Your Senses in the Shadows

Nighttime Visual Illusions and Spatial Disorientation

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By Nicole Hartman, FAA Safety Briefing Magazine

Like many kids, my daughters were afraid of the dark when they were young. Their inability to see in the darkness left them feeling vulnerable and exposed and caused their other senses (and imaginations) to run wild. Even though at a certain age they knew that monsters didn't exist, their guts still told them that something might be lurking under the bed, in the shadows. Fear of the dark is common in children and fortunately isn't dangerous in typical cases. However, false feelings at night are also prevalent in the cockpit and are far more hazardous.

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There are considerable benefits to flying at night. The darkness provides a different view, and you'll probably experience less chatter on the radio and

smoother air. Check out "Don't Be Afraid of the Dark" for some experts' perspectives on night flying. But these perks come with unique challenges and risks, including limited visibility. During nighttime operations, pilots can fall victim to optical illusions that drastically compromise their safety. So, let's shine a light on the types of illusions that you might encounter at night and what to do to combat them.

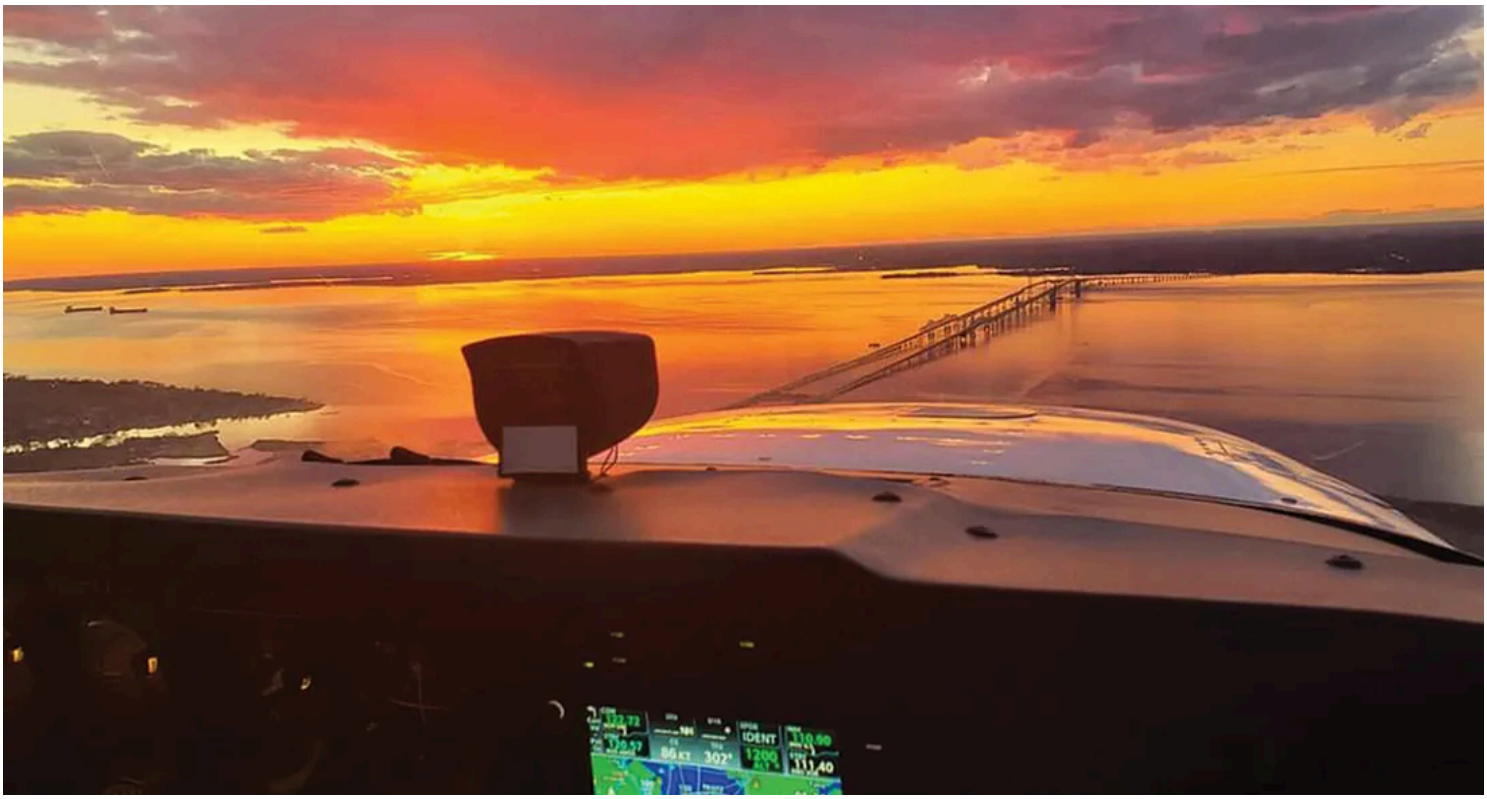
Sight Without Vision

During flight, visual reference is the most important contributor to accurate spatial orientation. By using visual references, the pilot can gather information about distance, speed, and depth. Any condition that deprives the pilot of natural visual references can rapidly cause spatial disorientation (spatial D). These include darkness, the focus of this article, along with clouds, fog, haze, terrain, and sky backgrounds with indistinct contrast (i.e., arctic whiteout or clear, moonless skies over water). Humans are visual

