Introduction to Human Factors

• “Human Factors” – what is it?
• Preview of coming attractions
• Methodologies for understanding human activities

© 2009 David L. Akin - All rights reserved
http://spacecraft.ssl.umd.edu
Synonyms for “Human Factors”

- Anthropometrics
- Bioastronautics
- Biomechanics
- Environmental medicine
- Ergonomics
- Experimental psychology
- Human engineering
- Human-machine systems design
- Human-computer interaction (HCI)
- Life sciences engineering...
The Scope of Human Factors

from Chapanis, Human Factors in Systems Engineering - Wiley Interscience, 1996
Taxonomy of Human Factors Methods

- Data collection techniques
- Task analysis techniques
- Cognitive task analysis techniques
- Charting techniques
- Human error identification (HEI) techniques
- Mental workload assessment techniques
- Situational awareness measurement techniques
- Interface analysis techniques
- Systems design techniques
- Performance time prediction/assessment tech.
- Team performance analysis techniques
Data Collection Techniques

- Interviews
- Questionnaires
- Observation
Interviews

- Structured, semi-structured, unstructured
- Closed, open, and probing questions
- Focus groups instead of multiple interviews
- Interviews take the longest to train of all data collection techniques
- Should last a minimum of 20 and maximum of 40 minutes
- Data collection: notes, audio/video recorder
Questionnaires

- Types of questions used
  - Multiple choice
  - Rating scales ("strongly agree", "agree"...)
  - Paired associates ("Which is more difficult, A or B?")
  - Ranking ("On a scale of 1-10...")
  - Open-ended ("What did you think of...")
  - Closed questions ("yes/no")

- Easy to collate and reduce data
- Usually have poor voluntary response
- Needs to be designed well for best results
Observation

- Provides “real-life” insight into actual operations
- Intrusive (Heisenberg’s principle)
  - “fly on wall”
  - “hanging over the shoulder”
- Time consuming (1 hr of audio = 8 hrs of transcription)
- Difficult to set up, expensive, time consuming
- Generally requires teams to cover all critical areas
Task Analysis Techniques

• Hierarchical Task Analysis (HTA)
• Critical Path Analysis (CPA)
• Goals, Operators, and Selection Methods (GOMS)
• Verbal Protocol Analysis (VPA)
• Task Decomposition
• Sub Goal Template (SGT) approach
• Tabular Task Analysis
Hierarchical Task Analysis (HTA)

- Ubiquitous; perhaps most common TA method
- Easy to implement; minimal training
- Generic; can be applied to any domain at any desired level of depth
- Descriptive rather than analytical
- Laborious for complex domain tasks
- Simple flowcharting/outlining processes
HTA Graphical Example

0. Boil kettle

Plan 0: 1-2-3-4-5

1. Fill kettle
2. Switch kettle on
3. Check water in kettle
4. Switch kettle off
4. Pour water

from Stanton et. al., Human Factors Methods - Ashgate, 2005
HTA Graphical Example

Plan 0: 1-2-3-4-5

1 Fill kettle
2 Switch kettle on
3 Check water in kettle
4 Switch kettle off
4 Pour water

Plan 1: 1-2-3 (if full then 4 else 3) -5

1.1 Take to tap
1.2 Turn on water
1.3 Check level
1.4 Turn off water
1.5 Take to socket

from Stanton et.al., Human Factors Methods - Ashgate, 2005
HTA Graphical Example

0 Boil kettle

Plan 0: 1-2-3-4-5

1 Fill kettle
2 Switch kettle on
3 Check water in kettle
4 Switch kettle off
4 Pour water

Plan 1: 1-2-3 (if full then 4 else 3) -5

2.1 Plug into socket
2.2 Turn on power

Plan 2: 1-2

1.1 Take to tap
1.2 Turn on water
1.3 Check level
1.4 Turn off water
1.5 Take to socket

from Stanton et.al., Human Factors Methods - Ashgate, 2005
HTA Graphical Example

from Stanton et al., Human Factors Methods - Ashgate, 2005
## HTA Tabular Example

<table>
<thead>
<tr>
<th>Step</th>
<th>Plan</th>
<th>Subtasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.</td>
<td>Boil kettle</td>
<td>Plan 0: Do 1 then 2 then 3 then 4 then 5</td>
</tr>
<tr>
<td>1.</td>
<td>Fill kettle</td>
<td>Plan 1: Do 1 then 2 then 3 (if full then 4 else 3) then 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Take to tap</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Turn on water</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check level</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Turn off water</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Take to socket</td>
</tr>
<tr>
<td>2.</td>
<td>Switch kettle on</td>
<td>Plan 2: Do 1 then 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.1 Plug into socket</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.2 Turn on power</td>
</tr>
<tr>
<td>3.</td>
<td>Check water in kettle</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Switch kettle off</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Pour water</td>
<td>Plan 5: Do 1 then 2 then 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.1 Lift kettle</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.2 Direct spout</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.3 Tilt kettle</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.4 Replace kettle</td>
</tr>
</tbody>
</table>

(from Stanton et.al., Human Factors Methods - Ashgate, 2005)
Cognitive Task Analysis Techniques

• Applied Cognitive Task Analysis (ACTA)
• Cognitive Walkthrough
• Critical Decision Method (CDM)
• Critical Incident Technique
Cognitive Walkthrough

- Select tasks to be analyzed
- Create task descriptions
- Determine the correct sequence of actions
- Identify the user population
- Describe the user’s initial goals
- Analyze the interaction between the user and the interfaces
  - Problems in selecting and evaluating an action
  - Changing goals due to execution and system response
Charting Techniques

