

Task 8: Color Vision Requirements for Pilots (Milburn)

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Requirements Statement
<p>Operational Shortfall or Knowledge Gap</p> <p>The National Transportation Safety Board (NTSB) made two safety recommendations (A-04-46 and -47) to the FAA describing needed research. The first involved the evaluation of the current FAA-approved color vision test protocols for effectively screening out pilot applicants with color vision deficiencies that could impair their ability to perform critical color-related aviation tasks. Additionally, the NTSB asked that the FAA look into the role that mild hypoxia might have had on color perception.</p>
<p>Benefit in Closing the Shortfall or Gap</p> <p>This research will examine the effects of mild hypoxia on color perception, the effectiveness of some of the FAA-approved color vision screening tests, the level of color perception needed to perform directions indicated by the PAPI (precision approach path indicator) lights as measured by a computerized, diagnostic color vision test called the Color Assessment & Diagnosis (CAD) test, and will document the colors in the cockpit and airport environments that must be discriminated by pilots.</p>
<p>Description of the Desired Product</p> <p>Ultimately, the desired product will be recommendations regarding the appropriateness of the FAA's current color vision screening procedure/tests for each class of medical certificate based on the aircraft/airport chromaticity data.</p>
<p>Schedule</p> <ul style="list-style-type: none">Review, obtain clearance, and publish joint FAA/Civil Aviation Authority (CAA) report of PAPI studyComplete data analysis for hypoxia study and prepare a draft reportCollect ecologically valid samples of cockpit display and external signaling colorsComplete the data screening and plottingDetermine whether gaps exist (e.g. display manufacturers or airport lighting systems) and if additional data are requiredIncorporate those representative chromaticities into a generic taskPrepare laboratory apparatus and stimuli, obtain Institutional Review Board (IRB) approval, collect performance data, plot and analyze dataDetermine whether the FAA's current color vision screening procedure is appropriate

Research Objective

The first objective of this task is to evaluate the impact of color-coding on the flight deck and airport environments and through color selection, improve the effectiveness of color use especially for color-deficient pilots. The second objective is to determine the effectiveness of each of the current FAA-approved color vision test protocols (including the color signal light test) at effectively screening out pilot applicants with color vision deficiencies that could impair their ability to perform critical color-related aviation tasks including (but not limited to) correct interpretation of glide path information and in-cockpit displays that use color to convey information. The third objective is to examine the effects of mild hypoxia on color perception of normal and color-deficient individuals. The fourth objective is to develop and validate practical color vision tests for pilot screening (if necessary).

Background

The National Transportation Safety Board (NTSB) determined that a contributing factor in the collision with trees on final approach of FedEx Flight 1478, Boeing 727-232, N497FE in Tallahassee, Florida on July 26, 2002 was the first officer's color vision deficiency. Consequently, the NTSB made two safety recommendations (A-04-46 and -47) to the FAA describing needed research. The first involves the evaluation of the current FAA-approved color vision test protocols for effectively screening out pilot applicants with color vision deficiencies that could impair their ability to perform critical color-related aviation tasks. Based on findings from that study, a second requested study is to develop a standard battery of tests to be performed at least once on each applicant for a Class 1 or 2 medical certificate that would prevent applicants with color vision deficiencies that could impair their ability to perform critical color-related aviation tasks from being certificated without limitations.

To obviate the problems associated with color vision deficient personnel using displays with multiple colors, scientists have recommended a human-centered approach to automation and the development of new displays that use color as a redundant cue. For example, if red is used as a warning to alert crew members, the red light should be accompanied by another cue, an auditory alert, or the flashing of the light. Thus, the red color-coding is used as a redundant cue in alerting the crew. There is recent evidence that even when color is a redundant cue, it does not ensure efficient detection of cues by all personnel.

Previous Activity on this Task

AAM-500 awarded a grant in FY06 to City University of London to continue research initially funded by the United Kingdom's CAA. Work under that research project funded the development of the CAD test and a PAPI simulation test that was used to determine the limits of color discrimination that can be considered "safe" in the aviation environment. The research validated the CAD test using a large number of normal trichromats (~250) and a variety of congenital color-deficient observers (~250). The research included a test that employed less favorable stimulus conditions (i.e., a dark background with small-sized disc stimuli) that are closer to those observed in the most demanding color discrimination tasks in the aviation environment. In the 4th quarter of FY08, City University provided a final draft of a report of their findings that the FAA will co-publish with the CAA.

Data collection was completed for a study investigating the effects of mild hypoxia on color perception. Those data have been entered into a database, cleaned, and preliminary analysis has been completed. Summary tables and cross-tabulations by pass/fail outcomes have been constructed in preparation for the report.

A research effort was initiated during FY08 to develop and validate appropriate screening procedures and practical tests appropriate for today's aircraft. The first step was to collect ecologically valid samples of cockpit display and external signaling colors and dimensionalize their chromaticities to high-precision color vision tests. Samples were collected from 34 airports and 17 aircraft and the next step is to complete the data screening and plotting. A generic color discrimination task was developed based on color samples observed in the cockpit. An IRB application has been submitted, the study design has been finalized, test materials have been assembled, and color vision equipment (including all currently FAA-approved tests and several new tests seeking FAA-approval) has been shipped to Rensselaer Polytechnic Institute (RPI) in Troy, NY for a collaborative study in conjunction with Task 12 to determine the usability of colored LED lights by pilots with color vision waivers.

