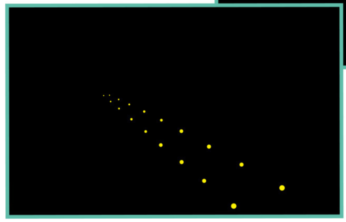
A Black-Hole Approach Illusion can happen during a final approach at night (no stars or moonlight) over water or unlighted terrain to a lighted runway beyond which the horizon is not visible. In the example shown in (Figure 8), when peripheral visual cues are not available to help you orient yourself relative to the earth, you may have the illusion of being upright and may perceive the runway to be tilted left and upsloping. However, with the horizon visible (Figure 9) you can easily orient yourself correctly using your central vision.

Figure 8



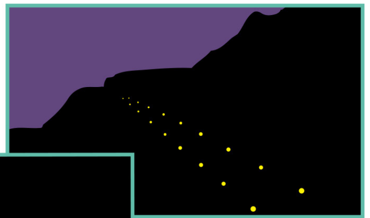


Figure 9

A particularly hazardous black-hole illusion involves approaching a runway under conditions with no lights before the runway and with city lights or rising terrain beyond the runway. Those conditions may produce the visual illusion of a high-altitude final approach. If you believe this illusion you may respond by lowering your approach slope (Figure 10).

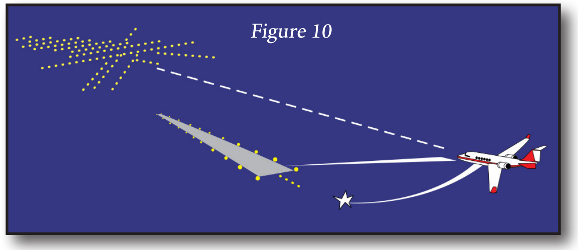


Figure 10

The **Autokinetic Illusion** gives you the impression that a stationary object is moving in front of the airplane's path; it is caused by staring at a fixed single point of light (ground light or a star) in a totally dark and featureless background. This illusion can cause a misperception that such a light is on a collision course with your aircraft (Figure 11).

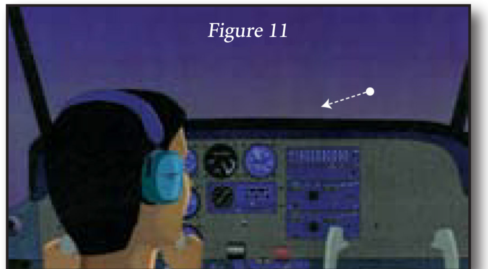


Figure 11

False Visual Reference Illusions may cause you to orient your aircraft in relation to a false horizon; these illusions are caused by flying over a banked cloud, night flying over featureless terrain with ground lights that are indistinguishable from a dark sky with stars, or night flying over a featureless terrain with a clearly defined pattern of ground lights and a dark, starless sky (Figure 12).

Figure 12

Vection Illusion: A common example is when you are stopped at a traffic light in your car and the car next to you edges forward. Your brain interprets this peripheral visual information as though you are moving backwards and makes you apply additional pressure to the brakes. A similar illusion can happen while taxiing an aircraft (Figure 13).

Figure 13

How to Prevent Spatial Disorientation

- Take the opportunity to personally experience sensory illusions in a Barany chair, a Vertigon, a GYRO, or a Virtual Reality Spatial Disorientation Demonstrator (VRSDD). By experiencing sensory illusions first-hand (on the ground), pilots are better prepared to recognize a sensory illusion when it happens during flight and to take immediate and appropriate action. The Aerospace Medical Education Division of the FAA Civil Aerospace Medical Institute offers spatial disorientation demonstrations with the GYRO and the VRSDD in Oklahoma City and at all of the major airshows in the continental U.S.
- Obtain training and maintain your proficiency in aircraft control by reference to instruments.
- When flying at night or in reduced visibility, use and rely on your flight instruments.
- Study and become familiar with unique geographical conditions where flight is intended.
- Do not attempt visual flight when there is a possibility of being trapped in deteriorating weather.
- If you experience a visual illusion during flight (most pilots do at one time or another), have confidence in your instruments and ignore all conflicting signals your body gives you. Accidents usually happen as a result of a pilot's indecision to rely on the instruments.
- If you are one of two pilots in an aircraft and you begin to experience a visual illusion, transfer control of the aircraft to the other pilot, since pilots seldom experience visual illusions at the same time.
- By being knowledgeable, relying on experience, and trusting your instruments, you will be contributing to keeping the skies safe for everyone.

