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What is Human Factors and Why is it Important?

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Structurally sound aircraft plummet to earth, ships run aground in calm seas, industrial machines run awry, and the instruments of medical science maim and kill unsuspecting patients, *all because of incompatibilities between the way things are designed and the way people perceive, think, and act.*

(Casey, 1993)

A Definition of Human Factors

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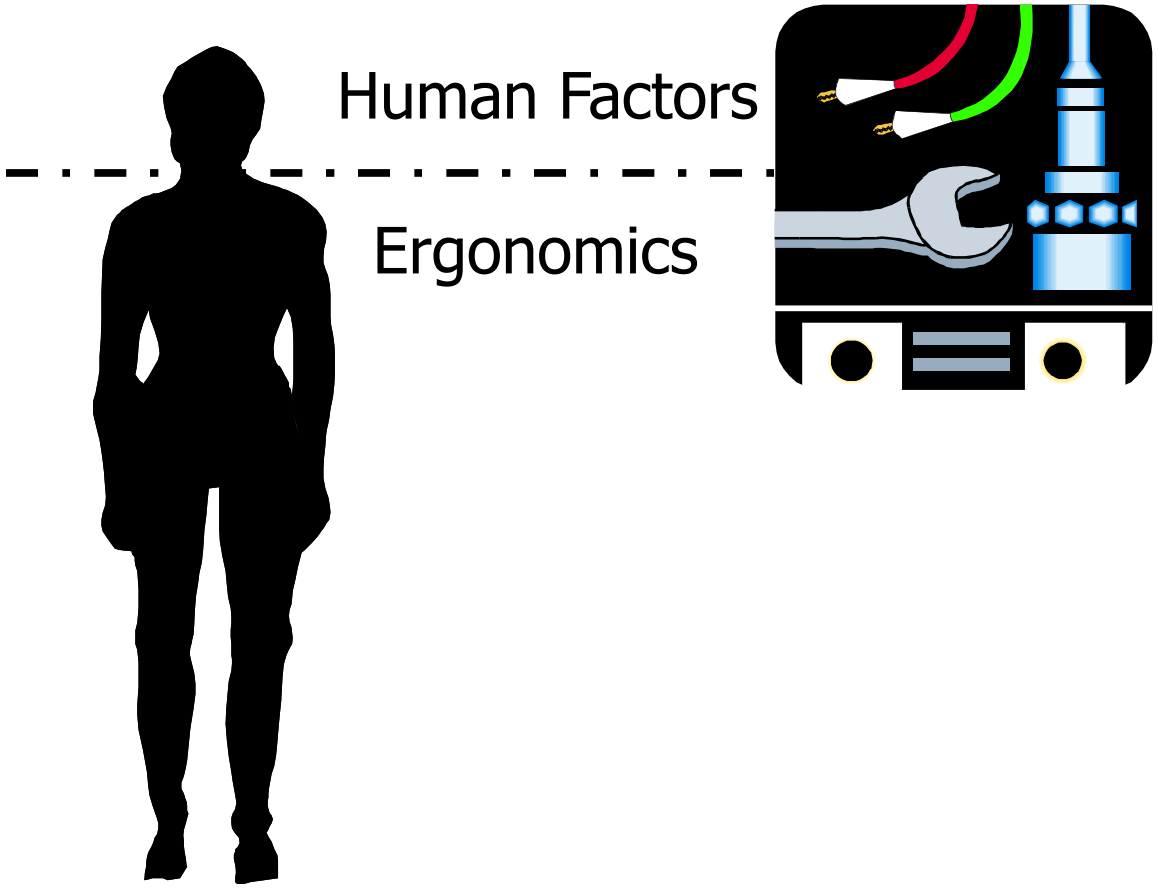
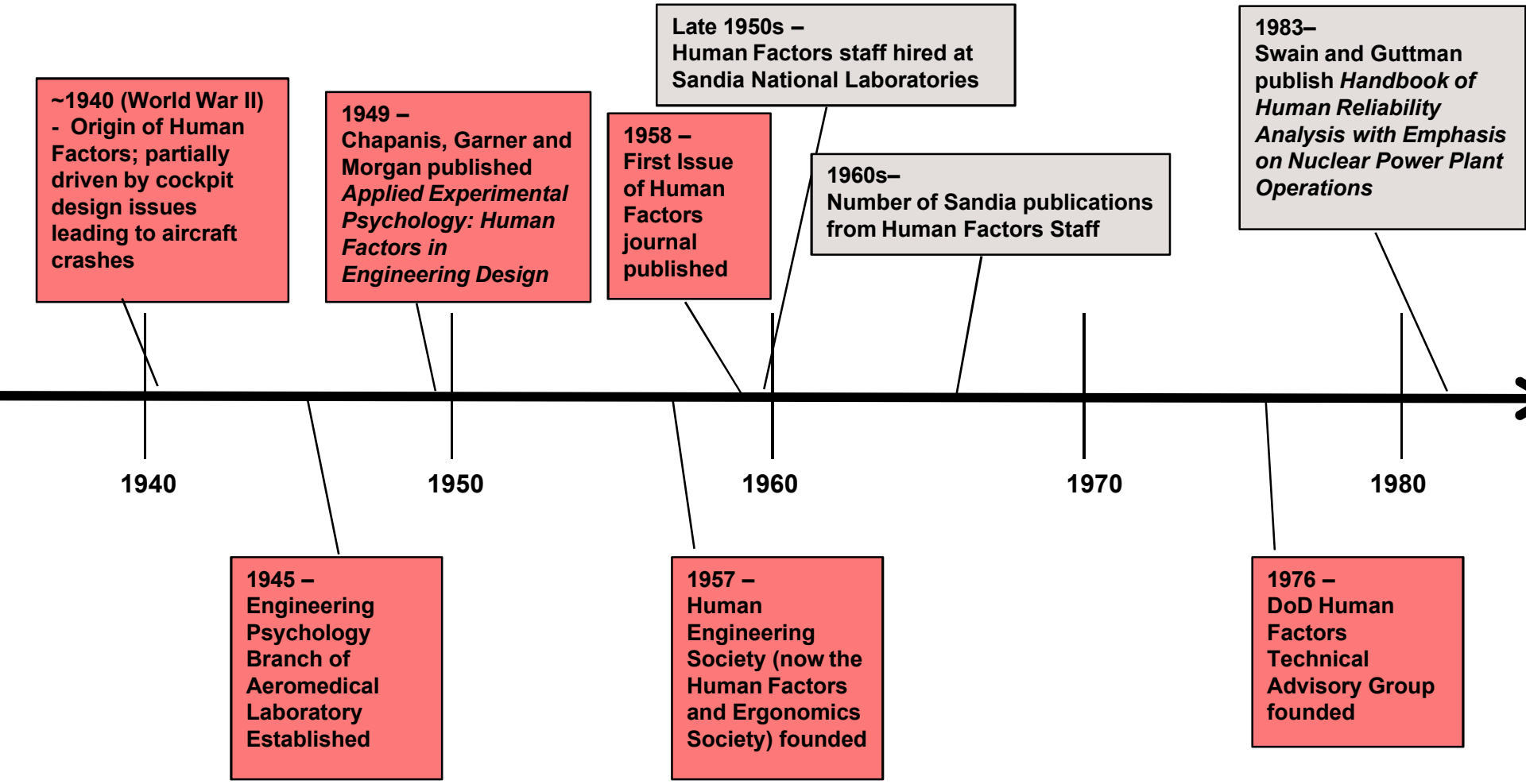
A discipline that discovers and applies information about human behavior, abilities, limitations and other characteristics to the **design of tools, machines, systems, tasks, jobs, and environments** for productive, safe, comfortable and effective human use.

