 - Professional certification
- Human factors is **NOT**
 - Human resources
 - Simple common sense



Human Factors in Systems Engineering

- System is a set of interrelated components that interact in an organized way to achieve a common goal
 - Equipment
 - Environment
 - People
- Systems engineering is an interdisciplinary approach to enable the realization of successful systems
- Human factors is an important element
 - Focuses on human element of the system
 - Identifies human capabilities and limitations impacting system performance
 - Analyzes critical interactions between people and equipment
 - Mitigates negative impacts of environment on human performance
 - Noise
 - Glare

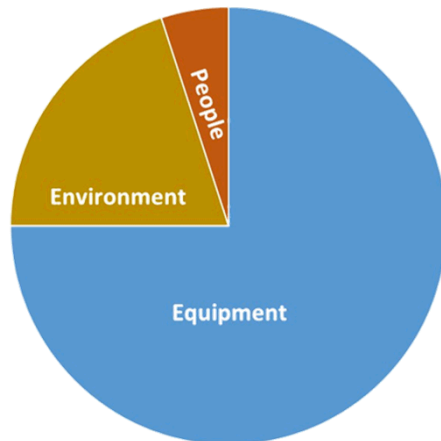


When Should Human Factors Be Included?

- Optimally in conceptual design phase
 - Ensure proposed design is congruent with human capabilities and limitations
 - Address human element early before HW and SW are firmly established
- Costs of incorporating human factors are reasonable if done early
 - Investment in human factors up front can yield cost savings
 - Avoid design changes late in development and rework during production or support activities
 - Costs to fix errors escalate exponentially over lifecycle
 - Errors can be 30 to 1500 times more costly to correct in operations as compared to design phase¹
 - Early incorporation of human factors means less reliance on training and procedures down the line
 - Errors are reduced when design is human-centered

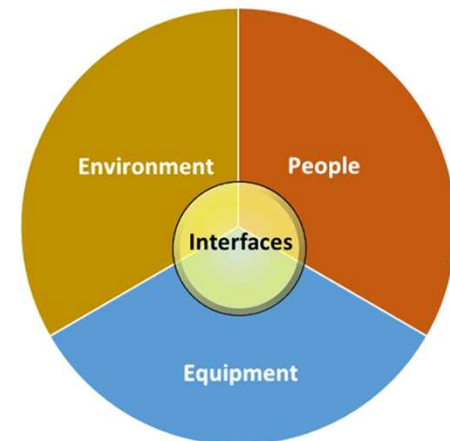
Systems Engineering Approaches

Typical



- People are a critical component of the system, ***yet***
- Most approaches typically “forget” the people until after the system is fielded²
- People and their interfaces with equipment and environment receive little to no attention

Ideal



- Focus equally on all system elements and their interfaces
- Recognize that most problems stem from people^{3,4}
 - Up to 45% of nuclear power plant accidents
 - 60% of aircraft accidents
 - 80% of NASA Type A/B mishaps
 - 90% of road traffic accidents

What is Human Error?

Failure of planned actions to achieve desired ends

Traditional View	Human Factors View
<ul style="list-style-type: none"> • Inevitable • Little can be done to prevent it 	<ul style="list-style-type: none"> • Performance is predictable • Humans are reliable in certain conditions
<p>Explanation of failures: blame the individual – find out what he/she did wrong</p>	<p>Explanation of failures: discover how people’s decisions and actions made sense under the given circumstances</p>
<p>Causes: carelessness, poor attitudes, and inattention to detail</p>	<p>Causes: increases in system complexity and poor system designs</p>
<p>Cures: “blame and train”</p>	<p>Cures: manage specific causes of error</p>