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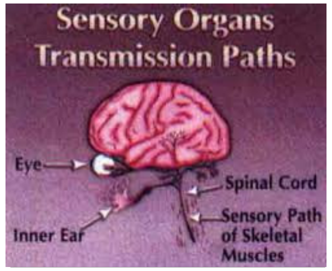
Spatial Disorientation
Visual Illusions

Seeing Is Not Believing

Spatial Orientation

Our natural ability to maintain our body orientation and/or posture in relation to the surrounding environment at rest and during motion. Genetically speaking, humans are designed to maintain spatial orientation on the ground. The flight environment is hostile and unfamiliar to the human body; it creates sensory conflicts and illusions that make spatial orientation difficult, and, in some cases, even impossible to achieve. Statistics show that between 5 to 10% of all general aviation accidents can be attributed to spatial disorientation, and 90% of these accidents are fatal.

Spatial Orientation on the Ground



Altitude DCS became a commonly observed problem associated with high-altitude balloon and aircraft flights in the 1930s. In present-day aviation, technology allows civilian aircraft (commercial and private) to fly higher and faster than ever before. Though modern aircraft are safer and more reliable, occupants are still subject to the stresses of high altitude flight—and the unique problems that go with these lofty heights. A century and one-half after the first DCS case was described, our understanding of DCS has improved, and a body of knowledge has accumulated; however, this problem is far from being solved. Altitude DCS still represents a risk to the occupants of modern aircraft.

Spatial Orientation In Flight

Spatial orientation in flight is sometimes difficult to achieve because the various types of sensory stimuli (visual, vestibular, and proprioceptive) vary in magnitude, direction, and frequency. Any differences or discrepancies between visual, vestibular, and proprioceptive sensory inputs result in a "sensory mismatch" that can produce illusions and lead to spatial disorientation.

Vision and Spatial Orientation

Visual references provide the most important sensory information to maintain spatial orientation on the ground and during flight, especially when the body and/or the environment are in motion. Even birds, reputable flyers, are unable to maintain spatial orientation and fly safely when deprived of vision (due to clouds or fog). Only bats have developed the ability to fly without vision by replacing their vision with auditory echolocation. So, it should not be any surprise to us that, when we fly under conditions of limited visibility, we have problems maintaining spatial orientation.

Central Vision

Central vision, also known as foveal vision, is involved with the identification of objects and the perception of colors. During instrument flight rules (IFR) flights, central vision allows pilots to acquire information from the flight instruments that is processed by the brain to provide orientational information. During visual flight rules (VFR) flights, central vision allows pilots to acquire external information (monocular and binocular) to make judgments of distance, speed, and depth.

Peripheral Vision

Peripheral vision, also known as ambient vision, is involved with the perception of movement (self and surrounding environment) and provides peripheral reference cues to maintain spatial orientation. This capability enables orientation independent from central vision, and that is why we can walk while reading. With peripheral vision, motion of the surrounding environment produces a perception of self-motion even if we are standing or sitting still.

Visual References

Visual references that provide information about distance, speed, and depth of visualized objects include:

- Comparative size of known objects at different distances.
- Comparative form or shape of known objects at different distances.
- Relative velocity of images moving across the retina. Nearby objects are perceived as moving faster than distant objects.
- Interposition of known objects. One object placed in front of another is perceived as being closer to the observer.
- Varying texture or contrast of known objects at different distances. Object detail and contrast are lost with distance.
- Differences in illumination perspective of objects due to light and shadows.
- Differences in aerial perspective of visualized objects. More distant objects are seen as bluish and blurry.

The flight attitude of an airplane is generally determined by the pilot's visual reference to the natural horizon. When the natural horizon is obscured, attitude can sometimes be maintained by visual reference to the surface below. If neither horizon nor surface visual references exist, the airplane's attitude can only be determined by artificial means such as an attitude indicator or other flight instruments. Surface references or the natural horizon may at times become obscured by smoke, fog, smog, haze, dust, ice particles, or other phenomena, although visibility may be above VFR minimums. This is especially true at airports located adjacent to large bodies of water or sparsely populated areas, where few, if any, surface references are available. Lack of horizon or surface reference is common on over-water flights, at night, or in low visibility conditions.

Visual Illusions

Visual illusions are familiar to most of us. As children, we learned that railroad tracks—contrary to what our eyes showed us—don't come to a point at the horizon. Even under conditions of good visibility, you can experience visual illusions including:

Aerial Perspective Illusions may make you change (increase or decrease) the slope of your final approach. They are caused by runways with different widths, upsloping or downsloping runways, and upsloping or downsloping final approach terrain. Pilots learn to recognize a normal final approach by developing and recalling a mental image of the expected relationship between the length and the width of an average runway, such as that exemplified in (Figure 1).