creatures; our bodies are not built for flying and all the sensations that go with it. Without adequate visual cues, you can easily be fooled into thinking that you are climbing when really, you're accelerating downwards. Additionally, if you're turning steadily without adequate visual cues, after a while you can easily be fooled into thinking that the turning has stopped and stabilized when the turning is still ongoing. In fact, after rolling to straight-and-level, a turn in the opposite direction can be incorrectly perceived and quickly turn into a nightmare.

NTSB data suggests that accidents involving spatial D are more common at night or in limited-visibility weather conditions. Since 90% of spatial D accidents are fatal, it's vital that pilots are aware of the dangers of losing their bearings.

So, what should you be on the lookout for when it's dark and the looking is difficult?



(Photo by Christopher Criswell)

Autokinesis

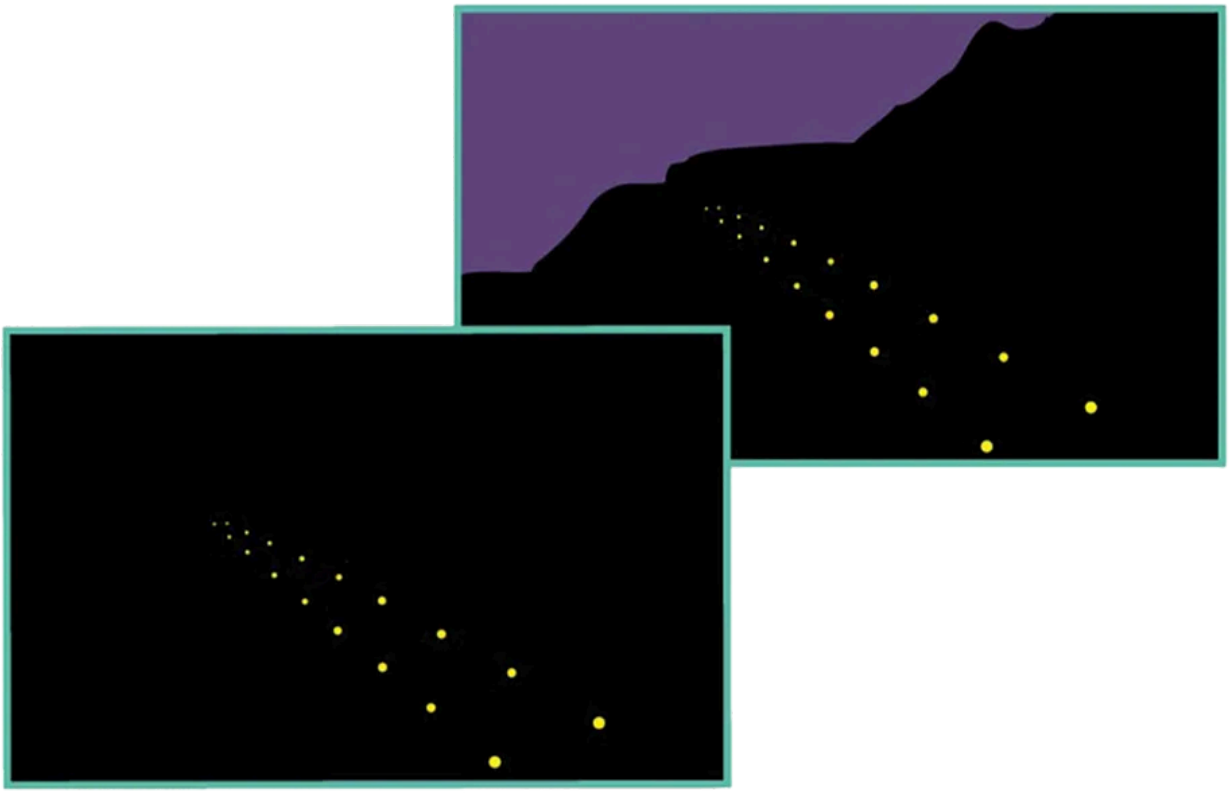
This illusion happens when a pilot stares at a bright, stationary light set against a pitch-black background, such as a star, a planet, or the light from another aircraft. After a few seconds, the light could appear to be moving toward the aircraft. You may have even experienced this illusion on the ground. Autokinesis occurs because motion perception is always relative to some fixed reference point, and in a dark sky, there are few, if any, reference points so the position of the single point of light is undefined. In an attempt to avoid the impending "collision," you may become disoriented, thinking you have shifted off course relative to the reference point. To prevent this illusion, avoid staring at one point of light for more than a few seconds and remember to conduct a systematic scan for traffic.

