TALLINN UNIVERSITY OF TECHNOLOGY

IAF0320

Computer Systems Engineering

Lecture 8
Human Factors

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The last sprint

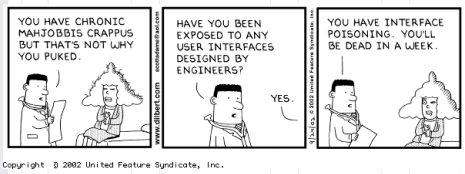
- Individual assignment: December 15, 00:00
- Possibility to improve your teamwork reports until December 15, 00:00
- Final test:
  - December 15, 16:00
  - January 5, 10:00 (ICT-315).
    - **Requires registration by e-mail!!**
- Final grades: January

Individual assignment

- Part A
  - 3 page essay about your teamwork effort and your document
    - Describe any issues that you encountered
    - Describe how you have resolved such issues
    - I am interested about YOUR views to the previous process. About the discussions you had and the decisions you made.
    - How this document could have been made better
    - How well the team worked and how happy you are with your own contribution

Individual assignment

- Part B
  - 3 page essay about your views to systems engineering (as a discipline and as a course)
    - What have you learned?
    - What is systems engineering for you and where it can be applied?
    - Which topics were most interesting (or unknown) for you?
    - Is the topic (and the course) relevant?
    - Which aspects were new for you?
    - Will this topic be important in your future professional life?
    - What other topics should be covered in this course?
    - What do you think about effort/credit points ratio?



Human Factors

Some materials from
- Rani A. Muhdi (U Auburn)
- MIT Course 16.842 Fundamentals of Systems Engineering
- Dr. Laura Moody (Mercer U)

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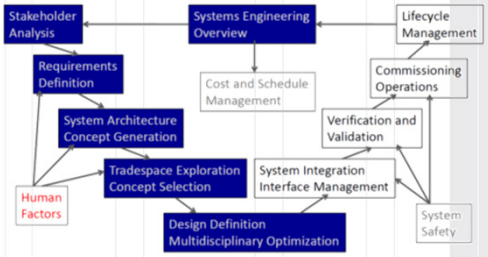
Human Factors



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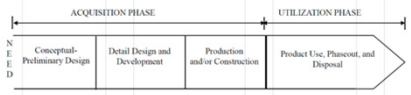
Traditional Systems Engineering Process Model



- Operational requirements drive technical performance measures which drive human factors requirements…..
  - Human considerations often are low priority

*Blanchard, B. S., & Fabrycky, W. J. (1998). Systems Engineering and Analysis (3rd ed.). Upper Saddle River, NJ: Prentice Hall.

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Introduction

- **Human Factors** - Also known as …

Human Engineering
Engineering Psychology

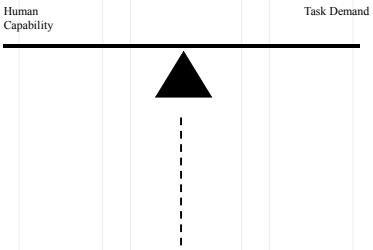
a multidisciplinary field concerned with applying human physical, mental, social, and psychological information to the design of "things" people use

Human Factors vs. Human Factors Engineering

- Human Factors (HF) is a body of information about human abilities, human limitations, and other human characteristics that are relevant to design.
- A branch of applied science aimed at matching machines and tasks with the abilities of their human operators.
- Human Factors Engineering (HFE) is the application of HF information to the design of tools, machines, systems, tasks, jobs, and environments for safe, comfortable and effective human use."

Alphonse Chapanis
Human Factors in Systems Engineering

Purpose of HF: Maintaining the Balance



Modern Human Factors Understands That …

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"things" subjected to HF Design

Handtools	farm tractors	computer hardware
Toys/games	wheel chairs	computer software
Assembly lines	artificial limbs	business organizations
Tooth brushes	bath tubs	submarines
Office furniture	telephones	cockpits
Cell phones	alarm systems	nuclear reactor
Advertising	highway systems	running shoes
Seat belts	helmets …	

Two main objectives of Human Factors

1. Enhance effectiveness and efficiency
- a. effectiveness –
- b. efficiency –

2. Enhance desirable human values
- a. increase –
- b. decrease –

Human Factors:

- Anthropometry
- Biomechanics
- Work Physiology
- Psychophysics
- Cognitive Engineering
- Organizational Psychology
- Human Computer Interaction
- Statistics
- Operations Research
- Tribology

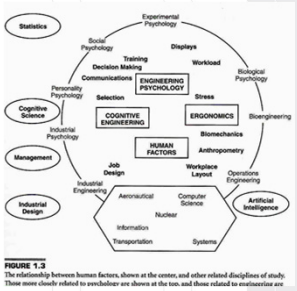

FIGURE 1.3
The relationship between human factors, shown at the center, and other related disciplines of study. Those more closely related to psychology are shown at the top, and those related to engineering are

Human Factors Specialization Areas

Aging	Aerospace Systems
Human Decision Making	Computer Systems
Consumer Products	Industrial Ergonomics
Environmental Design	Safety
Organizational Development	Industrial Hygiene

Human factors specialists work in teams comprised of ….

