Evolving Commercial Rotorcraft Cockpits

Herb Moran
Experimental Test Pilot
AgustaWestland
Discussion

• Historical Look at Rotorcraft Safety
• Rotorcraft Technology Changes Last 10 years
• Vision of the Future Commercial Rotorcraft Cockpit
• The Challenge for Rotorcraft Testers
But this presentation is about SAFETY!
Helicopter Crash Statistics

Statistics taken from the International Helicopter Safety Team, Year 2000 Report, Published Sep 2007
Helicopter Crash Statistics

Using NTSB and FAA data presented on the HAI website
2001 to 2005 Accidents/100,000 flight hours  9.1

Statistics taken from the International Helicopter Safety Team, Year 2000 Report, Published Sep 2007
Causal Factors

Statistics taken from the International Helicopter Safety Team, Year 2000 Report, Published Sep 2007
Phase of Flight

Year 2000

Approach
Climb
Cruise
Descent
Emergency descent/landing
Emergency landing
Ground
Hover
Landing
Maneuvering
Standing
Takeoff
Taxi

Statistics taken from the International Helicopter Safety Team, Year 2000 Report, Published Sep 2007
Flight Hours of Mishap PIC

Year 2000

Number of Accidents


Statistics taken from the International Helicopter Safety Team, Year 2000 Report, Published Sep 2007
Crash Causal Factors

Year 2000

Problem Category

Frequency

Supervisory Training Guidance Tools

Year 2000 Analysis

Statistics taken from the International Helicopter Safety Team, Year 2000 Report, Published Sep 2007
2001 to 2005 Accidents/100,000 flight hours

But this photo is 2013!
<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Examples of Technology Solution Suggested</th>
<th>#of Missions With This</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improve Investigation</td>
<td>Cockpit Recorder Voice/Data/Video</td>
<td>15 / 15</td>
</tr>
<tr>
<td>Prevent Parts and Systems Failures</td>
<td>Health Monitoring HOMP / HUMS</td>
<td>14 / 15</td>
</tr>
<tr>
<td>Increase Pilot Situational Awareness External Environment</td>
<td>RADALT, SVS, Dig Map, EVS, NVG, GPWS, AWOS, Radar, Multi Axis Video, Obstacle Detection, Stabilization, Coupled modes</td>
<td>10 / 15</td>
</tr>
<tr>
<td>Improve Crash Survivability</td>
<td>Crash Resistant Systems Crash worthy fuel systems, structure, seats</td>
<td>10 / 15</td>
</tr>
<tr>
<td>Increase Pilot Situational Awareness of Aircraft State</td>
<td>Caution, Warning on systems, Low Rotor, Roll Over, Low speed, Low Fuel, High ROD, Door Position</td>
<td>7 / 15</td>
</tr>
<tr>
<td>Prevent Catastrophic Strike</td>
<td>Wire strike and T/R strike protection</td>
<td>7 / 15</td>
</tr>
<tr>
<td>Improve Judgement with better Weather Reporting</td>
<td>Ground Systems</td>
<td>11 / 15</td>
</tr>
<tr>
<td>Avoid Inadvertent IMC</td>
<td>IIMC Avoidance Training and IIMC Emergency Training</td>
<td>9/15</td>
</tr>
</tbody>
</table>
CHANGE IS HAPPENING

- Authorities: Regulation
  - JAROPS 2004 (Now EASA CAT)
    - Environment Based Requirements
  - FAA 2012
    - Emergency Medical Services Requirements
- Manufactures: Technology Push ($Investment$
- Operators: Change Market Paradigms
  ($Operator buy-in to Value$)
AW139
First Certified in Europe 2003
Modified Honeywell Epic Flight Deck

Best Selling Medium Class Helicopter in World
AW139

First Certified in Europe 2003
Modified HoneyWell Epic Flight Deck

Manufactures: Technology Push

Operators: Change Market Paradigms

Best Selling
Medium Class
Helicopter
in World
Technology Race!

VALUE!
COST!
SAFETY!
CAPABILITY!
PERFORMANCE!
RELIABILITY!

Workload
SA
HMI

REGULATION
DEMAND

2003-2013 SAFETY!

CPLD MODES
AVS
AIRCRAFT STATE
TCAS II
EV
ATTD MODES
LPV
OEI
CPLD VFR APPR
TAWS
HUMS
OBSTACLE DETECTION
AWOS
NVG
RADAR
Video
The Race Continues

Future Rotorcraft Technology

- Powered Lift
- Automation
- Fly By Wire
- Sensor Fusion
- 9 Deg LPV
- Low Level IFR
- Dual Channel FADEC
The Market Yesterday

IFR, SVS, EVS, TAWS, DIG MAP, TCAS, ADSB CPLD VMC APPR, VIDEO, FLIR, LPV 9 Deg, Increased Aircraft State Indications, human error prevention
The Market Today

Integrated and Automated.
- No ECLs or Manual modes
- Centralized Systems Interface
- Cursor Interface
- Hands on Controls Interface
- Automated Systems Pages
The Market Tomorrow

- Touch Screens
- Icon driven menus
- Advanced AC State graphics
Future Rotorcraft

- Touch Screen MFD and PFD
- Automated Flaps
- Automated RPM Control
- Automated Nacelle
- Dark Cockpit
- Tactile Cueing
Future Rotorcraft

Our Hope for the future
-Human Friendly Flight Cues
-Intuitive SA of External World
-Very Low Work Load Cockpit
-Human Error Tolerant
-Human Error Prevention
-Easy Emergency Procedures
So What Does This Mean for Testers?

