Human Factors - A Brief Introduction

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Human Factors: Definitions

“Human Factors (or Ergonomics) may be defined as the technology concerned to optimize the relationship between people and their activities by the systematic application of the human sciences, integrated within the framework of system engineering.”


“…**Human factors** is not a pure science as it is not self referential, nor does it base its theories upon unique and exclusive conservation principles and postulates.[…] It is limiting to identify Human Factors as a discipline, as it goes far beyond the mere application of engineering, psychology, sociology and computer science principles. It enables us to represent **working contexts** and sociotechnical aspects in a theoretical form […] **for implementation in real systems** and for assessment of real working contexts.

**Human Factors**, together with computer science, is **the most relevant science that has been developed over the past 50 years** […].

Human Factors: Definition

- Ergonomics synonymous
- It’s a technology
  - Problem oriented, not discipline centred
- Human sciences
  - Seek and employ concepts and data selected upon relevance to a practical problem
- Applications in
  - Design
  - Safety Assessment
  - Training
  - Accident Investigation
- Scenarios for HF analysis are very complex
  - Methodology must be strictly and formally put into place
    - Trivial implementations
    - Unrealistic and misleading results
Human Factors?

- History
  - WWII, Aviation recognizes need for HF
    - 10% survival rate, technical.
    - Leading research
    - CVR/FDR provide unprecedented records
  - All safety concerned industries embrace HF
    - Transport (Exxon Valdez, 90+% of all car accidents, Waterfall)
    - Military
    - Industrial applications (Chernobyl)
  - Today, all industries recognize need
    - Functional Design (ignorants)
    - Sellability
    - Children’s toys
    - Legal implications

- Applies to everybody involved in operations
  - Engineers
  - Managers
  - Observers
Examples of poor ergonomics
Human Factors in Action

Communication
Situational Awareness
Decision Making
Human Factors in Action

• Aircraft investigation TV Show (reactive Human Factors)
  • TV show delving into Human Factors
  • Strip the Drama, interesting interactions
  • SOE most often come down to
    • A relatively minor hardware problem
    • Human error aggravates the situation, resulting in
      • Poor communication
      • Poor decision making
      • Dire consequences

• Read incident reports
  • www.ntsb.gov
Human Factors in Action

- Shuttle Columbia
  - The struggle for coherence
    - Low tire pressure left MLG
    - “strange failure of temperature transducers in hydraulic return line”
    - “Is there anything common to them?”
  - Selective information

Coherence:
Interpreting conflicting indications
Abstracting the process

• Analysing the factors
• Three interacting resources:
  • Software
  • Hardware
  • Liveware
• They exist not in vacuo, but in an
  • Environment
• Four key factors to consider in Human Factors

Software Hardware Environment Liveware
Software in Human Factors

- Rules & Regulations
  - e.g. CSIRO OHSC Regulations
- Laws
  - Civil code
- SOP’s
  - MUM
- Customs
  - Several ways of doing one thing, agree on one.
- Habits
  - Blackbelt XYZ is doing it that way, ergo I do too.

All governing the manner in which the system operates, and how the information is organized.
Hardware in HF

- Physical property. Examples:
  - Vehicles
    - Cars
  - Buildings
    - Antennas, vertex rooms,
  - Antenna components
    - Receivers, Cryo systems
  - Computers
    - Including the software that makes them run!
  - Networks

All expressing what it is we are controlling
Environment in Human Factors

- Physical factors
  - Weather
  - Landscape
  - System inherent properties
- Economic factors
  - Finances available
- Political factors
  - Support for Human Factors
- Social factors
  - Operators social and ethnic backgrounds

All elements over which the system designers have no control over.
Liveware in HF

• That’s us, the people!
The SHEL Model

- SHEL
  - Software
  - Hardware
  - Environment
  - Liveware
- Adding complexity
  - Observers
  - Engineers
  - Operations Staff
- Multiple Systems
- Multiple Environments
- Multiple People

Communication (COM), Self Management (SM), Situational Awareness (SA), Decision Making (DM)
System Safety

• Remind ourselves why we do this
  • Operate safely, reliably, all the time
  • Avoid incidents

• What is safe?
  • Risk free?
  • What does generally safe to operate mean?

• Eliminate the most common threats to the safety of a system
  • We humans have enormous creative potential, very often at the wrong time

• Let’s look at the factors in detail
  • Communication
  • Self Management
  • Situational Awareness
  • Decision Making
Communication

- Conveying information
  - Verify
  - Challenge
  - Respond
    - Example: Mopra post VLBI readiness

- Embracing a culture of honesty
  - Mistakes do not lead to repercussions
  - To Err is human!

