



# COLOR deficient?

**Aviation medical specialists are trying to define the role of color vision in safe flight operations.**

BY LINDA WERFELMAN



As technological advances infuse flight decks with increasingly colorful displays, disagreements persist among pilots, aeromedical specialists and regulators on a basic underlying question: What level of color vision is required for safe flight operations?

The International Civil Aviation Organization (ICAO) says that the increasing reliance on color-coded information in flight displays “means that adequate color perception continues to be important for flight crew and air traffic controllers.”<sup>1</sup>

ICAO also says that, unfortunately, “there is very little information which shows the real, practical implications of color vision deficiencies on aviation safety.”

Dr. Anthony Evans, chief of ICAO’s Aviation Medicine Section, said, “Many individuals seem to function very well with a degree of deficiency, and flying instructors are often ready to attest to the visual ability of some color deficient individuals. On the other hand, some — actually very few — safety tasks rely on good color vision for their safe execution.”

### Defining Deficiencies

Color vision deficiency is the inability to see some shades of color or, in the most severe cases, to be color “blind” — that is, to see all colors as black, white or gray. A color vision deficiency usually is an inherited condition but also can be caused by diseases such as diabetes, macular degeneration or sickle cell anemia, or by some medications used to treat heart problems, high blood pressure and other conditions. Color vision also may deteriorate with advancing age.

People see colors because light-sensitive pigments in the photoreceptors, or *cones*, in the retina of the eye enable each cone to detect the wavelength associated with either red, green or blue light. The information gathered by the cones travels through the optic nerve to the brain, which distinguishes among hundreds of shades of colors. When the cones are missing one or more pigments, the affected individual is unable to see the associated shades. Color vision deficiencies

range from mild to severe, depending on how much pigment is missing from the cones.<sup>2,3</sup>

ICAO statistics show that about 8 percent of men and 0.8 percent of women have color deficiencies that cause them to fail color perception tests — although percentages vary according to geographical regions. Of these, more than 99 percent have red-green deficiencies — that is, they are unable to differentiate some shades of red and green.<sup>4</sup>

Nevertheless, ICAO and civil aviation authorities around the world recognize that many people with mild color vision deficiencies can safely operate aircraft, and thousands of pilots who are unable to pass the most frequently administered test of color vision have been issued medical certificates after passing alternate tests.

ICAO’s standards instruct civil aviation authorities to test pilots and air traffic controllers “for the ability to correctly identify a series of pseudoisochromatic plates” — printed patterns that include numbers and backgrounds composed of differently shaded dots. According to ICAO’s standards, those who fail this test can still be considered fit for flight or air traffic control duties if they pass another test of their abilities to “readily distinguish the colors used in air navigation and correctly identify aviation colored lights.”

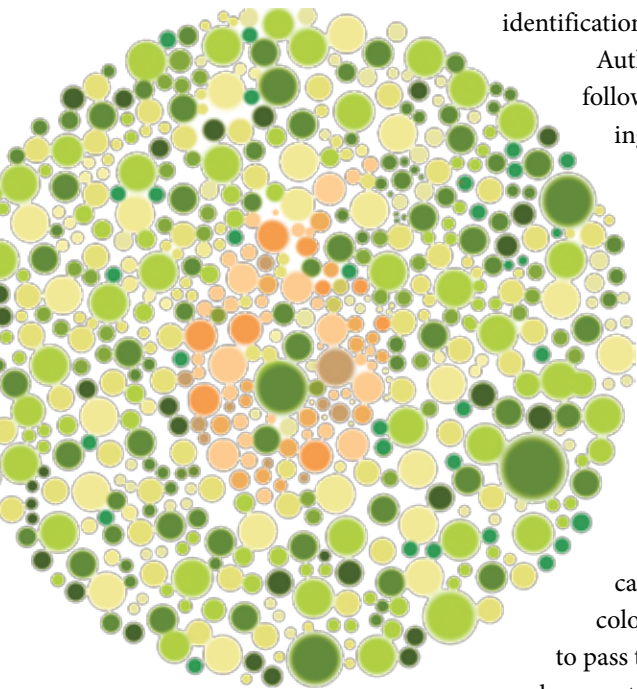
### Little Uniformity

Beyond these requirements, there is little uniformity in color vision standards established by civil aviation authorities in different countries.

“Every regulatory agency in the world has its own standards, its own exams,” said Dr. Russell Rayman, executive director of the Aerospace Medical Association. “If you go to 20 different countries, you’ll probably get 20 different answers.”

