National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: *June 10, 2004*

In reply refer to: A-04-46 and -47

Honorable Marion C. Blakey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On July 26, 2002, about 0537 eastern daylight time, Federal Express flight 1478, a Boeing 727-232F, N497FE, struck trees on short final approach and crashed short of runway 9 at the Tallahassee Regional Airport (TLH), Tallahassee, Florida. The flight was operating under the provisions of 14 *Code of Federal Regulations* Part 121 as a scheduled cargo flight from Memphis International Airport, in Memphis, Tennessee, to TLH. The captain, first officer, and flight engineer were seriously injured, and the airplane was destroyed by impact and resulting fire. Night visual meteorological conditions prevailed for the flight, which operated on an instrument flight rules flight plan.[1]

The National Transportation Safety Board determined that the probable cause of the accident was the captain's and first officer's failure to establish and maintain a proper glidepath during the night visual approach to landing. Contributing to the accident was a combination of the captain's and first officer's fatigue, the captain's and first officer's failure to adhere to company flight procedures, the captain's and flight engineer's failure to monitor the approach, and the first officer's color vision deficiency.

At the Safety Board's request, the first officer completed an extensive postaccident ophthalmic evaluation at the U.S. Air Force School of Aerospace Medicine (USAFSAM), which was intended to determine the extent of the color vision defect noted on his medical certificate and its possible significance during the approach to TLH. During this evaluation, the first officer passed the Farnsworth Lantern (FALANT)[2] color vision screen but failed seven additional

[1] For more detailed information, see National Transportation Safety Board, *Collision With Trees on Final Approach, Federal Express Flight 1478, Boeing 727-232, N497FE, Tallahassee, Florida, July 26, 2002*, Aircraft Accident Report NTSB/AAR-04/02 (Washington, DC: NTSB, 2004).

[2] The FALANT is a Federal Aviation Administration (FAA)-acceptable color vision screening test for FAA pilot certification that is intended to identify (for exclusion) people with significant red-green color vision deficiency who are unable to name aviation (and other) signal lights correctly, while "passing" people with mild red-green vision

red/green color vision tests. The USAFSAM specialists' report stated that the first officer had a severe congenital deuteranomaly that could result in "difficulties interpreting red-green and white signal lights." The report also stated the following:

> We believe that he would definitely have had problems discriminating the PAPIs [precision approach path indicators[3]]…because the red lights would appear not to be red at all, but…more indistinguishable from white than red….it would be extremely unlikely that he would be capable of seeing even the color pink on the PAPI…more likely a combination of whites and yellows and perhaps, not even that difference.

The USAFSAM conclusions are supported by the results of an Australian study, which showed that individuals with color vision deficiencies similar to the first officer's mistakenly identified the red light signal as white in up to 29 percent of the cases. The Safety Board notes that this error could be especially dangerous when interpreting a PAPI signal because it might lead a pilot to descend lower when the airplane is already too low. The Australian study recommended that "consideration should be given to replacing the Farnsworth lantern" as a color vision certification test for pilots.

The specialists at USAFSAM reported that most individuals with color vision deficiencies develop an ability to "differentiate" between normal colors based on cues other than hue or wavelength, such as differences in shade or brightness. The length of the first officer's military and civilian aviation career suggests that, in general, he had been able to compensate for his deficient color vision. However, during the approach to runway 9 at TLH, the first officer had to rely more heavily on his color vision because the PAPI lights were the only reliable source of glidepath information in the black hole[4] approach environment leading to runway 9. The first officer's interpretation of the PAPI lights would have been even more challenging because all four lights were red during most of the final approach. As a result, there would have been no differing levels of brightness for the first officer to perceive across the lights (as might have been apparent if both white and red PAPI lights were visible), nor would there have been a change in brightness to observe (as there might have been when a PAPI light transitioned from white to red during the descent). Either of these would likely have assisted the first officer's color interpretation.

It is possible that the first officer interpreted the uniform PAPI light indications as "white" because that was consistent with available visual indications (for example, the black hole illusion and the slight runway upgrade) that would lead him to perceive that the airplane was higher on the approach than it was. Such an interpretation would be consistent with the first officer's conduct of earlier portions of the approach, with occasionally excessive rates of descent

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deficiency. In this test, the applicant is asked to identify the color (red, green, or white) of two lights projected by the FALANT machine. The examinee must identify nine different light pairings.

[3] The PAPI light system at TLH consists of four boxes of lights that provide a visual indication of an airplane's position on the glidepath for the associated runway. If an airplane is on glidepath, two boxes should display white lights and two boxes red lights. If an airplane is beneath the glidepath, more red lights are visible to the pilots; if an airplane is above the glidepath, more white lights are visible.

[4] The term "black hole" refers to approaches conducted over unlit areas, water, or other featureless terrain.

and lower-than-normal engine power settings. However, just after the airplane descended through 500 feet above ground level, the first officer stated, "(I'm) gonna have to stay just a little bit higher, (or) I'm gonna lose the end of the runway." About this time, the flight data recorder data indicated that the airplane's descent rate began to decrease from about 1,400 feet per minute (fpm) to 900, then to 500 fpm. It was not clear exactly why the first officer moderated the descent rate at this time; however, it is possible that he was trying to reconcile a conflict between the 500-foot ground proximity warning system callout and a mistaken illusion of the airplane's elevation above the field. The Safety Board considers it unlikely that the first officer made this moderate reduction in the airplane's descent rate because he recognized the PAPI indication of four red lights; recognition of four red PAPI lights at such a late stage in the approach should have resulted in a more aggressive response (such as an immediate climb or a go-around).