(Chapanis, 1985)

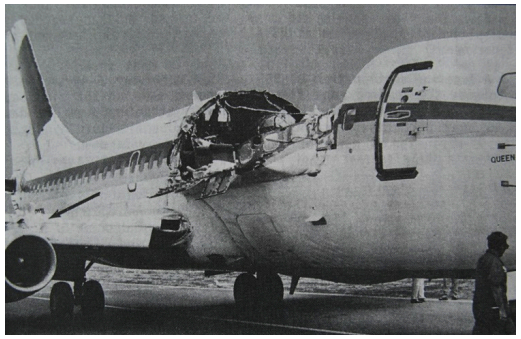
Human Factors vs. Ergonomics



Some milestones in the 60+ year history of Human Factors



HFE-related events



Aloha Airlines Accident, 1998

WWII Era Cockpit Design, 1940s

Medication Error for Dennis Quaid's Twins, 2007

DC-10 Accident, 1972

Herald of Free Enterprise, 1984

Three Mile Island, 1979

Current Status of Human Factors as a Technical Discipline

- HFES has more than 4500 members, and 23 technical groups
  - ~70% of members hold doctoral or masters degrees
  - ~15% of members hold bachelors
  - ~15% are students

Aerospace Systems	*Individual Differences*
Aging	*Industrial Ergonomics*
Augmented Cognition	*Internet*
Cognitive Engineering and Decision Making	*Macroergonomics*
Communications	*Perception and Performance*
Computer Systems	*Product Design*
Education	*Safety*
Environmental Design	*Surface Transportation*
Forensics	*System Development*
Health Care	*Test and Evaluation*
Human Performance Modeling	*Training*
	Virtual Environments

Current Status of Human Factors as a Technical Discipline

- HFES Website currently lists 70 Human Factors/Ergonomics Graduate Programs in the US (Primarily in Psychology or Industrial Engineering)
  - HF is still primarily a graduate level degree
  - Only 14 undergraduate programs listed

Why should you care about Human Factors Engineering?

- **Human involvement can introduce hazards into engineered systems**
- **The controls we employ to protect us against other hazards often rely on human performance**
- **Human error can result in impacts to safety, security, quality, reliability, productivity….**

A Classic Design Problem

Which control do you use to turn on the front right burner?

Photograph courtesy of www.baddesigns.com

Instructions must be clear…

Photographs courtesy of www.baddesigns.com

Do you notice the difference between these two signs?

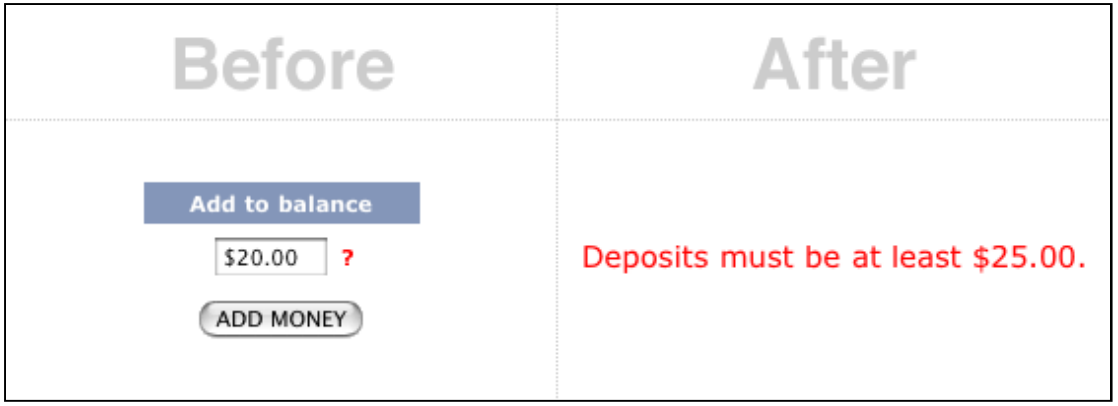
A Common Error ?

An accident waiting to happen?

Is the Control Effective?