For example, a 2005 review found that the European Joint Aviation Authorities (JAA), the Australian Civil Aviation Safety Authority (CASA) and the U.S. Federal Aviation Administration (FAA) all authorized a screening test using the same set of 15 pseudoisochromatic plates. Requirements for a passing score differed, however; the JAA required correct identification of all 15 plates,<sup>5</sup> CASA required correct

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identification of 13, and the FAA, correct identification of nine.<sup>6</sup>

Authorities also differ in their follow-ups to a failed screening test. For example, the

FAA allows applicants who fail the initial test to request one of several authorized alternate tests, administered by an aviation medical examiner or, in some cases, at schools of optometry.

Those who pass are issued medical certificates without limitations for color vision but are required to pass the same test again at subsequent medical evaluations.

Alternatively, an applicant can request a one-time test at an FAA flight standards district office. Those who fail this test receive medical certificates with permanent limitations “not valid for night flying or by color signal control.” The JAA says that if an applicant for a Class 1 medical certificate fails the pseudoisochromatic plate test, he or she can be considered “color safe” by subsequently passing “extensive testing with methods acceptable to the [JAA Aeromedical Section].” A failure results in the applicant’s assessment as “color unsafe” and not fit to fly.<sup>7</sup>

“There’s some commonality in regulatory standards, but there are also definitely differences,” Rayman said. “Some people think there’s no need for color vision testing. Others on the opposite side feel very strongly that it should be tested, should be a criterion for aeromedical qualification. I asked the question of a group of pilots one day, and they thought that in today’s modern cockpit, there should be a requirement for reasonably normal color vision.”

Dr. Quay Snyder, president and CEO of Virtual Flight Surgeons, an aeromedical consulting firm, said that in older aircraft, “you needed to identify light signals or navigation

lights, and the displays tended to be monochrome. Now, with multifunction displays, both in the aircraft and in the air traffic control environment, there are multitudes of hues and intensities that are used, and the color deficient individual may have problems perceiving some of those displays.”

Snyder, also an associate aeromedical adviser for the Air Line Pilots Association, International, added, “We have seen a number of color deficient pilots and controllers perform well, without any adverse impact on safety.”

Among those who agree is Dr. Arthur Pape, a former official of the Aircraft Owners and Pilots Association of Australia and a designated aviation medical examiner who won a court challenge of CASA’s color vision policies in the late 1980s. Pape, who has a color vision deficiency and holds a commercial pilot license, argued that color vision deficiencies were irrelevant to a pilot’s safe operation of an aircraft.

“The disability of defective color perception is confined to reduced sensitivity to that property of light defined by its wavelength,” he wrote in a paper published in 1994. “Color defectives have the same capacities as color normals to perceive form, motion, depth, luminance contrast, and so on ... [and] the same capacities as color normals for complex perceptual motor skills that form a part of ... flying airplanes.”<sup>8</sup>

### Contributing Factor

Only a few accidents<sup>9</sup> have been officially associated with a color vision deficiency, most notably the July 26, 2002, crash of a Federal Express Boeing 727-200F during a visual approach to Tallahassee (Florida, U.S.) Regional Airport in nighttime visual meteorological conditions. The three crewmembers were seriously injured and the airplane was destroyed in the crash, which the U.S. National Transportation Safety Board (NTSB) attributed to “the captain’s and first officer’s failure to establish and maintain a proper glide path.”<sup>10</sup>

The NTSB cited as one of several contributing factors “the first officer’s [the pilot flying’s] color vision deficiency,” which interfered with

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his ability to discern the red and white lights of the precision approach path indicator (PAPI).

Records showed that the first officer had passed all color vision tests during his 16 years as a U.S. Navy pilot but failed a test administered during an FAA medical evaluation in 1995; the test indicated that he had a mild red-green deficiency. The FAA issued a first-class medical certificate with a statement of demonstrated ability (SODA), based on his years as a Navy pilot and the results of his Navy color vision tests. His subsequent medical certificates were issued with the same SODA.

During a post-accident evaluation, the first officer passed the Farnsworth Lantern (FALANT) color vision test, which was designed to differentiate between people with mild red-green deficiencies, who pass the test, and people with more significant red-green deficiencies, who fail. He also passed a light-gun-signal test administered by an FAA medical examiner. However, he failed seven other red-green color vision tests and was determined to have a “severe congenital deuteranomaly” — a red-green deficiency that is the most common color vision defect.

