Human Factors Challenges in Poor Visibility Helicopter Operations

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Outline

- DVE in military and civil helicopter operations
- Superimposed displays to assist in DVE conditions
- Recent DLR activities and selected findings
- Conclusions / outlook
Helicopter flight in degraded visual environment (DVE)
Military operations

**Brownout**

- Responsible for 75% of mishaps in NATO member countries
- US Services’ largest overall cause of rotary-wing airframe loss

**Spatial disorientation**

- unawareness of lateral drifts prior to touchdown
  type I (unrecognized)

- illusion of self-motion (vection)
  the movement of the dust particles provokes the impression of banking or turning when in a level hover

- somatogravic illusion
  impression of pitching down when decelerating from forward flight

**Consequences such as roll-over, CFIT and collision with obstacles or other aircraft**

*(NATO report HFM Task Group 162, 2012)*
Helicopter flight in degraded visual environment (DVE)

Civil operations

External environmental awareness
listed among the top 3 most relevant factors of European civil rotary-wing accident causes

(van Hijum & Masson, 2010)

Adverse weather
2nd most common accident factor accounts for the largest number of deaths (40%)

(accidents in the Gulf of Mexico from 1983-2009) (Baker et al., 2011)

darkness (48%)
bad weather (17%)
both especially associated with fatal outcome

(based on NTSB records 1983-2005) (Baker et al., 2006)

SITUATIONAL AWARENESS
WORKLOAD
SPATIAL DISORIENTATION
FLIGHT SAFETY
Helmet-Mounted Displays (HMD)

Introduction

- reduced head-down time
- divided attention task benefits
- reduced eye accommodation
- conformal symbology
- flight performance
- lower WL
- higher SA
Helmet-Mounted Displays (HMD) / Head-up Displays (HUD)

Unexpected event detection cost

- Cost in detecting unexpected events in the world particularly if these events are not salient
  
  Meta-analysis by Fadden et al. (1998); Fischer et al. (1980), Larish & Wickens (1991); Wickens & Long (1994); Wickens (1997)

- Inattentional blindness
  
  Failure to notice a highly visible yet unexpected object in the visual field, caused by a lack of attention  
  (Mack and Rock, 1992, 1998)

Clutter

Attentional tunneling

Longer than optimal allocation of attention at the cost of neglecting events on other channels, or failing to perform other tasks  
(Wickens, Alexander, 2009)
DLR HMD activities
Overview

SIM study 1
- 12 pilots
- German Armed Forces
- German Federal Police
- 3925 (3078) flight hours
- 4 VFR, 8 IFR
- 1 → HMD experience
- 10 → brownout experience

SIM study 2
- 18 pilots (9 civil, 9 mil)
- German Armed Forces
- German Federal Police
- German and Swiss Air rescue
- 1 VFR, 17 IFR
- 4401 (3867) flight hours
- age 45 (7)
- 4 → HMD real flight experience
- 6 → HMD sim experience

- Flight and landing performance
- Concurrent task performance
- Expected and unexpected event detection
- Workload (HR/HRV, NASA TLX)
- Situation awareness (SART)
- Acceptance / usability
- Visual, perceptual, somatic issues with HMD
**Simulation environment**

**Overview**

**Generic Cockpit Simulator (GECO)**

- Airbus 350 cockpit layout
- 3 high resolution projectors (area of 180° by 40°)
- Rotary-wing flight controls (cyclic, collective, yaw)
- Flight dynamics of EC 135

**JEDEYE HMD, Elbit Israel**

- **Resolution**: 2 x 1920 x 1200 pixel @ 60 Hz
- **Field of view**: binocular, 2 x 80° x 40°
- **Head tracker**: magnetic, 400 Hz, accuracy 0,25°
- **Weight**: ~ 2,3 kg
- **Color**: Monochrome green (stereo able)
## Task design

### Event expectancy

<table>
<thead>
<tr>
<th>Expected</th>
<th>Unexpected</th>
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<tbody>
<tr>
<td>Near domain</td>
<td>Far domain</td>
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- **Expected Near Domain**
  - Monitoring task
  - Speed
  - Altitude
  - Route
  - Target search and identification

- **Expected Far Domain**
  - LOW FUEL WARNING

- **Unexpected Near Domain**
  - Obstacles/traffic in flight route

- **Unexpected Far Domain**
  - Obstacles/traffic in flight route
Findings
Unexpected warning on display

Longer RT with HMD if warning:
- occurred in poor visibility
- was truly unexpected

Poor visibility
- attention primarily focused on outside scene
  - time-critical search task
  - obstacle avoidance
  - maintain stable attitude

Salience alone did not aid rapid detection on the HMD, but added expectancy did.
Findings
Unexpected traffic in flight route

- no collision
- lateral maneuver was most frequently selected
- no significant differences in starting point of collision avoidance

Tendency towards a detection cost with the HMD!
- descriptive results indicate later start of avoidance maneuver
- vertical maneuver more frequently selected with HMD
- less time for adequate avoidance plan (pilot comments)

- one pilot did not detect it at all!

Distance at start of avoidance maneuver (m)

<table>
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<tr>
<th></th>
<th>HMD</th>
<th>PFD/ND</th>
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<tbody>
<tr>
<td>Distance</td>
<td>366.5</td>
<td>444.3</td>
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following Wickens (2005)
Findings
Target detection

High task difficulty

- 74% HMD cued
- 61% baseline
- 48% HMD un-cued

Detection cost for HMD un-cued targets!!
Findings

Target detection

Visibility issue

All targets were visible
No target was never detected

Cue precision and reliability issue

Highly precise
Highly reliable

False alarm issue

FA rate very low!
Tendency to respond even under uncertainty (more FA)

NONE-HITS RESULTED RATHER FROM A FAILURE IN CUE DETECTION THAN TARGET DISCRIMINATION
Conclusions

Flight performance
Landing performance
Pilot acceptance
Usability
Workload
Situation awareness

Clutter
Attention fixation (especially 2D symbology)
Unexpected event detection
Expected far domain event detection
Outlook