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The sudden loss of visual cues during periods of blowing dust and dirt, or blowing snow, typically results in an instantaneous and complete onset of instrument meteorological conditions (IMC), which can result in pilot disorientation and loss of control.<sup>1</sup> Coming at the end of an approach in otherwise unthreatening conditions, the startling onset of total IMC can exacerbate pilot disorientation.

Pilots who understand the phenomena of brownout and whiteout and know how to operate their aircraft to avoid — or, if that fails, to fly their aircraft out of — such adverse conditions are best equipped to avoid the severe consequences.

Brownout occurs in the presence of dust, fine dirt or sand. The smaller the particulate matter, the denser the cloud that develops when these particles are agitated by an aircraft's spinning propeller or rotor blades. IMC typically develops 10 to 20 ft (3 to 6 m) above ground level (AGL), and visual references to the ground are instantly obscured. In the best circumstances, pilots shift immediately to instrument flight and fly the aircraft out of the cloud; in the worst, loss of control leads to a crash.<sup>2</sup> Often, the result is a hard landing.

For example, in June 2004, a Eurocopter AS 350B3 on an emergency medical services (EMS) flight landed hard in Cibecue, Arizona, U.S., where a patient was to be picked up for transport to a hospital in Scottsdale.<sup>3</sup> The pilot was familiar with the landing zone, a baseball field, and in a previous landing and takeoff at this same location, he had encountered blowing dirt. On this approach, the pilot briefed the medical aircrew about the possibility of a dust cloud and selected a nearby grassy area for touchdown. About 3 ft (1 m) AGL and at a speed of 10 kt, a dust cloud

When an aircraft is engulfed in blowing dirt or snow, the onset of IMC usually is instantaneous.

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# Flying

developed, causing the pilot to lose all visual cues. The helicopter touched down hard, first on the right skid and then on the left. No one was injured, but the helicopter was substantially damaged. The U.S. National Transportation Safety Board (NTSB) cited as a probable cause the pilot's "failure to maintain a proper descent rate during the landing approach and misjudged landing flare, which resulted in a hard landing"; a contributing factor was "brownout conditions created by the dust cloud that interfered with the pilot's perception of proximity to the ground."

The sudden loss of external visual references also occurs during whiteout. There are two uses of the term whiteout: atmospheric whiteout — also referred to as flat-light conditions — and the more common blowing-snow whiteout. Atmospheric whiteout is encountered during flight and occurs when snow-covered ground cannot be distinguished from a white, overcast sky. As a result, the horizon is virtually indistinguishable. In blowing-snow whiteout, visibility is restricted drastically by ground snow that has been

driven into the air by propeller or rotor wash. Approaches and landings on snow-covered ground are particularly likely to create blowing-snow whiteouts. Whiteout also may be encountered some distance from shore during flight over large frozen bodies of water.

For example, in February 1995, a Beechcraft A100 King Air was nearing the end of a regularly scheduled flight from Sioux Lookout, Ontario, Canada, to Big Trout Lake, with nine passengers and a crew of two. The captain briefed an instrument approach with a circling procedure to the landing runway. During the approach, the crew could see the ground; visibility was estimated at 1.0 mi (1.6 km). To ensure safe separation from another aircraft, the crew flew the airplane away from the airport under visual flight rules; during this maneuver, as they flew the airplane over the frozen surface of a lake, they encountered whiteout conditions. The airplane struck the ice. Both pilots and seven passengers received serious injuries, and the airplane was destroyed. The Transportation Safety Board of Canada (TSB) said that the cause of the accident was that "while



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the crew were maneuvering the aircraft to land and attempting to maintain visual flying conditions in reduced visibility, their workload was such that they missed, or unknowingly discounted, critical information provided by the altimeters and vertical speed indicators.<sup>3</sup> Contributing factors were “the whiteout conditions and the crew’s decision to fly a visual approach at low altitude over an area where visual cues were minimal and visibility was reduced.”<sup>4</sup>

## Civil vs. Military

In civil aviation, brownout occurs infrequently. As in the EMS accident scenario, it is most likely in rural regions or where undeveloped landing zones are encountered. Helicopters are more likely than fixed-wing aircraft to encounter brownout.

Whiteout is much more frequent in civil aviation because snow is common in many locales and can be prevalent even in the most built-up environments. While helicopters — because of their many operations in remote, unconventional locales — are susceptible to whiteout caused by rotor wash, the

propellers of fixed-wing aircraft also can induce whiteout.

In military operations, because of frequent operations in hostile environments, brownout and whiteout are more frequent than in civil aviation. Two 1998 U.S. Army studies of spatial disorientation in helicopter operations found that the sudden loss of visual cues, as associated with brownout and whiteout, accounted for 25 percent and 13 percent, respectively, of all spatial disorientation accidents.<sup>5</sup> A 2004 report said that brownout has been the most frequent cause of aviation accidents during the war in Iraq,<sup>6</sup> and the U.S. military has identified brownout and whiteout as critical flight safety issues.