Typical Human Error Probabilities

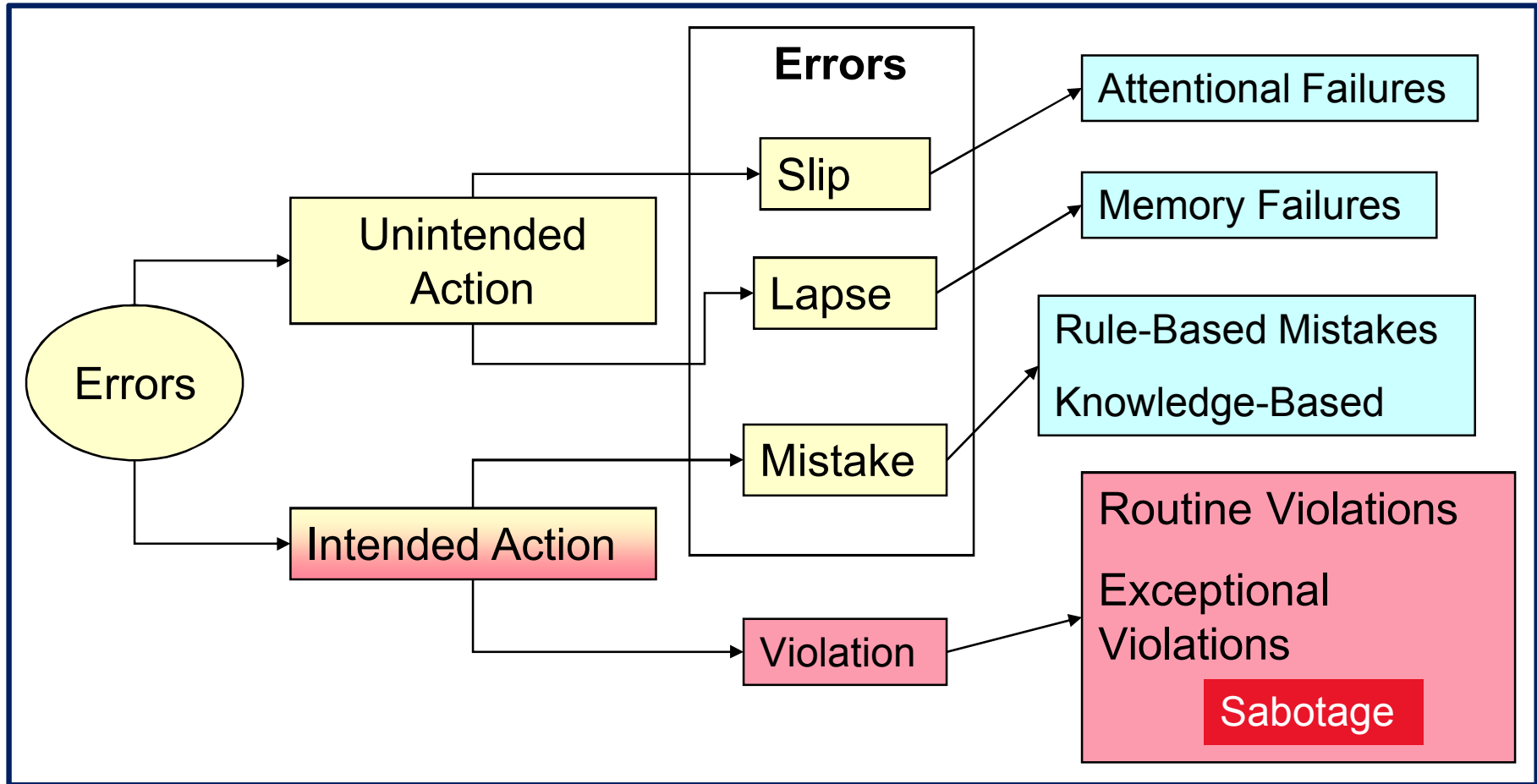
- 3 to 7 errors per hour are typical under normal conditions⁵
- Up to 15 errors per hour in stressful or unusual conditions⁵
- Pilots average 10 to 15 errors per hour⁶

Human Action	Human Error Probability
Select wrong switch	.003 (.001 to .009)
Mate connector incorrectly	.003 (.001 to .009)
Omit item in written procedure with >10 items, no checkoff	.01 (.003 to .03)

From Swain, A. D., & Guttman, H. E. (1983). *Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Application*. Technical Report NUREG/CR-1278-F SAND80-0020. Albuquerque, NM: Sandia Corporation.

- By comparison, toggle switch fails once per million hours

Human Error Taxonomy



- Different types of human error have different causes
- Prevention and mitigation can be tailored to error types

Preventing Human Error

Error Type	Description and Prevention
Slip	<p>Description: • Person does something, but not what they intended</p> <p>Cause: • Poor display-control compatibility or deviation from routine</p> <p>Prevention: • Better displays/controls</p> <p>Example: • Record part size as .25 inches instead of .28 inches</p>
Lapse	<p>Description: • Person forgets to do something they meant to do</p> <p>Cause: • Failure of prospective memory</p> <p>Prevention: • Checklists, procedures, explicit reminders</p> <p>Example: • Forget to replace a screw after inspection</p>
Mistake	<p>Description: • Person does what they intended, but act is inappropriate</p> <p>Cause: • Lack of knowledge</p> <p>Prevention: • Training to improve knowledge or better displays</p> <p>Example: • Turn right but did not see one-way street sign</p>
Violation	<p>Description: • Person intentionally commits an inappropriate act</p> <p>Cause: • Inadequate safety culture or insider threat</p> <p>Prevention: • Emphasis on safety culture or remedial training</p> <p>Example: • Intentionally ignore criteria in inspection procedure</p>

When and How Does Human Error Occur?

