

Pilot Color Vision Research and Recommendations

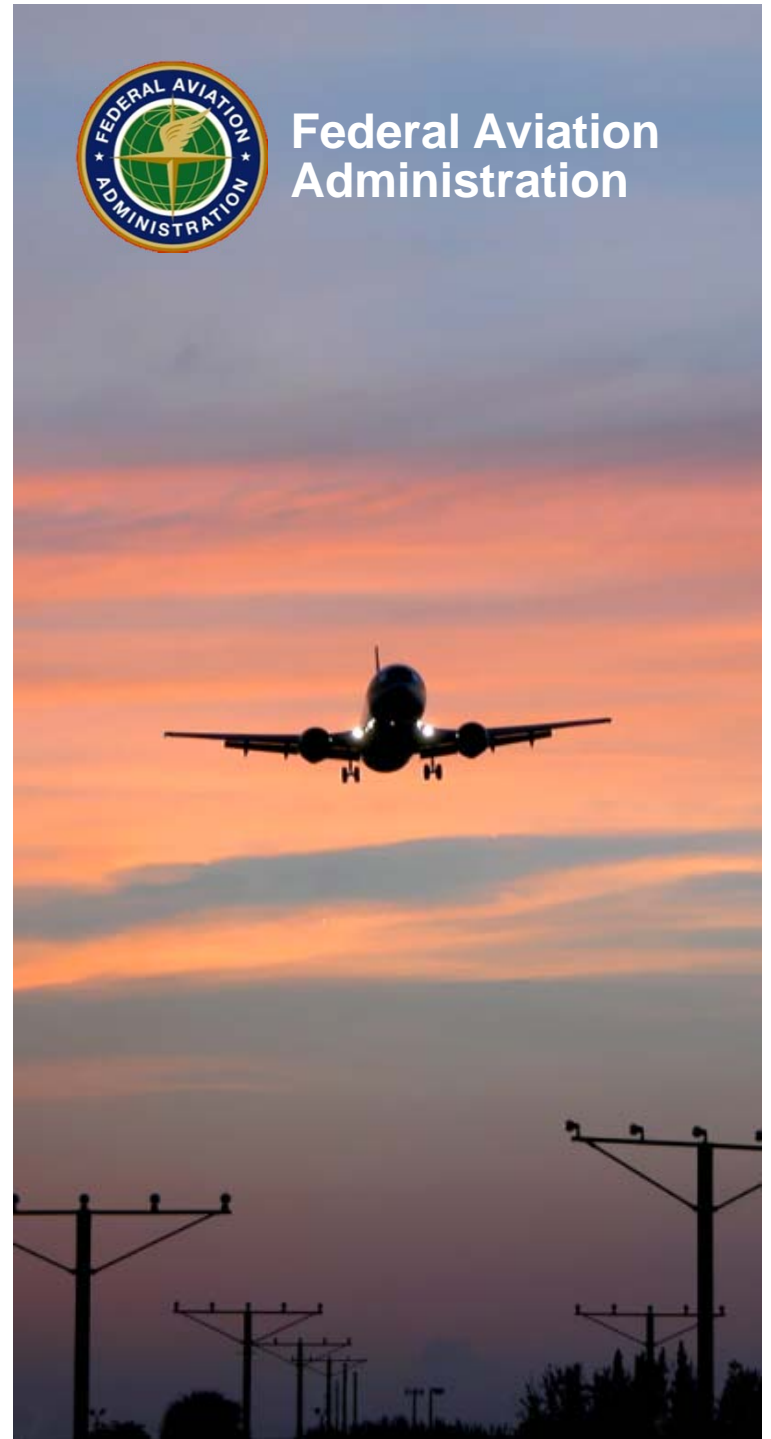
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Administration



Disclosure Information

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I have no financial relationships to disclose.

**I will not discuss off-label use and/or
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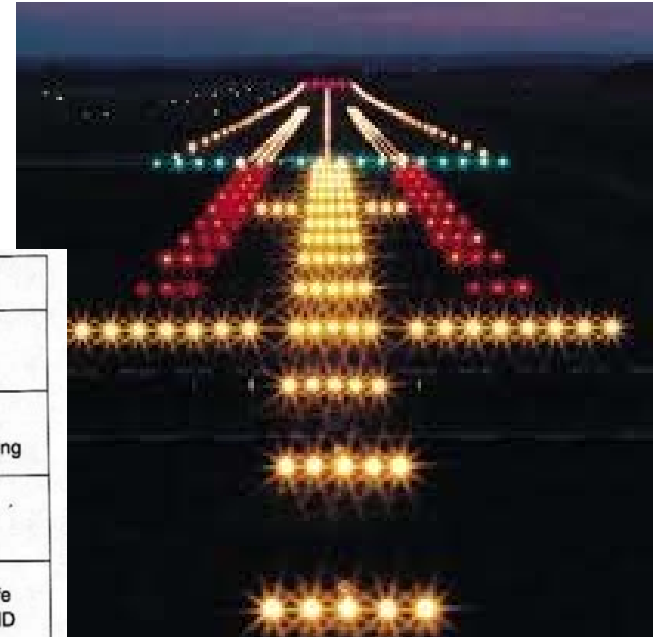
NTSB Recommendation

- **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



GROUND	Light Gun Signals	AIR
Cleared for Takeoff		Cleared to Land
STOP		Give Way Continue Circling
Cleared to Taxi		Return for Landing
Taxi Clear of Runway		Airport Unsafe DO NOT LAND
Return to Starting Point on Airport		Not Applicable
Exercise EXTREME CAUTION		Exercise EXTREME CAUTION



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 5th 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**