Pilot Color Vision Research and Recommendations

Presented to: Aerospace Medical Association
By: N. Milburn, T. Chidester, S. Peterson, C. Roberts, D. Perry, K. Gildea
Date: May 15, 2013
Disclosure Information

84th Annual AsMA Scientific Meeting

Thomas R. Chidester

I have no financial relationships to disclose.

I will not discuss off-label use and/or investigational use in my presentation.
NTSB Recommendation

- A-04-47 (Tallahassee FedEx B-727)
- Conduct research necessary to ensure color vision deficient airmen are either disqualified or qualified with appropriate limitations
- Research completed FY05-FY12
- Risk assessment and recommendations
## Use of Color

<table>
<thead>
<tr>
<th>GROUND</th>
<th>Light/Line Signals</th>
<th>AIR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleared for Takeoff</td>
<td>GREEN</td>
<td>Cleared to Land</td>
</tr>
<tr>
<td>STOP</td>
<td>RED</td>
<td>Give Way</td>
</tr>
<tr>
<td>Cleared to Taxi</td>
<td>Flashing GREEN</td>
<td>Continue Circling</td>
</tr>
<tr>
<td>Taxi Clear of Runway</td>
<td>RED</td>
<td>Return for Landing</td>
</tr>
<tr>
<td>Return to Starting Point on Airport</td>
<td>Flashing WHITE</td>
<td>Airport Unsafe DO NOT LAND</td>
</tr>
<tr>
<td>Exercise EXTREME CAUTION</td>
<td>RED</td>
<td>Exercise EXTREME CAUTION</td>
</tr>
</tbody>
</table>

- A color table for aviation signals and instructions.
- Images of cockpit views and map.

Aerospace Medical Association  
May 2013
Current AAM CV Testing Process

• **AME conducts clinical screening**
  – 15 acceptable tests/devices
  – Airmen who pass any are cleared without restriction
  – Otherwise, “not valid for night flight or under color signal control”
  – No limit imposed upon number of tests attempted

• **Medical Flight Testing (MFT) to remove restriction**
  – Class III – signal light and chart reading testing
  – Class I/II – additionally, demonstrate in an aircraft and in flight

• **Four concerns from research in response to NTSB Rec.**
  – Unlimited clinical test attempts
  – Unscreened yellow-blue deficiencies
  – Specific unreliable clinical instruments
  – Aircraft in which MFT is conducted
Types of Tests

- **Clinical Screening**
  - Commercial medical test or device diagnosing presence and type of deficiency

- **Precision**
  - Commercial, computerized test quantifying/scaling deficiency
  - Accuracy comparable to Anomaloscope; add YB screening

- **Job Sample**
  - Job-specific test simulating tasks presented in a work environment

- **Operational**
  - Opportunity to demonstrate ability in occupational context
  - FSDO Signal Light, Chart, and MFT
Assessing NTSB concerns

• Milburn and colleagues tested 266 subjects
  – 148 NCV; 118 CVD
  – Oklahoma and upstate New York

• **Selected set of recommended clinical tests**
  – With high sensitivity/specificity for CVD
  – Listed on next slide, referenced hereafter in document

• **Developed/assembled job sample tests**
  – Signal light gun
  – Airport approach/surface lighting (LED/Incandescent)
  – Cockpit display colors representing range measured in field
  – (One caution -- charting colors not tested, would be required of a deployed test; printed and digital prototypes in testing)

• Examined whether CVD subjects could discriminate job sample tests as well as NCV subjects

• Examined impact of current policy and alternatives
Recommended Clinical Tests

- Clinical Screening PIP (Direct AMEs to Randomize Order)
  - Richmond HRR 4th Ed
  - Waggoner HRR, Waggoner PIPIC
  - AOC HRR 2nd Ed (now out of print)
  - Dvorine 2nd Ed (now out of print) **
  - Ishihara-38 **, Ishihara-24 **, Ishihara-14 **
  - Optec 900 **
  ** require HRR supplemental YB plates

- Precision
  - Waggoner CCVT (computerized)
  - Colour Assessment and Diagnosis (CAD; computerized)
  - Cone Contrast Test (CCT; Netbook-based)
Criteria to judge testing policy validity

• Among NCV subjects (CAD thresholds<2.0)
  – 87% pass all job sample tests
  – Not higher due to multiple 5\textsuperscript{th} percentile cut scores
    (which define “what NCV subjects can do” on each test)

• If current CVD screening results in similar pass rates, we address NTSB concerns

• Lower pass rates among CVD subjects
  – Represent risk of inability to discriminate critical colors used to perform safely
Research Results

Among CVD subjects (CAD RG and/or YB)

• 23% pass all job sample tests
  – “Appropriately cleared” without restriction and minimized burden
  – Much lower rate than found for ATCS
  – Cockpit colors most frequently failed; less redundant coding than ATC counterparts