Poor consideration of interfaces between one or more system components

Incident

Error Type

Cause

Prevention

Pilot landing blunders

Slip

Poor knobs,
dials, switches

- Make controls distinct visually and haptically
- Use consistent layout

Killer Tamagotchi toy

Mistake

Multi-tasking
and distractions

- Put Tamagotchi in trunk
- Warn driver to re-orient to the road ahead

Missile silo explosion

Violation

Lack of
resources

- Remove ratchet from blast door site
- Avoid 12-hour days

Set phasers on stun

Mistake

Ambiguous
displays

- Use “wait” prompt
- Provide informative error diagnosis and recovery

“Forgotten” baby

Lapse

Changes in
routine

- Set up reminder cues
- Use STAR when outside normal routine

Ambiguous Labels or Procedures

- Human error can occur if procedures are difficult to interpret
 - Ambiguous or vague steps
 - Technically inaccurate information
 - Mismatch between procedural steps and order tasks must be performed
 - Critical information that is missing
 - Lack of graphics for complex steps
 - References / branching to other procedures
 - More than one instruction in a step
 - Overuse of critical steps

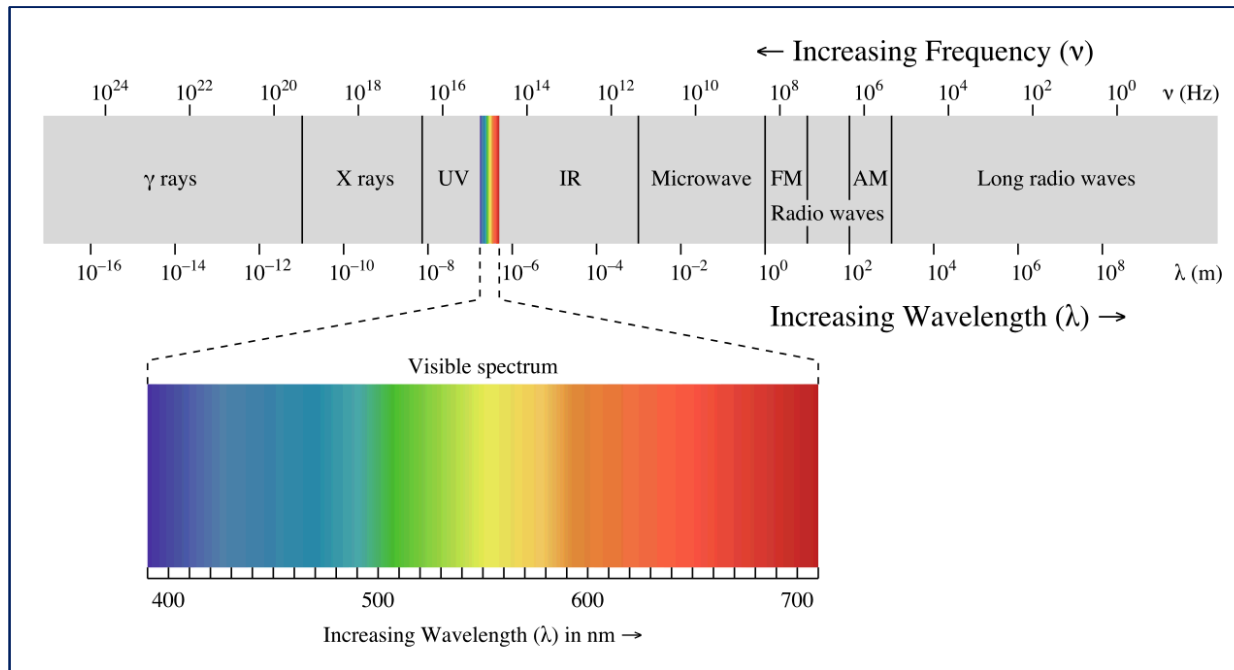
Turboprop plunges to the ground

Slip

- Elevator control cables incorrectly adjusted during maintenance due to ambiguous procedures
 - Unclear which steps were needed for cable tension adjustment only
 - Many extraneous steps applied to other aircraft, not the 1900D

Disregarding Human Limitations

- Human error can occur if people are asked to perform tasks beyond their capabilities
- Human vision limited to narrow band of electromagnetic spectrum
 - Colorblind people may have further limitations in visible range
 - People with normal color vision may still have problems if overall illumination, glare, and contrast are not taken into account