- Mutual respect
  - Between all parties concerned
    - Staff member
    - DA
    - visiting Astronomer
Self Management: Workload Management

• Important determinant, but not only factor, in causing human error
• Workload for tasks can vary greatly on how we do them
  • Count experiment
• For observers: How do you plan to
  • Drive to the observatory after a 20 hour air trip
  • Execute your observations, 12-14 hours a day?
  • Drive back
• Automation can help reduce workload
  • Autopilot, Cruise control
  • MAPS
• Automation can inflict new dangers
  • Removes operator from control loop (SA implications)
  • Start 1/100 example
Self Management: Fatigue and Circadian Rhythm

- Human performance suffers with inadequate rest
  - Problem not falling asleep, but underperformance, stupid mistakes
  - Performance assessments based on TOD, F104 experiments

Klein et al, Aerospace Medical Association, 1970
Self Management: Fatigue and Circadian Rhythm

- Circadian desynchronization (i.e. jetlag)
  - Direction of travel does matter. Overall performance disruption
    - E: -8.5%
    - W: -3.3%
  - Recovery time much shorter on westbound flight
- Rule of thumb:
  - 2h/day for each timezone gone west
  - 30m/day for each timezone gone east

Klein et al, Aerospace Medical Association, 1970
Self Management: Fatigue and Circadian Rhythm

- Operational countermeasures
  - Only sleep can cure fatigue (yawn)
  - Take naps, make sure someone else is monitoring your systems
  - Employ CRM methods

"Reprinted from The New Yorker"

"And the dim fluorescent lighting is meant to emphasize the general absence of hope."
Self Management: Training and Simulation

- Know the systems
  - Practise on a simulator.
- When planning observations, expect the unexpected
  - What are the system limitations?
  - How are you maintaining situational awareness?
Situational Awareness: Overview

• 3-level taxonomy (Endersley 1995)
  • Level 1: Failure to correctly perceive the situation
  • Level 2: Failure to comprehend the situation
  • Level 3: Failure to comprehend the situation into the future
• This is all assuming you are given a good set of SA monitoring tools!
• Achieving in maintaining a high level of SA is a product of
  • Good operating philosophy
  • Good training
  • Good SOP’s
  • Good communication
Situational Awareness: The right tools

- The Human Machine Interface (HMI) needs to be appropriately designed
- Ideally, it does not respond to a first name…
- So what are the options available for staff and observers?
  - Some hardware protection (MAPS / PMON)
  - Some software protection on top
  - Monitoring tools
  - Telescope control software, provides limited amount of feedback
Situational Awareness: Human Machine Interface

- Display data in a meaningful way
  - Mopra Generator example
    - mains power available true/false
- A picture says a thousand words.
  - And a logical systems synopsis page will save a million dollars, if it prevented that one fatal blow
- Appropriate use of color, shape and visual cues
  - Much easier to identify than reading and a multicolumn table

<table>
<thead>
<tr>
<th>Point</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cal. Off Count, Subband 1 - A Pol.</td>
<td>12345</td>
</tr>
<tr>
<td>Cal. On Count, Subband 1 - A Pol.</td>
<td>67890</td>
</tr>
<tr>
<td>Cal. Off Count, Subband 2 - A Pol.</td>
<td>34567</td>
</tr>
<tr>
<td>Cal. On Count, Subband 2 - A Pol.</td>
<td>89012</td>
</tr>
<tr>
<td>Cal. Off Count, Subband 3 - A Pol.</td>
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<tr>
<td>Cal. On Count, Subband 3 - A Pol.</td>
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<tr>
<td>Cal. Off Count, Subband 4 - A Pol.</td>
<td>56789</td>
</tr>
<tr>
<td>Cal. On Count, Subband 4 - A Pol.</td>
<td>01234</td>
</tr>
</tbody>
</table>

or

<table>
<thead>
<tr>
<th>Site power source</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>GCP31 - Mains power available at GCP</td>
<td>True</td>
</tr>
<tr>
<td>GCP31 - Generator start enabled</td>
<td>False</td>
</tr>
<tr>
<td>GCP31 - Generator start failed</td>
<td>False</td>
</tr>
<tr>
<td>Genset alarm summary</td>
<td>OK</td>
</tr>
<tr>
<td>Time since mains undervoltage</td>
<td>04:37:27.389</td>
</tr>
</tbody>
</table>
Situational Awareness: Comparison

- Let’s compare the old way of looking at 125 parameters for Mopra observing:
Situational Awareness: Comparison

- All of the previous 125 data monitoring points are integrated into this one display, giving adequate warnings on relevant malfunctions.
Situational Awareness: Comparison

- With some errors displayed
Situation Awareness: Comparison

- All of the previous 125 data monitoring points are integrated into this one display, giving adequate warnings on relevant malfunctions.
Situational Awareness: Supervisory principle

- Apply supervisory / manual control principles:
  - Do not automate everything
    - Automation bias
    - Boredom (keeping pilots busy)
- Keep human in loop
- Correspondingly design HMI
  - Logical diagrams, abstracting the real world most effective
  - Quick grasp designs, needles/angles before digital readouts
  - Sensible use of colour (research shows no more than 9), recommend no more than 4
  - Flash, animate
- Trust
  - Avoid nuisance warnings
  - Reliability
Where to go from here