- Process Charts
- Operational Sequence Diagrams
- Decision Action Diagram (DAD)
- Event Tree Analysis
- Fault Tree Analysis
- Murphy Diagrams
Event Tree Diagram

from Stanton et.al., Human Factors Methods - Ashgate, 2005
Fault Tree Analysis

from Stanton et.al., Human Factors Methods - Ashgate, 2005
Human Error Identification Techniques

- Cognitive Reliability Error Analysis Method (CREAM)
- Human Error Assessment and Reduction Technique (HEART)
- Human Error Identification in Systems Tool (HEIST)
- Human Error Template (HET)
- Human Error HAZOP
- Systematic Human Error Reduction and Prediction Approach (SHERPA)
HEI Techniques (continued)

- System for Predictive Error Analysis and Reduction (SPEAR)
- Task Analysis For Error Identification (TAFEI)
- Technique for Human Error Assessment (THEA)
- The HERA Framework
- Technique for the Retrospective and Predictive Analysis of Cognitive Errors in Air Traffic Control (TRACEr)
Human Error Template (HET)

- Standard taxonomy of errors
  - Failed to execute
  - Task execution incomplete
  - Task executed in wrong direction
  - Wrong task executed
  - Task repeated
  - Task executed on wrong component
  - Task executed too early/late/much/little
  - Misread information
- Apply and evaluate to each bottom-level task from HTA
- Consider consequence, criticality, interface role
Situational Awareness Measurement Tech.

- SA Requirements Analysis
- Situation Awareness Global Assessment Tech.
- Situation Awareness Rating Technique
- SA Subjective Workload Dominance Metric
- Situation Awareness Control Room Inventory
- Situation Awareness Rating Scales (SARS)
- Situation-Present Assessment Method (SPAM)
- SA Behavioral Rating Scales
- Mission Awareness Rating Scale (MARS)
- Crew Awareness Rating Scale (CARS)
Situational Awareness Rating Scales (SARS)

- List of 31 criteria in 8 categories from ACM SA
  - General traits
  - Tactical game plan
  - System operation
  - Communication
  - Information interpretation
  - Tactical employment BVR
  - Tactical employment visual
  - Tactical employment general

- Each criteria self-rated on 1(poor)-6(best) scale
Mental Workload Assessment Techniques

- Primary Task Performance Measures
- Secondary Task Performance Measures
- Bedford Scale
- Defense Research Agency Workload Scale
- Instantaneous Self Assessment Workload
- Malvern Capacity Estimate
- Modified Cooper-Harper Rating
- NASA Task Load Index
- Subjective Workload Assessment Technique
- Workload Profile Technique
- Cognitive Task Load Analysis
NASA Task Load Index (TLX)

- Subjective assessment on 6 scales
  - Mental demand
  - Physical demand
  - Temporal demand
  - Effort
  - Performance
  - Frustration level
- Rating from 1 (low) to 5 (high)
- 15 pairwise comparisons for assessment of relative importance of scales
- Final score is weighted average of scale values
Team Techniques

- Behavioral Observation Scales
- Comms Usage Diagram
- Coordination Demands Analysis
- Team Decision Requirement Exercise
- Social Network Analysis
- Team Cognitive Task Analysis
- Team Communications Analysis
- Team Task Analysis
- Team Workload Assessment
- Task and Training Requirements Methodology
Team Workload Assessment

- Builds off of NASA TLX technique
- Team performs mission/run/sortie/simulation
- Individuals fill out NASA TLX
- Group fills out TLX as a team, from point of view of team
- Compare ratings between individuals, and between individuals and team
- Best indicator has been shown to be rating of poorest-performing individual
Interface Analysis Techniques

• Checklists
• Heuristics
• Interface Surveys
• Layout Analysis
• Link Analysis
• Questionnaire for User Interface Satisfaction
• Repertory Grids
• Software Usability Measurement Inventory
• System Usability Scale
• User Trials
• Walkthrough Analysis
Walkthrough Analysis

- Experienced system operators perform “walkthrough” of system under consideration
- Subject (pretends to) perform each required action, explaining function of each control and display used
- Analyst(s) can halt walkthrough and ask questions at any point
- Highly useful in early stages of development
- Highly useful for teams of operators
- Requires experienced operator(s)
System Design Techniques

- Allocation of Functions Analysis
- Focus Groups
- Groupware Task Analysis
- Mission Analysis
- Scenario Based Design
- Task Centered System Design
Scenario Based Design

- Create a series of operating scenarios for systems
- Use Walkthrough Analysis approach to “simulate” actions of experienced operators
- Determine actions, possible outcomes, design modifications to improve results
- Many potential scenarios need to be created and “played out”
- Only as good as experts and scenario designers
Performance Time Assessment Techniques

- Keystroke Level Method
- Timeline Analysis
- Critical Path Analysis
Timeline Analysis

• Collect operating timeline data wherever possible
• Perform HTA on system
• Link performance time estimates to bottom-level HTA goals
• Construct a timeline graph of nominal and off-nominal performance of mission
• Workload analysis maps directly into timelines
• Predictive performance depends on error-free execution
References

• Neville A. Stanton, P. M. Salmon, G. H. Walker, C. Baber, and D. P. Jenkins, Human Factors Methods: A Practical Guide for Engineering and Design - Ashgate, 2005

• Alphonse Chapanis, Human Factors in Systems Engineering - Wiley Interscience, 1996