The Black Hole Approach

On a daytime approach or even a night approach over a well-lit area, you can use peripheral visual cues to confirm your glide path throughout your descent. You have feedback on your position relative to the runway. But on dark nights, approaching an airport with few lights or identifiable ground features can create the illusion that the aircraft is at a higher altitude than it actually is. The resulting black hole effect may cause you to come in with a too-low approach. Drawn in by the darkness, you may crash before reaching the runway.

The black hole effect can also occur when taking off from a brightly lit airport into a pitch-black, featureless sky. With no visual cues to reference, you can experience vertigo and disorientation. Training for the black hole effect, in a simulator and in flight, is the best way to prepare for this

situation. Additionally, always trust your flight instruments to maintain orientation and a stable approach. Use visual aids such as a Visual Approach Slope Indicator (VASI) or Precision Approach Path Indicator (PAPI), instrument approach if trained and available, and consider landing at a well-lit alternate. You can also discuss possible hazards with local pilots that are familiar with the airport.



The black hole effect.

False Horizons

Another potential danger is seeing something you think is the horizon and orienting yourself with it. During the day, you can simply align with the natural horizon of the earth to maintain straight-and-level flight. But on dark nights when there's no visible horizon, the brain can still trick itself into searching for a horizon to reference. For example, a sloping cloud formation, bright stars, or ground lights from a highway can create the

illusion that the aircraft is not aligned with the horizon. Using these references, you may align with an incorrect horizon and enter a dangerous attitude. To prevent this illusion, you should cross-check with the aircraft's attitude indicator. It won't be fooled by clouds, stars, mountainous or hilly terrain, and city lights.

An example of a false horizon illusion.

Flicker Vertigo

Flicker vertigo is an imbalance in brain-cell activity caused by exposure to the low-frequency flickering (or flashing) of a relatively bright light (e.g., a rotating beacon or a strobe light). Flicker vertigo can lead to incapacitation and loss of control of the aircraft. Although not technically an illusion, flicker vertigo is often cited as such because it can result in spatial disorientation. Symptoms often occur among helicopter pilots; however, pilots of fixed-wing and propeller-driven airplanes and crewmembers and

passengers can also experience the effects. If you start to experience flicker vertigo, look away from the light source causing the vertigo and the symptoms should subside. Flicker vertigo, which is not confined to night operations, is usually more of a minor irritation than a source of severe impairment to most pilots.