Design engineers	Industrial hygienists
Industrial engineers	Managers
Product engineers	Production workers
Computer scientists	Industrial psychologists
Safety professional	Occupational physicians
Personnel specialists	Occupational nurses

Human Factors Misconceptions

- HF is just the application of checklists and guidelines.
- HF is simply a matter of using yourself as a model for designing things or implementing a "one size fits all" approach
- HF is just common sense
- People can be trained to overcome design deficiencies
- Minor HF deficiencies are not important

HFE Focus

- Design **out** the potential for human error
- Design **in** ease-of-learning and ease-of-use

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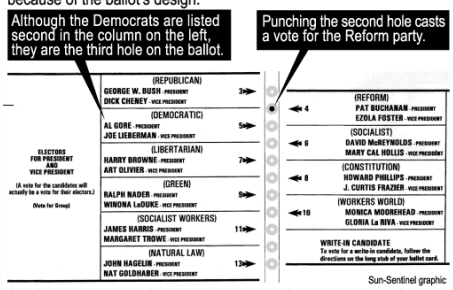
Confusion at Palm Beach County polls

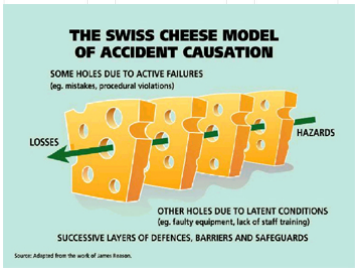
Some Al Gore supporters may have mistakenly voted for Pat Buchanan because of the ballot's design.



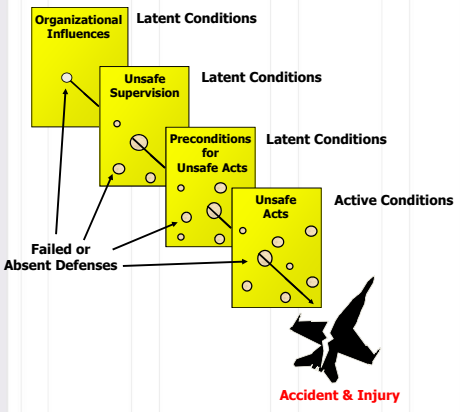
Sun-Sentinel graphic

Common Sense (Population Stereotypes)

	United States	Europe
Light Switches	Up is "On" Down is "Off"	Down is "On" Up is "Off"
Water Faucets	Counter-Clockwise is "On" Clockwise is "Off"	Clockwise is "On" Counter-Clockwise is "Off"



Where are the holes?
What do they consist of?
Why are the holes there in the first place?
Why do the holes sizes and locations change over time?
How and why can the holes line up to produce a mishap?



Popping the Trunk

- Some human factors issues to consider:
  - Physical limitations also need to be considered in design. When hiding controls, keep in mind that fingers have less visual acuity than eyes.
  - (Picture from Darnell, 2003)

The Role of Human Factors in Systems Engineering

S. Camille Peres, Danielle Smith, Carroll Thronesbery

Examples of Human Performance Issues in Complex Systems

- Gemini 9 – Gene Cernan (1966)
  - "Every time I'd push or turn a valve, it would turn my entire body in zero gravity. I had nothing to hold on to. And we take for granted gravity, because we can do that kind of work with ease if something is holding our feet to the ground. Nothing was holding me anywhere."
    - Face visor fogged up due to profuse sweating – he'd rub his nose on the faceplate to create a peephole.
    - Once in the vehicle, face was extremely flushed (nearly passed out) & hands were so swollen that when he pulled off the suit's gloves, some of his skin came with them. It was so much of a relief that he didn't care.
    - http://www.vectorsite.net/tamrc_16.html