A review of the aviation accident database maintained by TSB for the period 1990–2005 found 22 accidents in which whiteout was cited as a major or contributing factor. These were evenly divided between atmospheric and blowing-snow whiteout scenarios, and evenly divided between helicopters and airplanes.<sup>7</sup>

A similar review of the Aviation Accident and Incident Data System maintained by NTSB for the period

1978 through Oct. 20, 2006, found one accident/incident report involving brownout — the 2004 Eurocopter accident in Arizona — and 79 reports involving whiteout (Figure 1, page 46).<sup>8</sup> Of the 79 whiteout accidents/incidents, 57 (72 percent) involved airplanes, and 22 (28 percent) involved helicopters. Atmospheric whiteout was cited as a causal factor in 52 accidents/incidents (66 percent); of these, 43 involved airplanes and nine involved helicopters. The remaining 27 accidents/incidents (34 percent) involved blowing-snow whiteout; of these, 14 involved airplanes, and 13 involved helicopters.

## Prevention Is the Best Solution

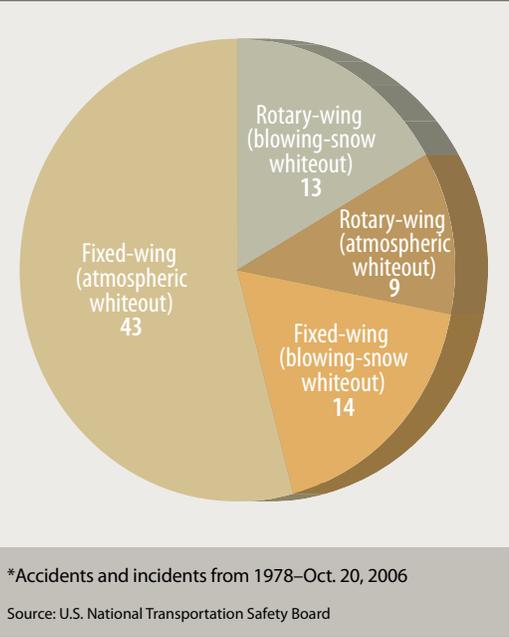
Pilot awareness of the potential for brownout and whiteout is the first step in preventing these accidents. Experience and confidence in handling these phenomena can be achieved through training, which should teach pilots to conduct a risk assessment before all landings. The pilot should determine the potential for brownout or whiteout, be aware of nearby obstacles in case visual cues are lost and have a go-around plan before committing to the approach.

When anticipating the occurrence of brownout or whiteout, available crewmembers should inform the pilot of any developing clouds of dirt or snow. Landing speed should be just fast enough to minimize the cloud’s effects and the terminating hover should be eliminated or minimized. The pilot should be ready for an immediate transition to instrument flight.

## Technological Remedies

Military services have been pursuing an aggressive program of prevention and mitigation of whiteout and brownout accidents and incidents. They have increased training, using enhanced

**Whiteout-Related  
U.S. Civil Aircraft Events\***



**Figure 1**

simulations of degraded visual environments in which these events occur. They also have investigated the use of advanced technologies, both as immediate and long-term solutions.

For example, the U.S. Navy is evaluating a device called the tactile situation awareness system (TSAS), which consists of a vest with small, pneumatically or electro-magnetically driven stimulators called tactors. The tactors provide a touch input to the pilot's body or

legs to signal that the aircraft is drifting or requires a correction. The use of TSAS is intended to reduce the pilot's overall workload, allowing other tasks that demand visual attention to be performed more effectively.<sup>9</sup>

Advanced sensing technologies — such as ultra-wideband radar and thermal and laser sensors — also have been studied to evaluate their ability to allow pilots to “see through” obscuring clouds.

Another technique being studied for combating brownout involves the use of chemical ground treatments to reduce the propensity of sand, dust and fine dirt to form obscuring clouds. For these treatments to be successful, they must be durable and resistant to weather exposure.

The most ambitious approach to preventing brownout and whiteout is a change in rotor blade/propeller design. This has been proposed for the US101, a U.S. variant of the Agusta Westland's EH-101 helicopter.<sup>10</sup> In contrast to standard designs, which push dust toward the fuselage and create brownout, the US101's blades push dust away from the fuselage.

Eventually, after testing by the military, some of these techniques are likely to find their

way into civil aviation. In the immediate future, however, pilots in civil aviation will have to rely on their knowledge, training and experience. They must understand the causes and effects of brownout and whiteout, and maintain sufficient instrument skills to avoid disorientation when the resulting inadvertent IMC occurs. ●

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**Notes**

1. A similar phenomenon sometimes affects helicopters hovering over water. This occurs when water droplets that have been blown upward then move downward and are seen in sunlight or moonlight; when this occurs, ground references are obscured. In reacting to this illusion, the pilot may initiate a descent that could result in unexpected ground contact at rates sufficient to damage the aircraft and produce injuries.
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