• Testing is always challenging
• Testing new technology even more challenging
• But What is New or Changing?
  – Software? Well standardized.
  – Flight Displays? Yes, they continue to evolve.
  – Highly integrated complex systems co-managed by computer and human? YES! This worries me!
Highly Integrated Complex Systems
Co-Managed by Computer and Human

• How Do We Test This?
  – What are the test tools?
  – What is the standard?
  – How do we cover all the possible interactions?
  – Can we avoid/reduce human startle factor?
  – Can we stop humans from creative interactions?
  – What are the lessons already learned?

• I am here to learn!

• I do have some opinions to offer.
Two Personal Examples

• Lose of Engine Control
  – Sticky fuel metering spool
  – Computer monitoring design error
  – Computer error, human did not understand

• Lose of Control In Flight
  – Air data failure
  – Unexpected Pilot Intervention
  – Human error, computer did not understand

• Both in a Controlled Test Environment
• Good Test Data
• Not Part of a Planned Test Point
Some Testing Suggestions

• Design Concepts
  – Computer Responsibility vs. Human Responsibility
  – HMI or CRM?

• Early Involvement in Design
  – HMI Meetings with all contributors
  – Testers, Controls, Avionics, Contractors...........
  – My Example; Weekly Meetings, Focused Discussion

• Laboratory, Ground and/or Air
  – The more realistic the better
  – Extensive play time in laboratory
  – My Example; Vehicle Man Systems Interface Lab
What About Flight Test?

• Full up Testing of Computer-Human interactions?

• Computer response to failure modes and human reaction?

• Hard To Do in a comprehensive manner!
Questions!
2006 Report

- World Accident rate 6.5
- US Accident Rate 5.6

<table>
<thead>
<tr>
<th>SPS Group (Level 1)</th>
<th>Count of Usage</th>
<th>Count of Accidents</th>
<th>% of Accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot Judgment &amp; Actions</td>
<td>299</td>
<td>140</td>
<td>92.1%</td>
</tr>
<tr>
<td>Data issues</td>
<td>176</td>
<td>122</td>
<td>80.3%</td>
</tr>
<tr>
<td>Safety Management</td>
<td>81</td>
<td>56</td>
<td>36.8%</td>
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<tr>
<td>Pilot Situation Awareness</td>
<td>67</td>
<td>50</td>
<td>32.9%</td>
</tr>
<tr>
<td>Ground Duties</td>
<td>58</td>
<td>50</td>
<td>32.9%</td>
</tr>
<tr>
<td>System Component Failure</td>
<td>51</td>
<td>46</td>
<td>30.3%</td>
</tr>
<tr>
<td>Mission Risk</td>
<td>32</td>
<td>28</td>
<td>18.4%</td>
</tr>
<tr>
<td>Maintenance</td>
<td>44</td>
<td>25</td>
<td>16.4%</td>
</tr>
<tr>
<td>Post-crash survival</td>
<td>27</td>
<td>20</td>
<td>13.2%</td>
</tr>
<tr>
<td>Regulatory</td>
<td>14</td>
<td>12</td>
<td>7.9%</td>
</tr>
<tr>
<td>Communications</td>
<td>11</td>
<td>11</td>
<td>7.2%</td>
</tr>
<tr>
<td>Safety Systems and Equipment</td>
<td>9</td>
<td>9</td>
<td>5.9%</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>7</td>
<td>7</td>
<td>4.6%</td>
</tr>
<tr>
<td>Personnel - Non Crew</td>
<td>4</td>
<td>4</td>
<td>2.6%</td>
</tr>
</tbody>
</table>

Table 8. Level 1 Standard Problem Statements by Accident
2006 Report

Number of Accidents by Primary Operation

- Utilities Patrol/Construction
- Electronic News Gathering
- Logging
- Offshore
- Firefighting
- Business
- Aerial Application
- External Load
- Law Enforcement
- Commercial
- Air Tour
- Aerial Observation/Patrol
- Emergency Medical Services
- Instructional/Training
- Personal/Private

Number of Accidents
Figure 3. Accidents and Fleet Weight Group Distributions
For CY2006, the accident analysis continued to reveal that the dominance of accidents include Pilot Judgment & Actions Standard Problem Statements (SPS). This is similar to conclusions of previous years. The absence of adequate preparation or planning by a pilot is often the initiating event in the accident sequence. Improving pilot judgment and the ability to safely handle problems is the most effective way to improve helicopter safety. The pilot is in the best position to change the outcome of a sequence of events; therefore, most interventions must affect pilot performance in a positive way. A specific problem with pilot situational awareness is often connected in accidents to Pilot’s Judgment & Action.
The JHSAT found in its first year of analysis that a major factor contributing to helicopter accidents was the **failure to adequately manage known risks**. Due to the lack of a systematic process, including leadership and accountability, **operators did not adequately prioritize and mitigate the risks that led to accidents**. Analysis of the accidents revealed continuing operational safety issues that could be corrected by more effective and systematic management of risk and by better training.
Fatalities Based on Phase of Flight

Statistics taken from the International Helicopter Safety Team, Year 2000 Report, Published Sep 2007