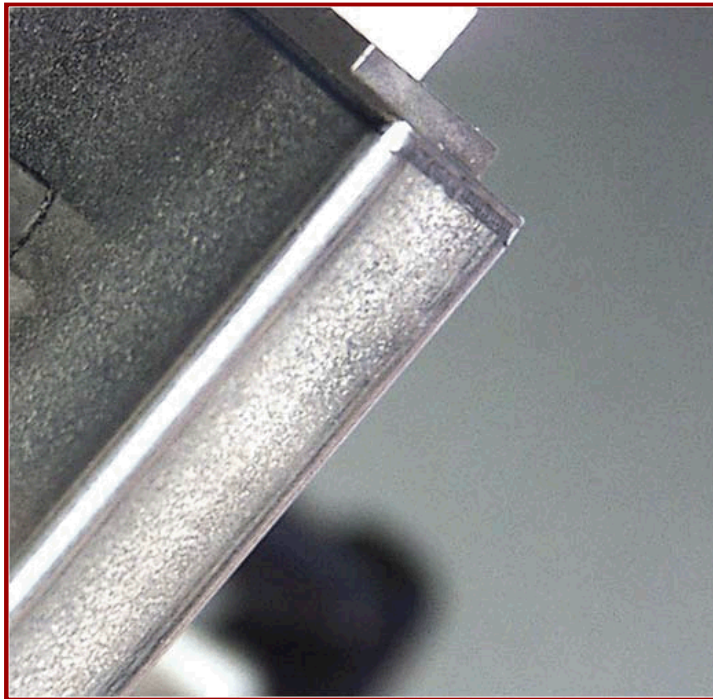


Disregarding Human Limitations - Example

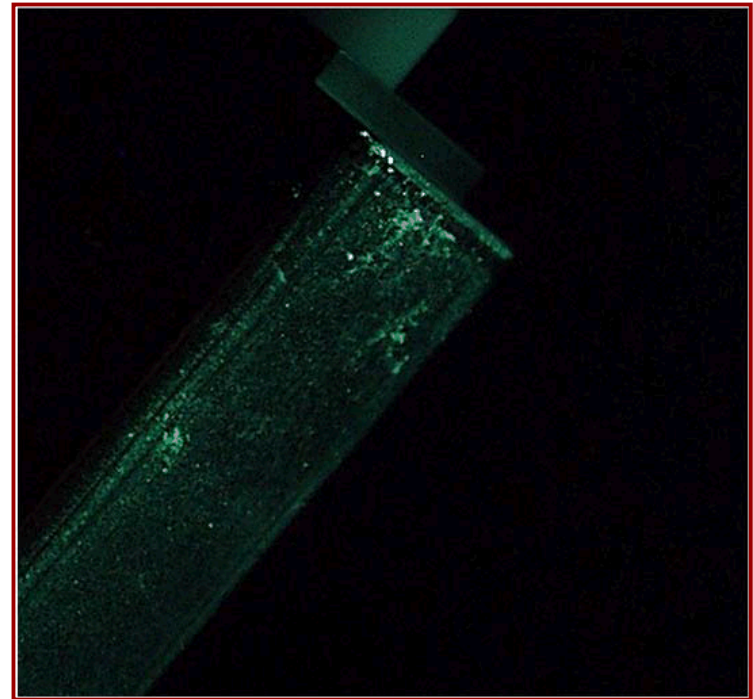
- Inspectors repeatedly missed gel contamination on a part
 - Undetected gel contamination causes ruptures during welding
 - Parts must be scrapped altogether
- Inspection under a green LED light eliminated the error

Mistake

BEFORE



AFTER



Conclusions

- Include human factors early in design
 - Achieve a balanced systems engineering approach
 - Cheaper and easier than attempting to mitigate human error in a fielded system
- Human error taxonomy helps identify causes and tailor future mitigations
- Human error is a symptom of poor system design, **not** a root cause



References

1. Steicklein, J. M., Dabney, J., Dick, B., Haskins, B., Lovell, R., & Moroney, G. (2004). *Error cost escalation through the project life cycle* (Report JSC-CN-8435). Houston, TX: NASA Johnson Space Center. Houston, TX.
2. Schatz, S. (2016, February). *Advanced distributed learning*. Paper presented at the 2016 National Defense Industrial Association (NDIA) Human Systems Conference, Springfield, VA.
3. Pheasant, S. (1991). *Ergonomics, work and health*. Gaithersburg, MD: Aspen Publishers.
4. NASA Armstrong Flight Research Center (2017, May). *Human factors and risk management: It's not rocket science*. Retrieved from https://sma.nasa.gov/docs/default-source/safety-messages/human-factors-and-mishap-prevention-v8---26-april-17_gg-cb-webversion_508v2.pdf?sfvrsn=2
5. Farris, R., & Richards, B. (2009, August). *Session 4b: Human performance and organizational resilience*. Paper presented at the 2nd International Symposium on Resilient Control Systems, Idaho Falls, Idaho.
6. Senders, J. W. (1980). Is there a cure for human error? *Psychology Today*, 17, 52-62.