Photographs courtesy of www.baddesigns.com

Some software examples



Why wait until after a mistake is made before providing instructions?

Why not design the form to prevent mistakes?

Examples from www.37signals.com

Goals of Human Factors in Design/Analysis

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- Ensures that the system is “adapted” to the human, rather than forcing the human to adapt to the system
- Allows the human to perform in the best manner of which he/she is capable, rather than hindering performance
- Ensures that the human is not subjected to extreme physical or mental stress or workload
- Provides personal satisfaction for the user

Humans in Engineered Systems

Systems are engineered with the intent that through the interaction of inter-related processes, they will operate in certain ways

- There is no escaping human involvement in engineered systems
- Humans are:
  - the most complex system component
  - the least understood system component
  - the system component most vulnerable to failure
- Humans present a remarkably diverse set of failure modes

Roles of Humans in Systems

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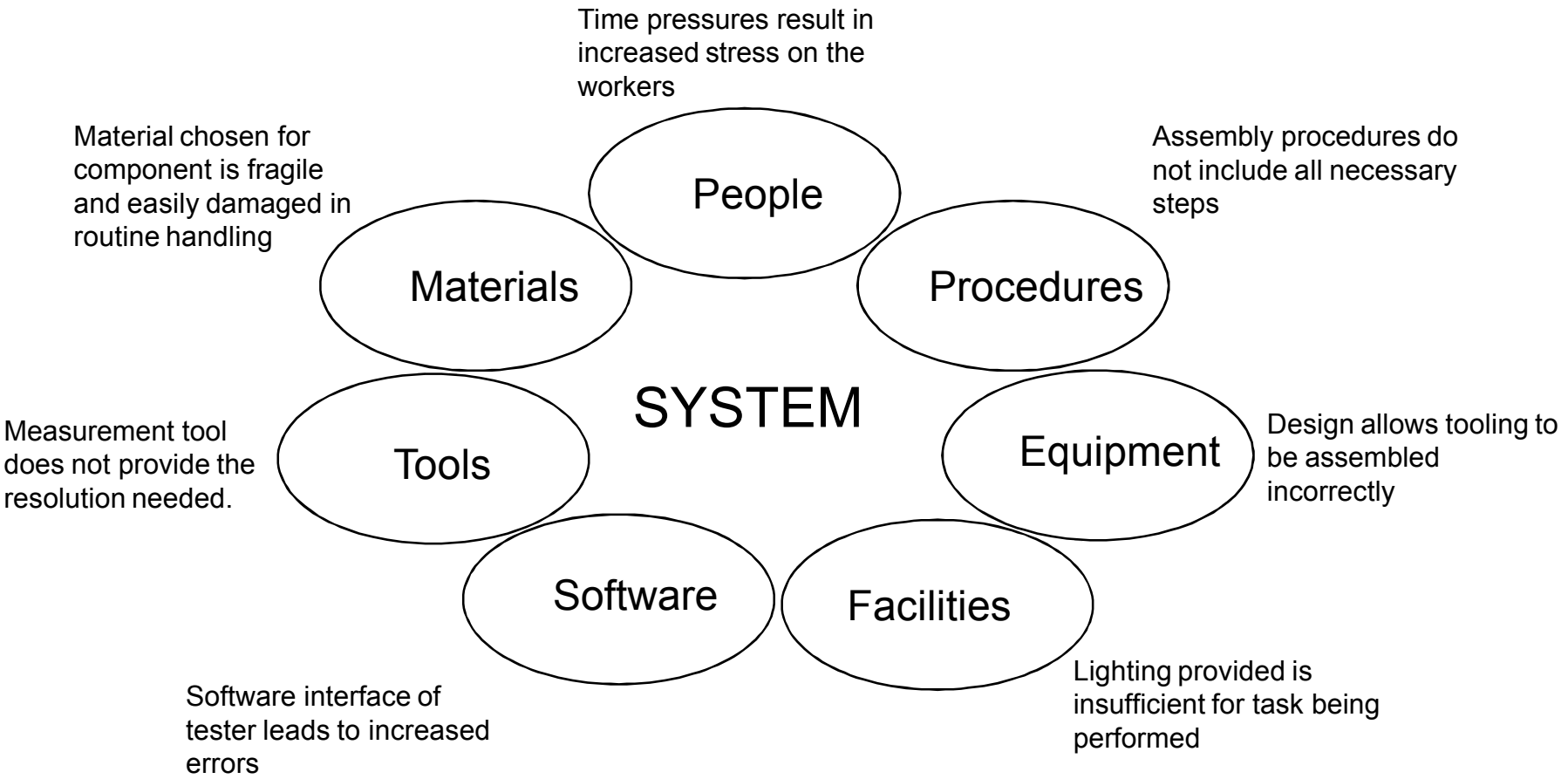
Human involvement at any point may introduce variability to the system



