The Aviator's Dilemma

Military aviators learn to second-guess their senses

BY STEPHEN L. MACKNIK, SUSANA MARTINEZ-CONDE AND ELLIS C. GAYLES

MAJOR PAUL "Goose" Gosden, U.S. Marine Corps, piloted his UH-1 Huey close air support helicopter across the Kuwait-Iraq border through the night's oily blackness. His aircraft was first to cross into Iraqi airspace in the second Gulf War, in support of Cobra attack helicopters tasked to destroy observation posts on Safwan Hill, near the infamous Highway of Death. Their mission was the opening salvo of Operation Iraqi Freedom, designed to kick in the door for the U.S. Army's Third Infantry Division, which would follow in a ground assault from Kuwait into Iraq. The Iraqi forces, however, anticipated the aerial sortie and had begun to destroy oil fields, filling the night air with oil smoke and haze so thick that it blinded the marines.

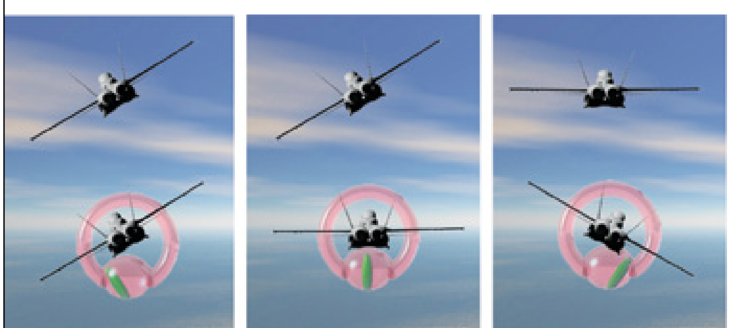
Military flight training ingrains night flying so deeply that pilots can do it practically in their sleep. Flying through an oil cloud at night, on the other hand, definitely ups the pucker factor. "Saddam had exploded the oil rigs to fill the air with oil. I couldn't see the Cobra in front of me or the stars or the moon. It was just black," Gosden recalled. To give yourself an idea of this feeling, start a mission in the helicopter combat Xbox game Apache (which one of us, Macknik, diligently toiled over as "research" for this article). Fly very high over enemy territory, then turn off your television (but not the Xbox) and try to land your helicopter blind as the bad guys begin to shoot at you. Remember, to simulate the experience of Gosden and his crew, you would have to commit to actually killing yourself if your simulated copter crashes; otherwise it's just a game.

Spatial D and the Leans

Gosden told his hair-raising story at the Aviation Survival Training Center in Marine Corps Air Station Miramar near San Diego, Calif., during a course one of us (Gayles) teaches. This air station was the storied home of the U.S. Navy's ("Top Gun") Fighter Weapons School, featured in the 1986 Tom Cruise movie.

Gosden—coincidentally "Goose" is the call sign of Cruise's wingman in *Top Gun*—continued, "We all had 'spatial D' or were suffering from 'the leans.'" Spatial D is short for spatial disorientation, a catchall term to describe the summed result of the various perceptual illusions and degraded sensory perceptions that may occur on a mission. It is the total failure of situational awareness and, shockingly, the most common cause of crashes in the navy, accounting for almost 80 crashes between 1990 and 2008. Performance fails because pilots can no longer pay attention to what is happening—everything is off-kilter. All they can do is scan the instruments continually to give themselves as much factual information about the aircraft as possible, to counteract the false information from deceitful bodily senses.

The leans is not a colorful military term for gastrointestinal distress, although the two phenomena are, unsur-



The leans, one of the most common vestibular illusions, occurs when the inner ear organ responsible for balance, the semicircular canal (*pink rings*), fails to continue to detect movement during a lengthy turn. As the aircraft turns, at first the endolymph fluid in the canal lags behind the turn, bending a hair cell (*green*), which signals the movement to the brain (*left*). In a prolonged turn, however, the vestibular system no longer detects the inertial difference between the canals and their fluid and no longer transmits the turning information to the brain (*center*). As the plane rolls out of the turn, the inertial difference between the fluid and canal reemerges but causes the misperception of turning in the opposite direction.

