The Black Hole Approach:
Don't Get Sucked In!

Whether you fly a piston single or a heavy jet, a long straight-in approach at night over featureless terrain is a well-proven prescription controlled flight into terrain. AVweb's Linda Pendleton examines the optical illusions involved, and offers suggestions for making sure that you don't become a thing that goes bump in the night.

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One of the major tenets of instrument flying is that you cannot rely upon your body -- or kinesthetic senses -- to keep you upright. Repeatedly, your CFII has pounded into your head the premise that you can only believe what your eyes tell you. Just watch those gauges and all will be well. And it's true -- if what you are looking at IS the gauges. When the view is out the windscreen, however, you cannot always believe your visual perceptions.

Great! First you can trust your eyes, then you can't. What's the deal here? Well, it's all in being human. This marvelous species you're so proud to be a part of has evolved over millions of years as a land-based animal moving at a normal speed of about three to four miles per hour. You can also manage occasional short bursts of up to 15 mph. Any time you go faster than that or put your eyes higher than eye level above ground you're subject to misperceptions.

Okay. So, you know that you can't always trust our perceptions. What is a black hole approach and what makes it so dangerous? The term "black hole" refers to the terrain below the approach to the airport, not the airport itself. Simply put, a black hole approach is a long, straight-in approach at night to a brightly lit runway over featureless and unlit terrain. Over the years, the black hole approach has claimed the lives of many pilots -- both novice and experienced. Night flying has always been more dangerous than daylight flying principally because of the lack of perceptual clues we all depend on to keep the shiny side up. You're all familiar with the false perceptions you can fall prey to caused by using a sloping cloud deck for a level horizon and the unsettling ambiguity caused by mistaking sparse ground lights for stars. You can overcome these visual traps, however, by simply referring to the flight instruments on the panel. The black hole approach is different in that a glance at the flight instruments won't always clue you in to the danger.

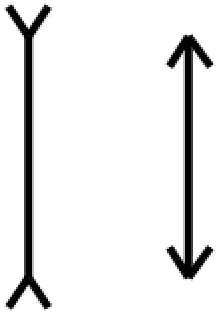

Figure 1: Which line is longer? (Mouse-over to check.)

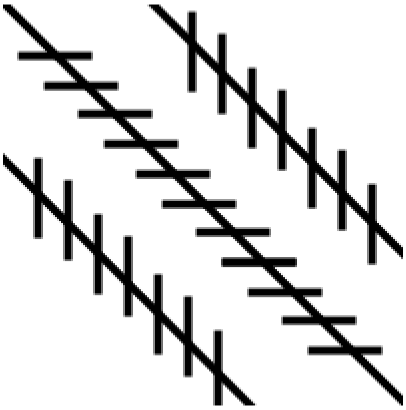

Figure 2: Are lines parallel? (Mouse-over to check.)

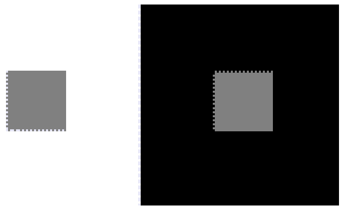

Figure 3: Which gray square is darker? (Mouse-over to check.)

Optical illusions

Before we talk about black hole approaches, let's explore some of the ways your perceptions can mislead you. That will give us a basis for a better understanding of the illusions you experience during a black hole approach.

Your eyes really don't do the seeing -- your brain does. Your eyes simply transmit electrical pulses and your brain does the work of making sense of those spikes of electricity. It perceives what it "sees" in the setting in which it is viewed. The surrounding objects and colors -- or lack of them -- will have a big effect on what sense your brain makes of the electrical impulses sent to it by the retinas. Look at Figure 1. Decide which line is longer and then roll your mouse over the figure and see the change. Now you've probably seen this a million times before and you know the answer, but pay attention to how fooled you brain is by the surroundings of the two vertical lines. Now look at Figure 2 and decide which lines, if any, are parallel. Again, you probably know the answer, but notice again the overwhelming perception that the three long lines are not parallel. Even when you know the answer, the false perception is overpowering. Figure 3 shows the effect surrounding color or intensity has on perception. Note the relative brightness of the smaller gray squares in the center of the black and white squares. Now roll your mouse over the figure and note the "change" in the gray squares. The small square surrounded by black seems brighter and closer than when it is surrounded by white, but both gray squares are in the same place and are the same color.