Understanding Human Performance

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- **Decision making is subject to a number of biases and heuristics.**
- **Hardware and workspaces must be designed to address anthropometric limitations of the users.**
- **Environmental factors may impact human performance.**
- **Physical and mental workload must be considered, and can not always be assessed by measuring performance.**

What Does Human Factors Consider?

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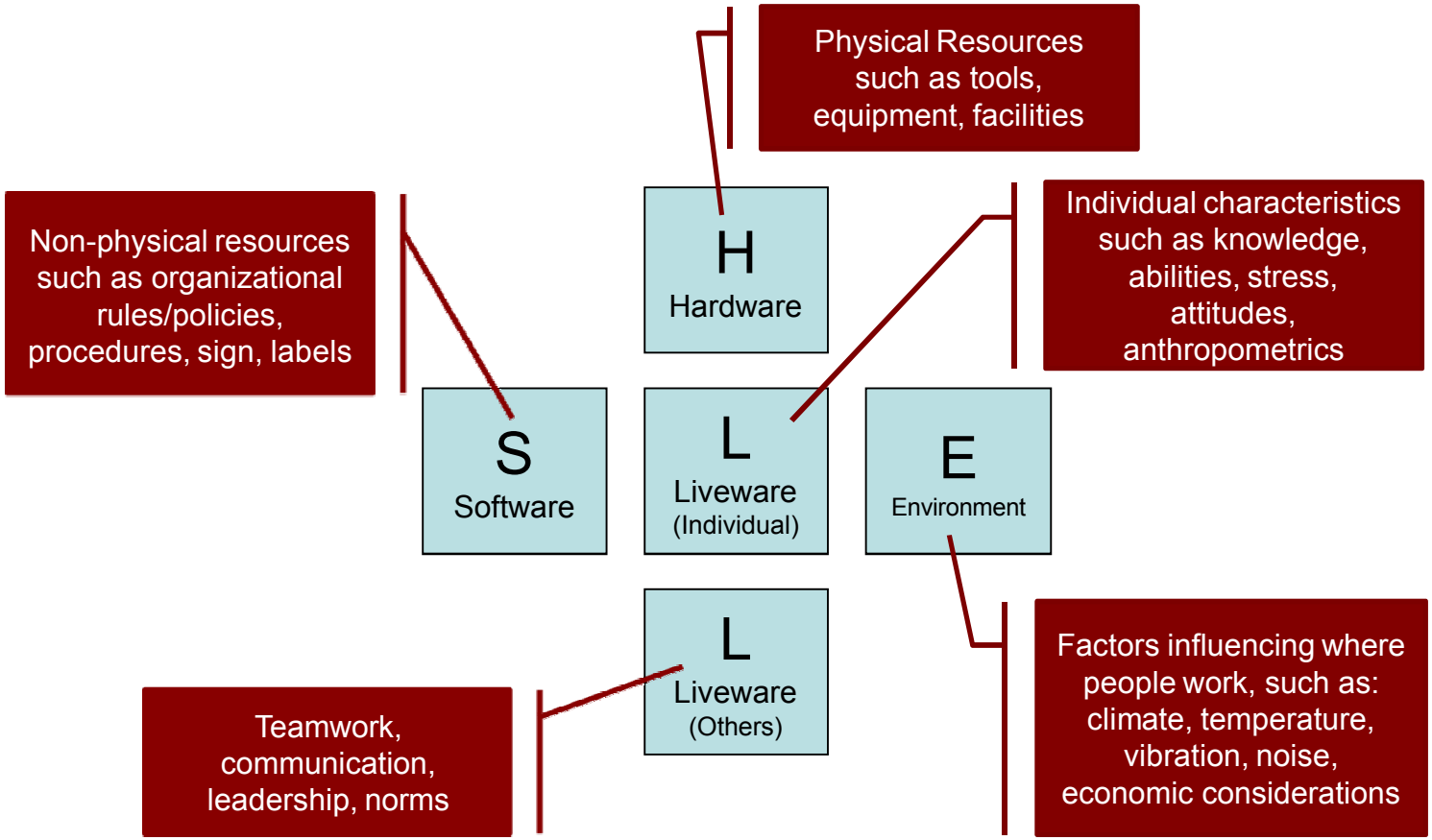
- "Knobs and Dials"
  - Are controls appropriately designed for the task being performed?
- Function Allocation
  - Which tasks are assigned to machines (e.g., automation) and which tasks are people asked to perform?
- Usability of Software, Hardware and Procedures
  - Are systems designed to be easily used?
- Physical and Mental Limitations
  - Can the people actually perform the tasks without suffering undue physical/mental stress?
- Environmental Factors
  - How do factors such as lighting, temperature, and noise impact performance?
- Potential for human error
  - Are systems designed to minimize the potential for human error and/or to mitigate the effects of human error?