GETTY IMAGES (*top*); COURTESY OF LCDR BRIAN D. SWAN, USN (RET.) (*bottom*)

> As important as visual input is for a pilot, **eyes can lie.** False horizons are everywhere.

prisingly, often experienced together. Rather the leans is a type of somatogyral illusion you feel in flight when your vestibular system (the inner ear organ responsible for balance and your sense of traveling through space) and your somatosensory system (skin and other bodily positioning sensors) together fail to provide you with an accurate description of where gravity indicates is down. The illusion happens when you come out of a tight acrobatic turn and the fluid in your vestibular semicircular canals system continues to flow even though you are no longer turning. As a result, you may feel like you are flying straight when in fact you are in a turn, something that investigators concluded happened when John F. Kennedy, Jr.'s plane crashed at Martha's Vineyard in 1999. Technically, the leans is the name of a solution to the problem: leaning your head until your instruments match your perception. Even so, most pilots use the term to relay the problem rather than the solution.

To get an idea of how critical your vestibular system is to your vision, hold up one finger in front of you at arm's length, then look at it as you rotate your head back and forth. Fine, no problem: your finger is nice and clear. Your vestibular system tracked the turning of your head and gave your eyes the information to stay on target. Now hold your head still and move your finger back and forth while following it with your eyes. Now there is no vestibular input because your head is stationary, so your finger becomes blurry. Motion sickness arises from a mismatch between vision and vestibular perception and is a major component of spatial D.

Iraqi Nightlife

Gosden survived his mission by virtue of using his aircraft's forward-looking infrared (FLIR) optical array, which gave him the ability, in tandem with skill and luck, to notice a line of infrared lights marking a column of American light armored vehicles (LAVs) on the ground. He could not see the ground, but the LAVs gave him just enough information about the landscape to allow him to land "safely"—that is, behind enemy lines in the middle of the desert surrounded by a high-speed battle.

The fog—or dust—of war can have pilots fighting their own senses and reliant on instruments, which are also badly degraded by a brownout.

FROM "A DUAL-MODE SENSOR SOLUTION FOR SAFE HELICOPTER LANDING AND FLIGHT ASSISTANCE," BY YAN CHRISTIAN VENOT AND PETER KIELHORN, IN *MICROWAVE JOURNAL*; JANUARY 17, 2008

"I knew that the ground behind those LAVs must be flat, meaning we could land there. We knew our position was behind enemy lines. But we didn't care—we had completed our flying for the evening. The other pilot on my helicopter, Captain Rodney 'Dino' Dean, was suffering from vertigo, which had the opposite result to what was happening to me [the leans]. It was a miracle we got down," Gosden said. "After landing, we got our weapons and set up a perimeter around the aircraft. When the sun came up, we could see well enough to fly out."

Training to Survive

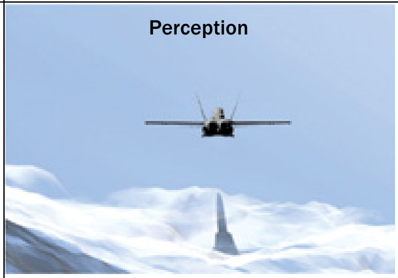
Night-vision devices such as personal goggles or the FLIR viewing system that Gosden used can ameliorate spatial D at night, but their performance is highly dependent on illumination, terrain contrast and particulates in the air. For instance, these devices offer little help during brownout conditions, where dust can severely degrade visibility. The main defense that pilots have against the dangerous misperceptions and illusions reviewed here is simply the awareness that they can happen.

Back at the Miramar station, the architecture of the training facility is vintage 1950s U.S. military, the lobby festooned with uniformed mannequins in ejection seats. The lecture hall decor is exactly what you would find on the Boat (navy lingo for an aircraft carrier): over-engineered steel recliner-size seats bolted to the floor, padded generously with genuine Naugahyde coverings. Flight suits abound.

"When naval aviation was young, we were crashing two planes a day," Gayles says, "mostly caused by inevitable equipment failures. Now we crash 20 planes a year or so, and every crash is a very big deal, covered by the press, and reported throughout the military. Most crashes are no longer the result of maintenance or equipment failures. Those problems have been reduced to the point that the main issue is human error. Pilots sometimes fly perfectly good aircraft into the ground."

Why does that happen among the most highly trained pilots in the world? The answer: every sensory and cognitive system is highly taxed when flying military aircraft. Visual illusions alone accounted for about 20 crashes from 1990 to 2008, making the combined contribution of illusions of all types twice as high as the next biggest crash cause: fatigue.