As a result of its investigation, the NTSB included in its final report two recommendations calling on the FAA to research the effectiveness of color vision tests used by aviation medical examiners and use the research

findings to develop a new standard battery of color vision tests.

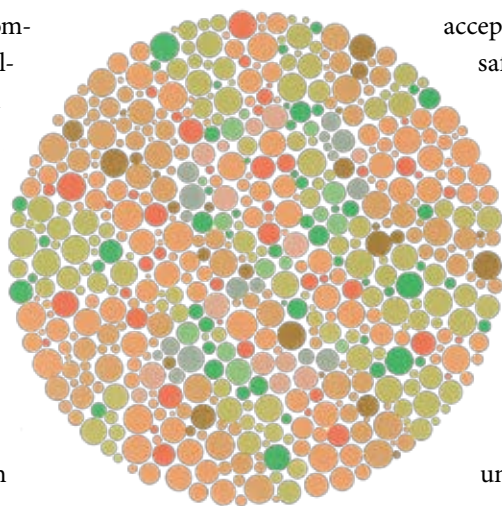
The FAA agreed to what it said would be a “substantial” research program, likely to continue for several years, saying that it recognized that color vision deficiencies, as well as the tests used to evaluate them, are controversial.

By late 2008, research had been completed but not yet made public on whether mild hypoxia might have contributed to the 2002 Federal Express crash. The study involved several color vision tests that were administered in an altitude chamber at simulated altitudes of 12,400 ft and 8,000 ft, with comparisons to test results recorded for participants at ground level.

Other research, cosponsored by the U.K. Civil Aviation Authority, was conducted under an FAA grant to City University London to compare pass/fail performance on various color vision tests with performance on simulated approaches involving PAPI lights.

Color vision research programs are continuing in several countries, not only to further explore the role of color vision in safe flight operations but also to develop new color vision testing protocols.

“A vast amount of work still has to be done in order to establish which color vision deficiencies can be accepted without loss of safety,” the JAA said in its *Manual of Civil Aviation Medicine*. Ultimately, that work will aid in decisions about which color vision tests can “effectively divide applicants into ‘color safe’ and ‘color unsafe’ groups.”<sup>11</sup>



Notes

1. ICAO. *Manual of Civil Aviation Medicine*. Part III, “Medical Assessment,” Section 11.8, “Color Vision.” Preliminary unedited version, October 2008.
2. American Optometric Association. *Color Vision Deficiency*. <[www.aoa.org/x4702.sml](http://www.aoa.org/x4702.sml)>.
3. Mayo Clinic. *Poor Color Vision*. <[www.mayoclinic.com/print/poor-color-vision/DS00233/](http://www.mayoclinic.com/print/poor-color-vision/DS00233/)>.
4. ICAO.
5. A similar requirement is included in a proposal under consideration by the European Aviation Safety Agency.
6. Evans, Anthony D.B.; Barbur, John L. “Colour Vision Standards in Aviation.” *ADF Health* Volume 6 (October 2005): 62–66.
7. JAA. *Joint Aviation Requirements, Flight Crew Licensing — Medical*. Section 1, “Requirements,” Item 3.225 “Colour Perception.” Dec. 1, 2006.
8. Pape, Arthur. *The Aviation Colour Perception Standard*. Association Colours in Cockpit Web site, <[www.vfcev.de/content/eng-index.html](http://www.vfcev.de/content/eng-index.html)>.
9. In its response to two NTSB safety recommendations, the FAA said that, in addition to the Federal Express crash in Tallahassee, it had identified two other accidents involving pilots with valid medical qualifications in which a color vision deficiency was cited as a contributing cause. One was an Aug. 29, 1992, incident in which the pilot of a Mooney 20F with “a waiver for partial color blindness to red and green” landed on a closed runway that was marked with orange crosses in the dirt 50 ft (15 m) beyond each end. The pilot’s “limited ability to detect the orange-colored marking” was cited as a contributing factor, along with his anxiety following a near-midair collision that preceded the landing. The other incident involved a Navy F4J lost on Aug. 5, 1980, “when a severely color deficient pilot failed to interpret correctly the colored navigation lights of other aircraft in the area, leading to the false impression of a collision.”
10. NTSB. *Collision With Trees on Final Approach: Federal Express Flight 1478; Boeing 727-232, N497FE; Tallahassee, Florida; July 26, 2002*, Report NTSB/AAR-04/02.
11. JAA. *Manual of Civil Aviation Medicine*. Chapter 13 “Aviation Ophthalmology,” Section 10 “Colour Vision.” Feb. 1, 2005.