The SHELL Model of Human Factors



SHELL Model (Hawkins, 1976)

How can Human Factors contribute?

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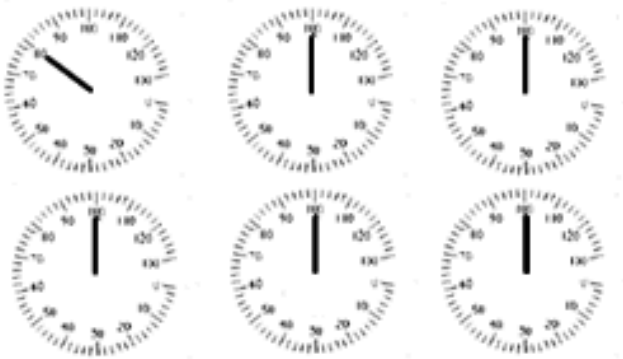
- Human Reliability Analysis
  - Quantify the likelihood of human error during component assembly
- Human Error Prevention
  - Design of assembly procedures
- Human Error Analysis
  - Investigate incidents/accidents to understand the active and latent errors, and develop corrective actions to prevent recurrence
- Task Analysis
  - Understand all of the tasks that a technician must perform, in order to better design a process and/or a procedure
- Vulnerability Analysis
  - Understand how a proposed defense will withstand attacks
- Hardware Design
  - Design tooling to reduce the likelihood of errors and injuries
- Physical Workspace Design
  - Design a benchtop assembly task to minimize errors and to maximize productivity
- Software Design
  - Design and evaluate an usable Interactive Electronic Procedure system
- Cognitive Modeling
  - Predict human decision making in a particular domain
- Empirical Evaluation of Human Performance
  - Design a study to evaluate human performance on a particular task

The Impact of Physical Workload

The Impact of Displays

How easy is it to recognize the device showing an abnormal reading?



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The Impact of Control Design

New Mexico

••• ALBUQUERQUE JOURNAL THURSDAY, OCTOBER 27, 2005 C3

Blast Blamed on Equipment

Refinery Had Faulty Seals

BY MELANIE DABOVICH
The Associated Press

Federal investigators said Wednesday an April 2004 explosion at the Ciniza refinery east of Gallup that seriously injured four workers was due to faulty equipment and seals.