Proposed or Planned Research

This research will evaluate the impact of color-coding on the flight deck and airport environments by incorporating the chromaticity data collected from airports and aircraft into a simulation of aviation tasks and evaluating the effectiveness of color use especially for color-deficient pilots. The research design will include each of the current FAA-approved color vision test protocols (including the color signal light test) and some new proposed tests to examine whether they effectively screen out pilot applicants with color vision deficiencies that could impair their ability to perform critical color-related aviation tasks including (but not limited to) correct interpretation of glide path information and in-cockpit displays that use color to convey information. If necessary, this research will lead to development and validation of practical color vision tests for pilot screening if the current method is inappropriate. The research will examine the data from the FY08 study to determine the effects of mild hypoxia on color perception of normal and color-deficient individuals.

All currently FAA-approved tests and several new tests seeking FAA-approval have been shipped to Rensselaer Polytechnic Institute in Troy, NY for a collaborative study in conjunction with Task 12 to determine the usability of colored LED lights by pilots with color vision waivers. Data collection is scheduled to begin in mid-February. The contract for subjects has been awarded to Companies of JJ Young of Albany, NY. A telecom is scheduled for early January with the contractor, RPI, and the task PI to discuss the logistics of the study that are related to recruiting participants and what they should expect while serving as research subjects. A computer-based test involving the generic pilot color discrimination task will be administered to subjects of varying color vision abilities. The study protocol also includes the FAA's current secondary screening test called the Signal Light Gun test which will be used to compare to screening test performance. Data collection will require 4-6 weeks for a team of researchers. Data will be entered into data files continuously during the data collection phase to accelerate the data analysis phase. Data file structures, variable names, pass/fail criteria, and cross tabulation table syntax have already been established, which will further facilitate the data analysis. Several new computer-based color vision screening tests will be presented and we look forward to examining their performance as potential screening tests because of their robustness to deception by applicants.

Research Question(s)

- i)* What is the validity of the Aviation Lights Test for predicting performance on simulated red-white VASI/PAPI lights under time constricted conditions?
- ii)* Is the current color vision screening appropriate for all classes of medical certificates given the extensive use of color in the cockpit and in the airport environment?
- iii)* To what extent does mild hypoxia impact normal and color-deficient pilots' color discrimination?

Technical Approach

Current Year

To determine the appropriateness of the FAA's current color vision screening tests given the increased usage of color in the cockpit and in the airport environment, one goal of FY08 was to make chromaticity measurements of those colors currently in use. Consequently, measurements were taken at 34 airports and of 17 aircraft. The purpose for taking the measurements was to document specific chromaticities and incorporate those representative chromaticities into a generic task that would allow an individual to demonstrate his/her ability to discriminate the documented colors. The performance outcome data would then be plotted onto CIE color space and compared to dimensional diagnostic scores for individuals as a function of color vision classification. To accomplish this, the steps that must be completed are to 1) Dimensionalize chromaticities of color samples, 2) Examine the data of ecologically valid samples of cockpit display and external signaling colors and determine whether gaps exist (e.g. specific display manufacturers or specific airport lighting systems), 3) Prepare test stimuli, obtain IRB approval, and collect data.

Out-Years

Recommendations regarding the appropriateness of the FAA's current color vision screening procedure/tests for each class of medical certificate based on the aircraft/airport chromaticity data.

Air Traffic Resources Required

None

Information Technology Resources Required

Back-up data on non-networked computer. Calibration of Viewsonic monitor for the Cone Contrast test

Calibration

The PI will ensure that the Photo Research 650, the LMT Luminance Meter L1009, the Minolta CS-100, the CAD test and any CRT monitors used for data collection are calibrated prior to beginning data collection

FY10 Milestone Schedule		
Description	Proposed Start Date	Proposed Completion Date
Review and publish joint FAA/CAA report of the PAPI color vision study	FY09 Q1	FY09 Q3
Examine the data of ecologically valid samples of cockpit display and external signaling colors and determine whether gaps exist (e.g. specific display manufacturers or specific airport lighting systems)	FY09 Q1	FY09 Q3
Complete data analysis for hypoxia study	FY09 Q2	FY09 Q3
Prepare a draft report of the hypoxia color vision study	FY09 Q3	FY09 Q4
Test normal and color vision deficient subjects to validate precision tests against flight deck operation use of color in displays and signaling devices.	FY09 Q3	FY10 Q2
Complete data analysis for evaluation of ALT/PAPI study	FY09 Q3	FY09 Q4
Dimensionalize chromaticities of color samples	FY09 Q1	FY09 Q3
Prepare test stimuli, obtain IRB approval, and collect data	FY09 Q4	FY10 Q2

FY10 Deliverables		
Description	Proposed completion date	Actual completion date
Joint FAA/CAA report of the PAPI color vision study	FY09 Q3	FY09 Q3
A report on the validity of the Aviation Lights Test for predicting performance on red-white PAPI lights under time constricted conditions.	FY09 Q4	FY09 Q3
Report of effects of mild hypoxia on color vision.	FY10 Q3	
Report findings from normal and color vision deficient subjects to validate precision tests against flight deck operation use of color in displays and signaling devices.	FY10 Q4	