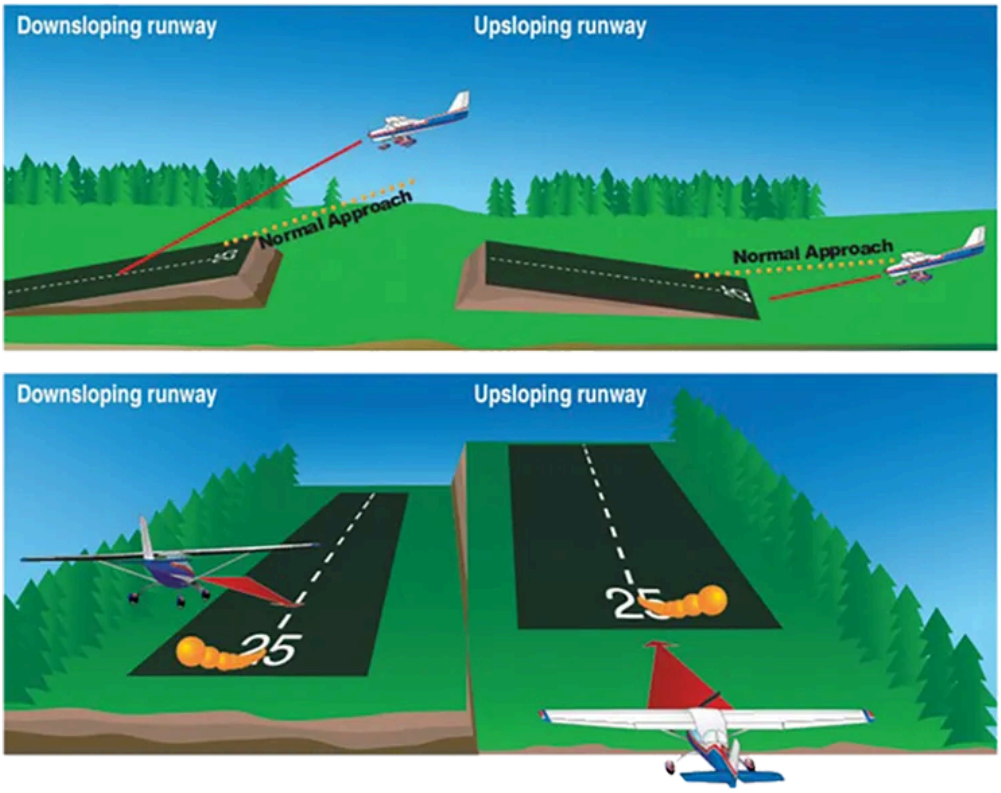
Head-up Illusion

Another night-flying illusion that can occur during takeoff is the head-up illusion. As your eyes transition from the bright lights of the airport to the relative darkness of the sky, you may suddenly feel that the nose of your plane is pitching up more than it should. Aircraft acceleration exacerbates this phenomenon. At zero acceleration, the vector of gravity is straight down. As you accelerate, the vector shifts slightly behind you, causing you to feel like you're starting to pitch up even before you rotate. As you pitch up to climb out and continue to accelerate, the feeling only intensifies. Your instinct would be to correct this by pushing the stick forward and lowering the nose, but if you are experiencing a head-up illusion, this action could cause a crash. As with other illusions, be aware of the potential and crosscheck what you are feeling versus what your instruments are reading before making any input corrections.

Sloping Terrain Illusions

At night, an upward-sloping runway or upward-sloping terrain can create the illusion that the aircraft is higher than it actually is. To compensate, you might fly a lower-than-normal approach, which could lead to a controlled flight into terrain accident. A down-sloping runway or down-sloping terrain can have the opposite effect, resulting in flying a higher-than-normal approach. When planning your route, consult the appropriate U.S. Chart Supplement for diagrams and information on a runway's slope, terrain,

lighting, and availability of visual glideslope indicators. If your aircraft is equipped and the runway is served by an instrument approach with vertical guidance such as an Instrument Landing System (ILS) or Wide Area Augmentation System with Localizer Performance with Vertical guidance (WAAS LPV), make use of the glide path, even when approaching the airport VFR.



An example of sloping runway illusions.

The Night in Nightmare

On Jan. 22, 2005, an instrument-rated pilot of a Beechcraft *Bonanza* and his passenger were killed when they crashed on final approach at Brownwood Regional Airport in Brownwood, Texas, during dark night conditions.

The flight departed Dallas Executive Airport (RBD) on an instrument flight rules (IFR) flight plan to Brownwood. Upon arrival, the pilot was cleared for

a visual approach to Runway 35. While descending into the airport, the Bonanza hit power lines and trees before striking the ground. Witnesses heard the airplane overhead and then a loud explosion. One witness noted that the airplane was at about 500 feet above ground level, three miles south of the airport, and heading north.

The weather at Brownwood was reported as winds 360 degrees at 9 knots, visibility 10 statute miles, sky clear, temperature 57 degrees F, dew point 45 degrees F. Witnesses to the accident said that it was dark, the sky was clear, and the winds were calm.

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After the accident, the investigator conducted a test, with the help of the local fire department, to see if the pilot could have seen the runway from the point where the Bonanza hit the wires. On a night with moonlight and weather conditions similar to those at the time of the accident, the investigator used a ladder truck to raise numerous firefighters to the height of where the airplane hit the wires. All indicated that at a height of 40 feet, the airport was clearly visible, but many thought they were 150 to 200 feet above the ground. Because of a lack of lighting and sloping terrain, they experienced the black hole illusion with no visual horizon.

The NTSB determined that the cause of the accident was the pilot's failure to maintain proper altitude and clearance while on final approach. Contributing factors included the pilot's lack of familiarity with the airport,

the light conditions, the lack of a visual approach glide slope indicator, and spatial disorientation.

Good Night

When my daughters were anxious about going to sleep, I would check in their closets and under the bed to show them that there was nothing to be afraid of. But when it comes to night flying, seeing is not always believing. Flying at night can be incredible, but remember that darkness does not discriminate, and pilots of all skill levels are susceptible to these illusions. If you encounter a visual illusion while flying at night, the solution is almost always to trust your instruments, not your eyes.

Learn More

- Spatial Disorientation Visual Illusion brochure (PDF download)
- GAJSC Spatial Disorientation fact sheet
- *Aeronautical Information Manual* (AIM), Chapter 8

- *Instrument Flying Handbook*, Chapter 3
- #FlySafe GA Safety Enhancement Topic: *Vestibular Illusions*

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