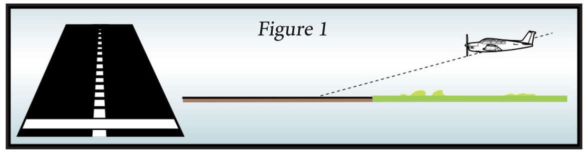


Figure 1

A final approach over a flat terrain with an **upsloping runway** may produce the visual illusion of a high-altitude final approach. If you believe this illusion, you may respond by pitching the aircraft nose down to decrease the altitude, which, if performed too close to the ground, may result in an accident (Figure 2).

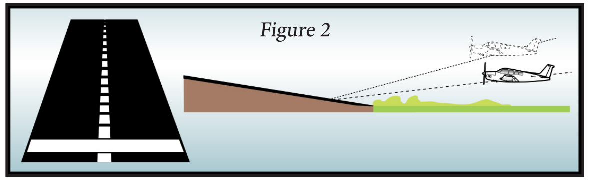


Figure 2

A final approach over a flat terrain with a **downsloping runway** may produce the visual illusion of a low-altitude final approach. If you believe this illusion, you may respond by pitching the aircraft nose up to increase the altitude, which may result in a low-altitude stall or missed approach (Figure 3).

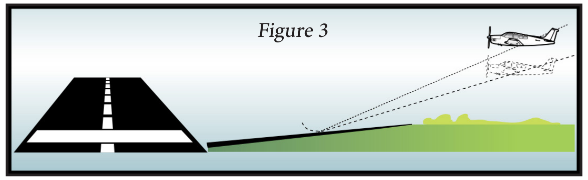


Figure 3

A final approach over an **upsloping terrain** with a flat runway may produce the visual illusion that the aircraft is higher than it actually is. If you believe this illusion, you may respond by pitching the aircraft nose-down to decrease the altitude, resulting in a lower approach. This may result in landing short or flaring short of the runway and risking a low-altitude stall.

Pitching the aircraft nose-down will result in a low, dragged-in approach. If power settings are not adjusted, you may find yourself short of the runway, needing to add power to extend your flare. If you do not compensate with power, you will land short or stall short of the runway (Figure 4).

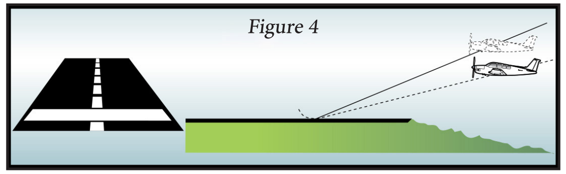


Figure 4

A final approach over a **downsloping terrain** with a flat runway may produce the visual illusion that the aircraft is lower than it actually is. If you believe this illusion, you may respond by pitching the aircraft's nose up to gain altitude. If this happens, you will land further down the runway than you intended (Figure 5).

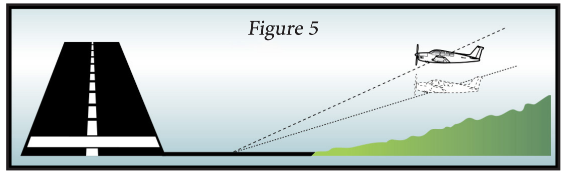


Figure 5

A final approach to an **unusually narrow runway** or an **unusually long** runway may produce the visual illusion of being too high. If you believe this illusion, you may pitch the aircraft's nose down to lose altitude. If this happens too close to the ground, you may land short of the runway and cause an accident (Figure 6).

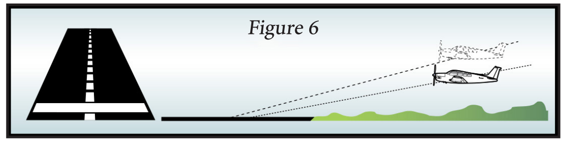


Figure 6

A final approach to an **unusually wide runway** may produce the visual illusion of being lower than you actually are. If you believe this illusion, you may respond by pitching the aircraft's nose up to gain altitude, which may result in a low-altitude stall or missed approach (Figure 7).

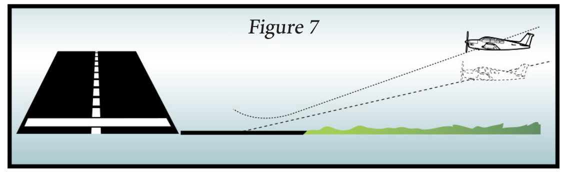


Figure 7