- Implement HFE practices:
  - Just some examples:
    - Interfaces between teams need to be documented
    - Communication protocols must be established
    - A thorough process analysis
- Example: TRIPOD (part of HERMES)
  - Human Error Risk Management in Engineering Systems
TRIPOD Method: A bottom up approach

• TRIPOD method developed by UMan/Leiden 1997
  • Identifying the root causes of accidents and incidents

General Failure Type

Defences

Accidents, incidents, losses

Unsafe Acts
TRIPOD Method: A bottom up approach

• Unsafe Acts
  • Performing inappropriate or hazardous actions may break the system defences and barriers

• Accident/Incident, losses
  • Result of unsafe acts and failure of defences

• General Failure Types
  • Latent conditions
    • Engendered from past events
    • Result of erroneous organisational decisions affecting the performance of the front line operators
## TRIPOD Method: A bottom up approach

<table>
<thead>
<tr>
<th>Process</th>
<th>GFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statement of Goals</td>
<td>Incompatible Goals</td>
</tr>
<tr>
<td>Organisation</td>
<td>Organisational deficiencies</td>
</tr>
<tr>
<td>Management</td>
<td>Poor communication</td>
</tr>
<tr>
<td>Design</td>
<td>Design failures</td>
</tr>
<tr>
<td></td>
<td>Poor defences</td>
</tr>
<tr>
<td>Build</td>
<td>Hardware failures</td>
</tr>
<tr>
<td></td>
<td>Poor defences</td>
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<tr>
<td>Operate</td>
<td>Poor training</td>
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<td></td>
<td>Poor procedures</td>
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<td></td>
<td>Poor housekeeping</td>
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<tr>
<td>Maintain</td>
<td>Poor training</td>
</tr>
<tr>
<td></td>
<td>Poor procedures</td>
</tr>
<tr>
<td></td>
<td>Poor maintenance management</td>
</tr>
</tbody>
</table>

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CSIRO.  Human Factors – A Brief Introduction
Summary

• Systems designed according HFE methods
  • maximise usability, scientific output, availability
• Mind your communication skills (challenge response)
  • Implement measures for staff
• Be situationally aware
  • Prepare systems suitable for the intended operator group
• Decision making
  • Educate and train staff
  • Provide assistance to operators/observers through automated systems that do not leave the person out of the loop.

Thank you for your time!
Questions?
• Level 1, Arial Regular 20pt
  • Level 2, Arial Regular 18pt
    • Level 3, Arial Regular 16pt
      • Level 4, Arial Regular 14pt
        • Level 5, Arial Regular 14pt

• These font sizes are recommended
• You can increase font sizes providing the hierarchy of information is maintained (ie. slide heading is largest, followed by Level 1, then Level 2 and so on)
• Font size must be consistent across all slides
• Do not use font sizes smaller than displayed here. If you do not have enough room to fit your text, spread your content over multiple slides
Two column layout with pullout box

- Level 1, Arial Regular 18pt
  - Level 2, Arial Regular 16pt
    - Level 3, Arial Regular 14pt
      - Level 4, Arial Regular 12pt
        - Level 5, Arial Regular 12pt

- For two column layouts
  PowerPoint automatically reduces the font size

- You can increase the font size as stated on slide 3
Approved colour palette for PowerPoint

- **Primary colours:**
  To be used first and foremost in your presentations
  - CSIRO Blue: R0 G153 B204
  - CSIRO Green: R190 G214 B0
  - CSIRO Grey: R153 G153 B153
  - Black: R0 G0 B0

- **Secondary colours:**
  Useful for complex diagrams and charts
  - Blue: R89 G152 B200
  - Red: R203 G80 B86
  - Green: R116 G161 B142
  - Yellow: R235 G171 B0
Use of colour palette for diagrams - example

Clay Platelet

PET

Gas Molecules

Gas Molecules

Acceptability of breads

Relative frequency

0.8
0.6
0.4
0.2
0

Negative (score 1-3)
Neutral (score 4-6)
Positive (score 7-9)

Refined wheat
Wholemeal wheat
BarleyMax
Use of colour palette for diagrams - example

- When using graphics they must remain inside the text margins.
- Graphics are not permitted to overlap the background graphics (i.e. diagonal lines, grey and blue strips at the top, footer, CSIRO logo at the bottom).
- By staying within the margins your presentation will remain clean and tidy, and be easier for your audience to take in.
This is an example of a Section Divider slide Arial Regular, 44pt
Troubleshooting

- The background image disappears when I print
  - Make sure your presentation has not turned off the background
  - From the Tools menu select Options then click on the Print tab
  - Under printing options ensure Background printing is checked
  - If the background still disappears select all slides, go to the Format menu – Background, uncheck Omit background images from master, and Apply to all

- The file size of my presentation is very large
  - If your presentation has multiple images the file size will be large. You can compress your images to help the final size
  - Compress images by using the Picture toolbar
  - Either change the resolution of your images (which can affect the quality of your image so make sure to re-look at your images if you select this option) or compress pictures which works with colour without affecting the quality of your image
  - Deleting cropped areas of images will also reduce the file size
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Operations Scientist

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Thank you