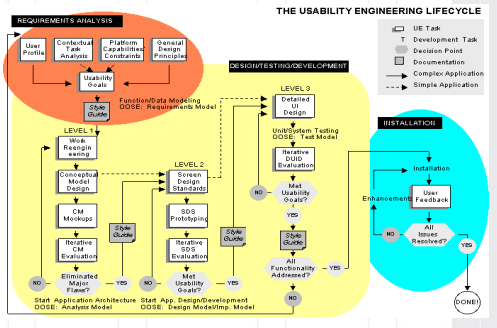
More recent example…

- International Space Station (ISS)
  - 2-week drop in vehicle pressure could have resulted in the crew's needing to evacuate (2004)
  - Determined a hose near window responsible for pressure loss.
  - http://www.space.com/missionlaunches/exp8_update_040123.html
- Perspectives on solutions
  - SEs - all connections on hoses need a higher tolerance for "tugging"
  - HFEs - put mobility aid near all windows (not have hose connections look like handles)

Focus of SEs and HFEs

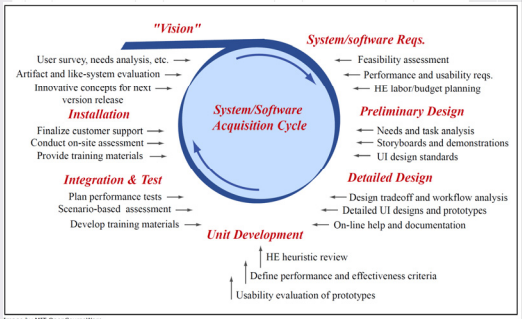
- Both SEs and HFEs are vested in system success
- Focus of System Engineers
  - Integration of ALL systems to insure
    - system success
    - stakeholder satisfaction
- Focus of Human Factors Engineers
  - Integration of the needs of the human into ALL systems to insure
    - optimal performance
    - safety
  - This ultimately contributes to system success and stakeholder satisfaction

Human Factors Engineers do Human Centered Design



Graphic from Deborah Mayhew - http://drdeb.vineyard.net/index.php?loc=11&nloc=1

Human Systems Engineering*



* Aptima, Inc. rendition

Incorporation into SE Process

- Apply established methods and design principles throughout design cycle for any system that comes into contact with human users or maintainers

Design Formulation / Conceptual Design			Design & Implementation			Ops
Mission Definition	System Definition	Prelim Design	Final Design	Fab & Int	Deployment	Ops
♦MDR	♦SRR	♦SDR	♦PDR	♦CDR	♦FRR	♦ORR

- •Operational Analysis
- •Benchmarking
- •Concept of Operations (ConOps)
- •Preliminary Function Allocation
- •Task Analysis
- •Usability evaluation (low-fi)
- •Function allocation & workload
- •User Interface Specification
- •Usability evaluation (med-fi)
- •Performance-based requirements (design option trade-off analyses)
- •Workload analyses

Efficiency of Human-Centered Design

- Including HFEs throughout process can decrease Total Cost of Ownership
  - Incorporating HF early in design cycle may impact initial cost and schedule but will reduce long-term costs (e.g., Training, Maintenance, Staffing, Safety)
  - E.g. Military Human-Systems Integration programs – MANPRINT
- Currently
  - HF is often only utilized near the end of the development cycle
  - This results in a low Return on investment (ROI)
    - If a design issue is not addressed during conceptual design, it is 10 times more costly to fix it during development, and 100 times more costly to fix it after the product is released (Pressman, 1992)

What's different now?

- Historically, development and implementation of technology has been the primary focus of many industries
  - Work-arounds and training have worked as band-aids for poor user interface
- Currently, with the increasing need for the human to be autonomous, this will no longer suffice
  - NASA - Mission control personnel cannot augment crew performance with Mars missions
  - Software design - Increasing competition has made usability a key selling point

How can HFE help?

- HFEs know how to collect (and can help prioritize) stakeholder needs, wants, and desires
- HFEs can help with system validation —ensure the new system provides necessary and useful human task support
- HFEs know how to verify human performance requirements

How can HFE help?

- At a minimum HFE can contribute to SE team by:
  - Improving Concept of Operations (ConOps) and verifying its usefulness with end users
  - Performing early design trade analyses –
    - human-system capabilities, system cost, task allocation
  - Assisting with preliminary hazard analysis
  - Assist with matching early requirements and design to task descriptions and human performance capabilities

Early Concept Definition

- Identify how system will be used
  - Systems engineer know implied system functions and requirements
  - If HFEs privy to this information, can establish necessary human-task support for integrated human-system performance
    - Specialized methods and techniques for obtaining accurate, useful information from end users
    - Identify user's needs for task support requirements
    - Provide feedback to users about implications for task support
    - Get evaluations from users about value of planned task support
- Informs a well defined Concept of Operations (ConOps) for improved human-system performance

What HFEs need to do…

What they do best
Know the USER!