• Using recommended clinical tests and pilot cut scores
  – 14% pass all clinical tests
    • 80% then pass all job sample tests, representing half of those appropriately cleared without restriction; these subjects do not represent NTSB concerns
  – 14% fail one clinical test
    • 47% then pass all job sample tests, representing a quarter of those appropriately cleared without restriction, but includes 53% at-risk subjects
  – 72% fail two or more clinical tests
    • Only 20% pass all job sample tests, representing 30% of those appropriately cleared without restriction, but overwhelmingly at-risk subjects
    • Job sample test failures increase with number of clinical test failures

• Failing even a single test represents a doubling of risk of inability to discriminate colors required to perform safely
Research Conclusions

• NTSB concerns are valid for those who take multiple clinical screening tests
• Current policy clears without restriction some pilots who should not be cleared w/o MFT
  – 53% who failed one clinical test were unable to perform all job sample tests
  – Failing a second or more tests increases risk
    • Only 20% pass all job sample tests
• Pilot failing one clinical screen requires more scrutiny; a second clinical test cannot predict safe performance of duties
Research Recommendations

• Limit opportunity to pass clinical screening to a single test attempt per medical exam
  – Testing multiple times accumulates measurement error, sacrificing test validity

• Add HRR supplemental yellow-blue plates to red-green-only tests
  – Yellow-blue deficiency represents a safety gap in present standard
  – Color avionics, medications, and conditions affecting color vision potentiating yellow-blue issues

• Remove from the AME Guide certain tests not recommended by this research
  – Tests with a limited number of trials fixed in position are subject to memorization and loss of sensitivity and specificity

• Require airmen that fail any clinical test to pass computer-based precision testing to be cleared without restriction by an AME
  – Finding: Precision tests identify 83% of CVDs who pass all job sample tests
  – More time consuming and costly than clinical screening but less than a MFT
  – Will reduce the number of persons requiring a MFT
Research Recommendations (cont.)

• Require airmen failing precision testing to complete FSDO charting/signal light testing and/or MFT
  – Continuing current policy

• **Ensure MFT aircraft type is representative of type of intended operation**
  – Allow airmen passing flight testing in technologically advanced aircraft to be cleared across category/class
  – Otherwise, limit passing airmen to electromechanically-instrumented aircraft
  – Identify special cases such as NVG helicopters with different palette
Cost Impact

• **Cost of precision tests to AMEs (as of January 2013)**
  – Assuming AAM requires AMEs to purchase one precision test
  – CAD, CCT, or Waggoner CCVT *test cost*
    • $195 WCCVT, *software on your computer; future upgrade cost*
    • $3885 CCT, *only available with bundled hardware*
    • $9952 CAD, *only available with bundled hardware*
  – These tests produce consistent results, add YB assessment, accurately predict ability to perform job sample tasks, while reducing MFTs
• **Color Vision clearance rates**
  – Assuming 8% male and 1% female CVD rates among pilots
  – 94.7% of pilots cleared without restriction by clinical screening
    • 4.3% with a deficiency; additionally, anticipate 1% of NCV pilots screened in error
  – 3% cleared without restriction following precision testing
  – 1% cleared by FSDO charting/signal light testing and/or MFT (best guess, based on job sample tests)
  – 1.3% would remain restricted from night flight and color signal control
Alternatives Considered

• Require only precision screening of all pilots
  – Takes longer than recommended clinical tests without benefit for 94% who pass
  – Less effective than combining recommended clinical with secondary precision for those who fail
    • Used alone, no available secondary screen other than MFT
    • As a secondary screen, precision is safety-definitive, where second clinical is not

• Develop occupational test inserted between clinical and flight tests
  – Only remaining avenue to pre-MFT clearance for 25% of appropriate CVD clearances
  – However, $210K development cost over two years, infrastructure costs for use
Policy Considerations

- SMS Principles apply to color vision screening process
- Detecting risk: NTSB recommendation
- Quantifying risk: AAM-500 studies
- Mitigating or accepting risk
  - AAM-500/201 proposal
  - Alternatives include acceptance of risk among 1.3% of population we believe would not pass an MFT
  - DIWS (Skaggs, Norris, & Johnson, 2012) indicates less than 1% of pilots diagnosed with CVD
    - However, 1.6% of Class 1 medicals
    - Population is self-selected, or process has not detected/diagnosed CVD
    - Perhaps less than 0.4% of all pilots would not pass MFT
Summary

• Research suggests current policy clears some pilots warranting more scrutiny

• We recommend
  – Single clinical test per exam from limited list
  – Add YB screening
  – Precision testing if clinical test failed
  – MFT if precision testing failed
  – Consider aircraft type in which MFT conducted

• SMS balancing of cost/risk among small group of pilots