Night Flying

hazards of spatial D

By Capt Brian Farrar, Nellis AFB, Nev.

Night flying — for some it's the best time to be airborne (i.e., less air traffic, the concealing cover of darkness, inertial navigation system direct whenever you ask for it, and quiet radios). However, it's also the perfect time to experience spatial disorientation. Disorientation in flight is extremely hazardous because a pilot can make erroneous control inputs in response to his or her false perception and that can lead to a mishap. Even though aircrew members receive training on recognizing spatial disorientation during physiological refresher courses and routinely pre-brief the mere existence of such hazards when night flying, current statistics on nighttime aircraft accidents indicate we should review the specific nature of these pitfalls more frequently. The following visual illusions are prevalent occurrences during night flying. Let's look at each one by describing the illusion, explaining its effects, and reviewing methods to prevent or recover from visually-induced disorientation.

Distance Illusions

Assuming that the dots in Figure 1 represent illumination from aircraft beacon lights, which aircraft is closer?

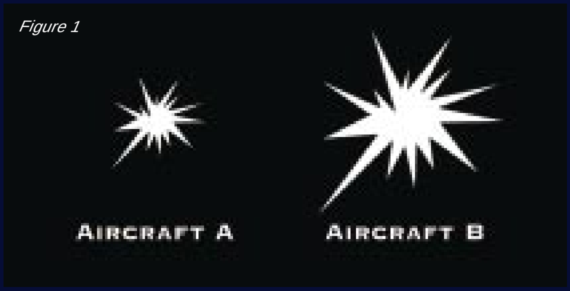

Figure 1

Actually, there isn't enough visual information available to answer the question. During the daytime, reflected light provides detail for the human brain to assess distance. However, during night flying, most of the light received by the human eye is transmitted directly from illumination sources as in the example above. If Aircraft A in the given example has low-illumination lighting and Aircraft B has very bright lighting, Aircraft B may actually be farther away.

This illusion is common when engaging or rejoining an aircraft without knowing its distance. Implementing training rules that forbid visual-only engagements and require a positive source of range information, such as radar, has drastically reduced the potential for midair collisions. Distance illusions can cause accidents during visual formation flying. If visual lookout is the primary means of maintaining formation position, the previously described lack of distance cues may cause horizontal distance to increase without notice. If the trailing pilot maintains a continuous line of sight to the lead aircraft and if that line of sight is relatively high, then vertical separation between aircraft will also increase as horizontal separation inadvertently grows. If the trailing pilot fails to monitor actual altitude, the potential exists for "impact with the ground" or another aircraft at a lower altitude. Stacking high on the lead aircraft, cross-checking actual altitude, and ensuring a stable distance between aircraft by using radar or air-to-air tactical air navigation prevents this illusion from taking over the formation.

Visual Autokinesis

Autokinesis, sometimes called autokinetic effect, is perceived movement exhibited by a static dim light when it is stared at in the dark. Air Force Research Laboratory scientists assess that after 6 to 12 seconds of visually fixating on a light, it appears to move up to 20 degrees per second in a particular direction or several directions in succession, and that the larger and brighter the object, the less the autokinetic effect. Autokinesis is most common in very dark conditions with only one or two lights present and is uncommon with three or more lights present.

The exact physiological cause of autokinesis remains unknown, but it is believed to be related to tiny fixation movements of the eye and the loss of the surrounding references (i.e., peripheral or ambient vision), which normally stabilize visual perception. The dark, empty environment conducive to autokinesis does not allow one's ambient vision the opportunity to establish spatial orientation while the brain attempts to resolve distance to the light source. To counter or minimize the effect, a pilot should shift his gaze frequently to avoid prolonged fixation on the light; view the source beside or in reference to a relatively stationary structure such as a canopy frame; make eye, head, and body movements to destroy the illusion; and monitor flight instruments to prevent or resolve any perceptual conflict.

False Horizon Illusions

To maintain horizontal and vertical orientation, the human brain subconsciously uses the visual system to monitor the Earth's horizon or lines relative to the known horizon. These cues are compared to those encountered by the vestibular (inner ear) and somatosensory (seat-of-the-pants) systems in order to provide positional orientation. Because there is little reflective light at night to monitor the horizon, "any straight line will do." In the absence of any discernible horizon, starlight can look like ground lighting; starlight reflecting off of water can confuse the visual picture; and in northern regions, the aurora borealis causes similar disorientation.

The best defense against misinterpreting a perceived horizon cue is to depend upon the attitude indicator. A good calibration check during ground operations prior to takeoff and a continuous cross-check in flight to confirm correct operations will help you "trust your instruments" even when your eyes and brain tell you "up" is the other way.