Understand the Users and Their Needs

- Who are the users?
- What needs to be done?
- What is most important?
- How is the system interaction designed?
- Who does what?

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Function Allocation via Fitts' List?

Attribute	Machine	Human
Speed	Superior	Comparatively slow
Power Output	Superior in level in consistency	Comparatively weak
Consistency	Ideal for consistent, repetitive action	Unreliable, learning & fatigue a factor
Information Capacity	Multi-channel	Primarily single channel
Memory	Ideal for literal reproduction, access restricted and formal	Better for principles & strategies, access versatile & innovative
Reasoning Computation	Deductive, tedious to program, fast & accurate, poor error correction	Inductive, easier to program, slow, accurate, good error correction
Sensing	Good at quantitative assessment, poor at pattern recognition	Wide ranges, multi-function, judgment
Perceiving	Copes with variation poorly, susceptible to noise	Copes with variation better, susceptible to noise

Hollnagel, 2000

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Sheridan and Verplank's 10 Levels of Automation of Decision and Action Selection

Automation Level	Automation Description
1	The computer offers no assistance: human must take all decision and actions.
2	The computer offers a complete set of decision/action alternatives, or
3	narrows the selection down to a few, or
4	suggests one alternative, and
5	executes that suggestion if the human approves, or
6	allows the human a restricted time to veto before automatic execution, or
7	executes automatically, then necessarily informs humans, and
8	informs the human only if asked, or
9	informs the human only if it, the computer, decides to.
10	The computer decides everything and acts autonomously, ignoring the human.

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Interaction Design Tips

Nelson Soken

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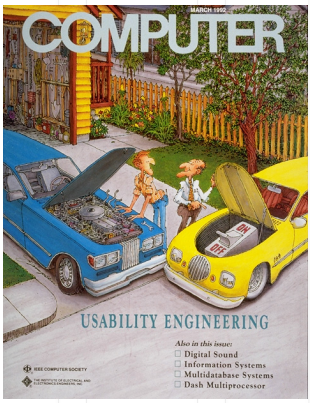

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Design/Redesign the Product Concept

- Parallel Design
- Participatory Design
- Style Guides
- Prototypes

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General Design

- Interactions should be:
  - Predictable
  - Consistent
  - Implicit
  - Present Appropriate, Simple Information
  - Reduce Information Load
  - Put the User in Control

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Usability Evaluation

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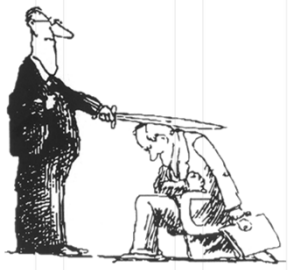
Usability Testing



Usability testing is not the blessing of the interface

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What Is a Usability Study

- A subjective and objective evaluation of how well a system meets the needs of its users.
  - System – a combination of the product, the environment, and the user
  - Needs – expectations, knowledge, skills, abilities, performance, norms…
  - Users – purchasers, managers, end users, maintainers…
- Usability is an iterative process

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What Is a Usability Study

- Types of usability studies
  - Inquiry – used to obtain information about users likes/ dislikes, needs, system understanding via observation, interview, and survey
    - Field observation, Focus groups, Interviews and Questionnaires
  - Testing – used to identify where interface could better support user by having users work on typical tasks with the product
    - Performance measurement, Thinking aloud, Teaching method
  - Inspection – used to identify deviation from established guidelines or standards through expert review
    - Heuristic evaluations, Cognitive and Pluralistic walk-throughs, Feature and label inspections

How Do You Prepare a Study

- Map Usability Concerns to Participants
  - Determine sample size
    - Within-subjects requires fewer participants than between-subjects
    - Usability focused on finding gross problems, statistical power less important, small frequent samples OK

- Usually 5-8 participants
  - 4 participants will find 70% of major usability issues
  - 8 participants will find 85%, diminishing returns above 8*
- Use a larger sample if investigating a specific interface issue

* Nielsen and Landauer, 1993. A mathematical model of the finding of usability problems. Proc. ACM INTERCHI '93 Conference, Amsterdam, the Netherlands, 24-29 April

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Recap: Typical HFE Deliverables

- HFE Plan
- HFE Analyses (e.g., user profiles, task analyses, use error analyses)
- User Interface (UI) Design concepts, mockups, prototypes
- UI Design Requirements
- UI Design Specifications
- Usability Testing Reports and Summaries

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Questions?

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