"The mechanical integrity program at this refinery did not prevent repeated failures of seals" on pumps in the refinery's alkylation unit, Johnnie Banks, lead investigator for the U.S. Chemical Safety and Hazard Investigation Board, said at a news conference in Albuquerque. The unit is where high-octane ingredients for gasoline are made.

The refinery, owned by Scottsdale, Ariz.-based Giant Industries Inc., fixed things as they broke rather than trying to address why seals were not functioning, he said.

There were 23 maintenance work orders submitted on the pumps in the year before the explosion, Banks said.

He said Giant should have determined the cause of the malfunctions and implemented a program to prevent them.

Leland Gould, executive vice president for Giant, said Wednesday company officials had just received the report and needed time to analyze it before they could comment.

The board's investigation found the design of valves on the pump contributed to the accident.

Giant in 1998 replaced valves that closed by a hand wheel mechanism with those that were closed by a bar-type hand wrench. The investigation said the company did not evaluate what hazards the change in design could cause.

Before the explosion, workers thought the valve was shut by the position of the wrench when in fact it was open, investigators said.

Operators "did not adequately verify that the pump involved in this incident was isolated and depressurized before attempting to remove it," the board's report said.

The agency had zeroed in on the possibility of an open valve early in its investigation into the fiery April 8, 2004, explosion. Giant initiated its own investigation as well.

According to the federal report, workers performing regular maintenance on the pumps the day before the explosion discovered a leaking seal. An operator turned a shut-off valve to what he believed was the "closed" position, and then placed locks and tags on the valve to prevent inadvertent opening and to indicate it had been closed.

When mechanics came in the next day to repair the problem, they disconnected the pump, thinking the valve was shut.

They were removing the pump when they noticed seepage of alkylate, a volatile chemical compound used in making gasoline. Suddenly, the valve began leaking at high pressure and temperature, blowing over a mechanic at an adjacent pump and breaking his ribs, the report said.

The first explosion occurred within a minute and triggered a second, the investigation found.

One employee was covered in alkylate, which ignited, the report said.

That worker, Mike Saunders, attended the news conference in a wheelchair but did not speak.

Another worker, Vince Azua, also attended and did not speak. His attorney, Kathy Love, said Azua wanted to hear the outcome of the investigation before deciding whether to sue.

Both Saunders and Azua suffered second- and third-degree burns across the front of their upper bodies, arms and faces.

The Impact of Procedure Design (1)

Excerpt from USA Today 10/2/2003

Plane Repair Manual May Confuse

"The manual contains a poorly drawn diagram that could cause mechanics working on the same part of the plane to wrongly adjust a component that raises and lowers the plane's nose, according to the sources and others familiar with the manual … Investigators found that the maintenance manual contained a diagram that directed mechanics to set the rear wing so it would behave the opposite of what pilots intended. However, those familiar with the manual say the text is correct. The manual also calls for a check that should have caught any error."

Some applications of Human Factors

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- Task analysis to help understand the role of humans in a complex system
- Design of systems, processes and interfaces (e.g., hardware and/or software) to support effective and efficient human-system integration and human performance
- Reviews of system designs, processes, assembly procedures, handling procedures, test procedures, maintenance procedures
- User acceptance/usability testing
- Facilitation and/or participation in root cause analysis or other retrospective analysis to understand human error
- Human reliability analysis to assess the risks attributable to human error in a complex system and suggest ways of reducing system vulnerability to human error impact
- Literature reviews to help understand a human factors related problem, and/or to support experimental design for research programs
- Training on human factors
- Research and Development into HF issues

Attributing accidents to actions of front-line operators is an oversimplification…Both the performance and the inherent accident potential…are functions of the way their parts – engineered and human – fit together and interact.

(Meshkati, 1999)

Famous last words

"That's not a problem – the instruction manual will tell the user not to do that."

"The users will get used to it."

"Operators will never do that!"

Contact Information

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