This challenge is why Gosden and this group of aviators are here today, to receive their once-every-four-years refresher in situational awareness, aviation physiology and crash-survival training. They are lectured, questioned and then dunked unceremoniously into a huge, cold saltwater pool inside a crash simula-



Pilots have a natural tendency to consider any straight line in the cloud deck as a false "horizon" (*left*). Unfortunately, the illusion that a cloud deck is the true horizon can overwhelm the senses, requiring pilots to concentrate on instruments; coastlines, ridge lines and even well-lighted highways can also cause this dangerous effect.

tor while wearing a blindfold. It's scary, and the only people having fun are the two of us (Martinez-Conde and Macknik) on the side of the pool looking in.

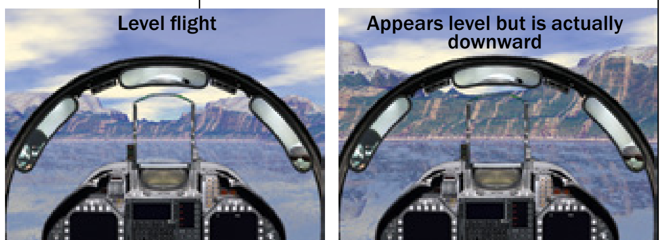
Shifting Horizons

As important as visual input is for a pilot, eyes can lie. For example, when flying above a cloud deck, there is a natural tendency to perceive any relatively straight line in the visual field as a horizon—which can lead to very undesirable results in a fast-moving aircraft.

False horizons are everywhere around you in the clouds. Your aircraft's attitude may seem level, even if you are tilted and in a turn. Mountain ridges might lead you astray as well, and at night the combination of clouds, stars, mountains and lights on the ground can produce impossibly confusing percepts that lead the aircraft away from the safety of true straight and level flight.

Don't think that you are safe from your own perception, however, just because you are flying above water on a clear day. A fixed horizon can still put you in the drink. Consider what may happen if you approach the beach from over the horizon. You may line up the beach in your sights and then keep it there in anticipation of going "feet dry" (flying from over sea to over land), but if so you will never reach land: the beach is fixed, unlike a true horizon, and the only way to keep it stationary in your sight is to point your aircraft progressively downward.

Beaches make a particularly insidious false-horizon illusion. Because they are in a fixed location, the pilot will tend to point the aircraft ever downward to maintain the horizon ahead.



Choosing a fixed horizon in proximity to wires or cables stretched across a valley is especially problematic. As you approach the fixed horizon (such as where a valley floor and mountain wall meet), you slowly and unnoticeably nose down. As you descend, the approaching wires will appear to rise as if they will pass well above you, whereas in fact they remain well below the aircraft. If you don't spot the wires until they are very close (because of mountain haze or the fog of war), your natural reaction may be to push the stick forward to dive under the wires. This reaction is what happened to the U.S. Marine pilots of an EA-6B Prowler aircraft on a training mission in 1998 near an active Italian ski resort in the Alps. The aircraft sliced through two wires, which held a cable car holding 20 skiers 370 feet above the ground. None survived.

One might think that objective information from instruments is the logical solution to subjective sensory illusions. The proliferation of instrumentation is part of the problem, however, because of mounting attentional demands on the pilots, which cause cognitive overload during combat and other stressful flight scenarios. This kind of mental distress is an important contributor to spatial D. New avionics are designed with simplicity, not complexity, in mind, and pilots learn how to scan their instruments at just the right times, under conditions of simulated duress. Systematic instrument scanning demands discipline, which may be one of the first casualties of battle, but until we learn better ways to overcome insidious in-flight illusions, it is one of the main techniques that keep pilots and crews safe. **M**

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(Further Reading)

◆ **Spatial Orientation in Flight.** A. J. Parmet and W. R. Ercoline in *Fundamentals of Aerospace Medicine.* Fourth edition. Edited by Jeffrey R. Davis, Robert Johnson, Jan Stepanek and Jennifer A. Fogarty. Lippincott Williams & Wilkins, 2008.
◆ **Let's Keep You Flying.** Capt. Nick Davenport, USMC, in *The Navy and Marine Corps Aviation Safety Magazine,* Vol. 55, No. 1, pages 3–5; January/February 2010.

COURTESY OF LCDR BRIAN D. SWAN, USN (RET.) (*top*); COURTESY OF LCDR BRIAN D. SWAN, USN (RET.), SOURCE: CDR FRED PATTERSON, USN (RET.) (*bottom*)