HUDs, HMDs, and SDO
A Problem or a Bad Reputation?

Richard L Newman

Recent Trends in Spatial Disorientation Conference
San Antonio, Texas
November 2000
SUMMARY

• Background
• Development of Standards
• Unusual Attitude Research
• Unusual Attitude Issues
• Conclusions
BACKGROUND

- HUD Characteristics
- HMD Characteristics
- Other Novel Displays
HUD CHARACTERSISTICS

- Absence of Upright Versus Inverted Cues
- Clutter
- Digital Data and Rate Information
- Full Scale Pitch Angles
- Pitch Ladder Precession Passing Zenith or Nadir
- Accommodation Traps
- Framing
- Velocity Vector vs Pitch Control
KLOPFSTEIN HUD

- Waterline
- Horizon
- Velocity Vector
- Triangle indicates ALPHA for approach

Limit ALPHA for
W touches this mark,
stall is reached

HUDs, HMDs, and SDO
HMD CHARACTERISTICS

- Conflicting Frames of Reference
- Head-Tracker Shortcomings
HDD CHARACTERISTICS

- Clutter
- Conflicting Frames of Reference
- Declutter of Important Information
- Standby Display
DEVELOPMENT OF HUDs AND HUD STANDARDS

- First Step -- F-18
- RAE FastJet Development
- Development of Air Force Symbology
- Civil HUD Development
- Military Transport HUD Development
F-18 HUD SYMBOLOGY

HUDs, HMDs, and SDO
FASTJET HUD SYMBOLOGY

HUDs, HMDs, and SDO
MIL-STD-1787 HUD SYMBOLOGY
C-130J HUD SYMBOLOGY
MIL-STD-1295 HMD SYMBOLOGY
UNUSUAL ATTITUDE RECOVERY RESEARCH

- HUD Disorientation Studies
- HMD Disorientation Studies
- Pathway Unusual Attitude Study
HUD DISORIENTATION STUDIES

- Navy Studies (HUD vs ADI)
- Pax River Studies
- Navy Orientation Cues
- Brooks Studies
- UK Studies
HMD DISORIENTATION STUDIES

- Fixed-Wing
  - Wright-Patt and Brooks
  - Optokinetic-Cervical Reflex
- Rotary-Wing
  - Display stabilization (Ames Studies)
HEAD-DOWN STUDIES

• Helicopter Display (Ft. Rucker)
• Pathway (Wright-Patt)
• Synthetic Vision (NASA)
UA Recovery

• Review of HUD Characteristics
• UA Recovery Techniques
  – Fighter/Attack
  – Transport/Helicopter
## HUD UA CHARACTERISTICS

<table>
<thead>
<tr>
<th>Format</th>
<th>UA Mode</th>
<th>Pitch Ladder</th>
<th>Scaling</th>
<th>Pivot</th>
<th>Aircraft Symbo</th>
<th>Other Cue</th>
<th>Scales</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-18</td>
<td>No</td>
<td>“bendy bars”</td>
<td>1:1</td>
<td>Pitch Marker</td>
<td>CDM or FPM</td>
<td>Pitch Marker</td>
<td>Digits</td>
</tr>
<tr>
<td>FastJet</td>
<td>No</td>
<td>tapered</td>
<td>variable</td>
<td>CDM</td>
<td>CDM</td>
<td>CDM</td>
<td>CP’s</td>
</tr>
<tr>
<td>‘1787</td>
<td>No</td>
<td>tapered/bendy</td>
<td>1:1</td>
<td>CDM</td>
<td>CDM</td>
<td>Ghost Horizon</td>
<td>CP’s</td>
</tr>
<tr>
<td>Civil</td>
<td>No</td>
<td>straight</td>
<td>variable</td>
<td>Pitch Marker</td>
<td>FPM</td>
<td>Pitch Marker</td>
<td>Digits</td>
</tr>
<tr>
<td>C-130J</td>
<td>Yes</td>
<td>straight</td>
<td>1:1</td>
<td>Pitch Marker</td>
<td>Pitch Marker</td>
<td>Augie Arrow</td>
<td>CP’s</td>
</tr>
</tbody>
</table>
CONCLUSIONS

- HUDs do not cause spatial disorientation
- HUDs have some UA characteristics which can be improved.
- Research has had several benefits:
  - symbology
  - recovery standardization
  - pilot training
  - UA recovery as part of T&E
CONCLUSIONS

• HMDs still need research. (They are about where HUDs were in mid 1980s.)
• Does the HMD promote SDO?
  – conflicting orientation cues
  – head tracker
• What recovery techniques are appropriate?
• What symbology should be used?
CONCLUSIONS

• Novel displays (pathway or synthetic vision) are better off, but still need development.
• We must exercise the same care that we did for HUDs.
• Incorporation of spatial orientation and UA recovery must be part of test and evaluation.
• Research is being applied to general aviation inadvertent IMC loss-of-control.
I wish to thank

- Jeff Schroeder of Flight Dynamics for providing drawings of HUD Symbologies.
- Kevin Greeley of Lockheed for reviewing the manuscript.