Black Hole Effect

Night flight into an area with a lack of ambient cues is known as a black hole effect. Our ambient visual system supports correct spatial orientation by allowing the brain to monitor the relative position of objects that reflect or illuminate light around us. At night, these cues are often lost over water or near sparsely populated areas.

Many black-hole-related mishaps occur during the landing phase of flight. When few surface lights exist between a landing aircraft and the runway, pilots tend to fly too low and some have crashed short of the threshold. Countering disorientation in black hole conditions requires disciplined reliance upon flight instruments as discussed for false horizon illusions. Furthermore, in the landing environment, where much more time is spent in visual cross-check outside the cockpit, pilots must rely upon accurate glideslope indicators when available. These indicators include avionics such as instrument landing systems or visual glideslope indicators.

Vection Illusion

Vection illusion is the sensation of self-motion induced by relative movement of viewed objects. You may have experienced this when automobile traffic next to you starts moving at a stoplight. In response, you jam on your brakes harder thinking that you're moving backward. In this case, your ambient visual system has detected movement from an object at a different rate than assumed by the brain. Therefore, the brain interprets self-movement at a different than actual rate.

A common vection illusion encountered during night flying occurs when a well-lighted aircraft penetrates a cloud, haze, or precipitation. Upon penetration into the visible moisture, the pilot's ambient visual system signals a speed increase, and the natural tendency is a throttle reduction to slow the aircraft. An unwarranted power decrease could cause a dangerous sink rate or even a stall to occur. In order to prevent such error, the pilot must recognize conditions that can induce a vection illusion as described and must rely upon performance instruments (particularly the airspeed indicator) for throttle adjustment decisions. A landing light extending or retracting in visible moisture can also cause vection illusion. As the rotating light beam reflects off visible moisture, the ambient visual system assesses movement about the aircraft's pitch axis though no rotational movement actually exists. With the pilot's brain signaling a pitching moment, a dangerous nose-high or nose-low situation could develop. Again, the pilot must predict the possibility of a vection illusion in the described environment and depend upon attitude instruments for pitch-change decisions.

Runway Illusions

Before discussing false runway perceptions in the landing environment, one must first understand the concepts of size and shape constancy. Size constancy is the human expectation for familiar things to be the same size in most situations. Shape constancy is the expectation for familiar things to be the same shape when viewed from a given position.

As a pilot practices approaches at his home airfield or at those with similar runway size and gradient, visual cues resulting in effective approaches and landings are stored in subconscious memory. If this stored mental picture is applied during a visual approach to a runway of different size or shape, a pilot may flare too high or low, land short or long, or even mistake a lighted taxiway or road for the runway environment.

Figure 2

Figure 3

Combating incorrect flare height at a strange field is difficult since the terminal portion of a landing is almost exclusively a visual event, and the visual system is being deceived. A pilot's best defense to prevent a dangerous landing is to be aware of runway size at the landing field and anticipate the resulting flare tendency in comparison to his common reference.

Judging distance is similarly a challenge. For example, Runway A in Figure 2 represents a lighted runway of a width to which a pilot is accustomed. If that pilot approaches a narrower runway of the same length (represented by Runway B), the approach will appear steep due to size constancy even though the aircraft is at the same distance and approach angle. Similarly, a wider runway of the same length will make the approach appear shallow as illustrated by Runway C. Cross-checking instrumentation or visual glide slope indicators helps ensure the proper approach angle.

Runway With Illusions

Even if a runway is identical in size to a familiar runway, a different slope can cause dangerous illusions as well. As mentioned before, the human brain expects familiar shapes to look familiar in a given situation. Therefore, if the sight picture changes without the observer noticing, then the observer may unknowingly change his or her position in space to reestablish the normal sight picture.

For instance, if a pilot is accustomed to the sight picture represented by Runway A in Figure 3 and approaches Runway B (which is of the same size but on a downslope), the pilot may increase altitude and fly a steeper approach in order to maintain the normal picture. On the upsloping Runway C, the pilot would try to fly a more shallow approach. This illusion is particularly hazardous at night since there are few visual cues for terrain and obstacle avoidance.

Once again, cross-checking landing system instrumentation or visual glideslope indicators will help ensure the proper approach angle.

Runway Slope Illusions

The night aviation arena with its many illusions is one of the most difficult in which to remain spatially oriented. Armed with a better understanding of distance illusions, visual autokinesis, false horizon cues, black hole effects, vection illusions, and runway illusions, as well as having an improved awareness of how the human visual system can be deceived, pilots can decrease their vulnerability to mishaps. As we have shown, our eyes often deceive us, but modern technology provides us the means to maintain or regain positional awareness with avionics, approach systems, and other mechanical means ... if we use them.