The Safety Board is aware of other instances in which pilots with valid medical certificates were involved in accidents related to deficient color vision, including a U.S. Navy pilot who passed the FALANT screen and a general aviation pilot operating with a waiver for color vision deficiency. In addition, the Safety Board has observed color vision deficiency-related issues in other transportation modes.

It is apparent that in some situations, accurate color vision may be critical to a degree that is not currently reflected in the application of the aviation medical certification standards,[5] specifically in those situations in which color discrimination capabilities are critical to the safe execution of the task and there are no redundant cues to aid the discrimination. Based on the available evidence, the Safety Board concludes that the first officer suffered from a severe color vision deficiency that made it difficult for him to correctly identify the color of the PAPI signal during the below-glidepath, nighttime, visual approach to runway 9 at TLH.[6]

The Safety Board notes that current aviation medical certification standards for color vision and related screening tests do not emphasize the full complexity of color in modern operational situations, which include not only navigation lights, PAPI/visual approach slope indicator displays and light gun signals, but may also involve color cockpit displays, including weather radar, other flight instruments and gauges, and annunciator panels. Another possible shortcoming of current color vision certification standards and related screening tests is that they may not appropriately evaluate a pilot's ability to rapidly discriminate among colors. Therefore, the Safety Board concludes that existing aviation medical certification standards for color vision and use of related screening tests may not ensure detection of color vision deficiencies that can be detrimental to safety; it is possible that in some emergency situations, the speed of color recognition may assume an importance that is not currently reflected in the standards.

The Safety Board further notes that some color vision screening tests currently in use in the aviation industry are inadequate to confirm that a pilot has the "ability to perceive those

[5] FAA medical standards for color vision require that pilots at all levels of certification possess the "ability to perceive those colors necessary for the safe performance of airman duties."

[6] Another instance during the accident flight may provide an additional example of the first officer's deficient color vision adversely affecting his ability to perform his duties. His initial mistaken identification of a flashing white light as the rotating beacon at TLH reflected his failure to discern the color properties (green and white) of an airport rotating beacon.

colors necessary for the safe performance of airman duties" as required by the certification standards. For example, the FALANT screening test, which is an approved color vision screening method for aeromedical certification, failed to identify the first officer's severe color vision deficiency. In addition, according to a November 5, 2003, USAFSAM letter, other color vision tests (including the psuedoisochromatic plate (PIP) test[7]) have failed to detect color vision deficiencies in pilot applicants. The letter indicated that the USAF now uses a battery of tests that it believes identifies all color vision deficiencies in applicants.

Federal Aviation Administration (FAA) records indicate that there is a substantial pilot population who, like the first officer, have color vision deficiencies but successfully completed the FALANT or other color vision deficiency screening test. For example, during postaccident testing, the first officer successfully completed the FAA's light gun signal test,[8] and as a result, the first officer was issued a first-class medical with no restrictions, limitations, or Statements of Demonstrated Ability (SODA). The high success rate of the light gun signal test among individuals who have previously failed another FAA-acceptable color vision screening test (about 95 percent) suggests that this test may not identify all the individuals with severe color deficiencies that could affect their ability to safely operate an aircraft. (The issuance of a color-vision-related SODA to the first officer on the basis of operational experience appears to fall outside current and past available written FAA guidelines regarding appropriate aeromedical disposition of an airman who fails a color vision test.) Further, it is likely that, in some circumstances, these color vision deficiencies may also result in unsafe conditions.

Therefore, the Safety Board concludes that one or more of the color vision screening tests currently approved for use in the aviation industry (for example, the FALANT) are not adequate and that these tests should be identified and their use discontinued. The Safety Board believes that the FAA should conduct research 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 color-related critical aviation tasks, including (but not limited to) correct interpretation of glideslope information and in-cockpit displays that use color to convey information. The research should take into account the time typically available to perform each task, particularly under emergency conditions, and the potential effect of mild hypoxia (as might occur at typical cabin altitudes) on color vision deficiencies. Further, the Safety Board believes that the FAA should, based on the results of the research requested in the previous recommendation, 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 color-related critical aviation tasks from being certificated without limitations.

[7] PIPs used by the FAA for aeromedical certification are cards with colored spots or patterns that are selected and arranged such that individuals with normal color vision will see a number or figure.

[8] Although operational use of light gun signals in the current aviation environment is very limited, the light gun signal test is still used by the FAA to establish a color-deficient individual's ability to use color operationally.

Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

> Conduct research to determine the effectiveness of each of the current Federal Aviation Administration-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 color-related critical aviation tasks including (but not limited to) correct interpretation of glideslope information and in-cockpit displays that use color to convey information. The research should take into account the time typically available to perform each task, particularly under emergency conditions, and the potential effect of mild hypoxia (as might occur at typical cabin altitudes) on color vision deficiencies. (A-04-46)

> Based on the results of the research requested in Safety Recommendation A-04-46, 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 color-related critical aviation tasks from being certificated without limitations. (A-04-47)

Chairman ENGLEMAN CONNERS, Vice Chairman ROSENKER, and Members GOGLIA, CARMODY, and HEALING concurred in these recommendations.

Original Signed

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Chairman