Seeing is not believing! But why would the brain play such tricks on you? It's all a part of how you make sense of the world around you. The visual surroundings of an object give you valuable clues about its size and distance from you. Lines can show perspective, which is an indicator of distance. The brightness of an object is another attribute the brain takes into account when determining the nearness of an object. We perceive dimmer objects to be farther away than bright ones.

Night perils

Pilots have recognized since the early days of aviation that flying at night is more dangerous than flying in the daylight. In fact, flying at night in good weather is closer to a flight in IMC than it is to VMC. The low level of light means that the rod cells in the retina of the eye are going to be doing most of the work since they are more sensitive to very weak light energy. Unfortunately, the rods permit seeing only black, white, and grays. Since you base much of your perception of size and distance on color variation, you have a handicap already. Terrain and clouds can be almost impossible to see at night until it's too late and as was said earlier, ground lights can be mistaken for stars and horizons.

But what makes the black hole approach so different and so lethal? Well, first, referring to the attitude indicator, altimeter, and turn coordinator won't immediately alert you to the problem. Pilots who succumb to the black hole illusion are convinced, sometimes until it is too late, that they are on the proper glide path and all is going well. Second, although you may know intellectually that the illusion is taking place, you will still have an overwhelming urge to believe your false impressions. You can't take any training to keep from experiencing this illusion. Like hypoxia, it WILL happen to you and your best defense is knowledge and avoidance.

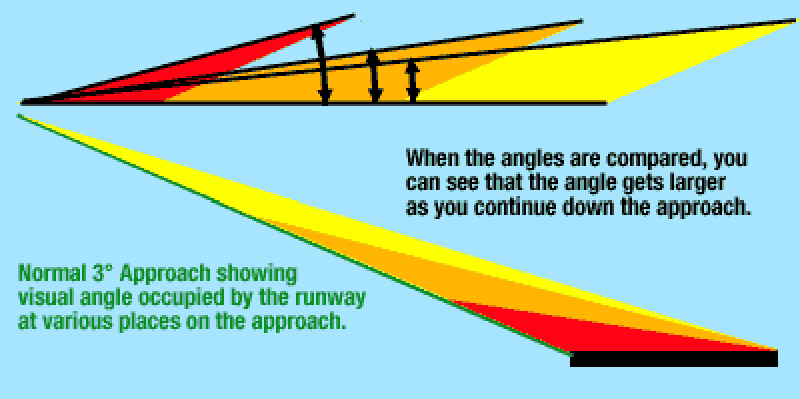

Figure 4: The visual angle subtended by the runway during a normal three-degree approach should get larger and larger as you continue the approach.

Many researchers have studied the black hole illusion. Two Boeing engineers, Dr. Conrad L. Kraft and Dr. Charles L. Elworth, conducted a study in a specially developed night visual approach simulator flown by Boeing's senior pilot-instructors and came to some surprising conclusions. As you are aware, pilots flying a normal three-degree glide path see a constantly changing view of the runway. While the aiming point on the runway will remain stationary in the field of view, the visual angle occupied by the runway is constantly changing. Figure 4 illustrates how this visual angle changes during the approach. (I exaggerated the angles to make the illustration clearer, but the concept remains valid.)

When black isn't beautiful

What Kraft and Elworth discovered is that pilots conducting an approach over featureless terrain at night tend to keep the visual angle of the runway constant. Now, I'm going to ask you to think back to high school geometry. Do you remember the theorem that says that if two inscribed angles intercept the same arc of a circle, the angles are congruent? Whoa! That was a mouthful -- and worthy only of a high school geometry teacher. Let's look at another picture. Figure 5 shows a circle with an arc AB. Angles ACB and ADB are inscribed angles that intercept the same arc, AB, and therefore they are congruent, or equal. Do you see where I'm going here? It follows that if this theorem is true then you can turn it around to say that if two angles intercept the same arc of a circle and are congruent, then those two angles are inscribed on the circle, meaning that their vertices are on the circumferences of the circle.

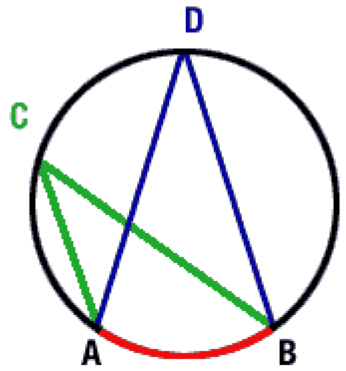

Figure 5: Equal angles (ACB and ADB) inscribed in a circle subtend equal arcs (AB).

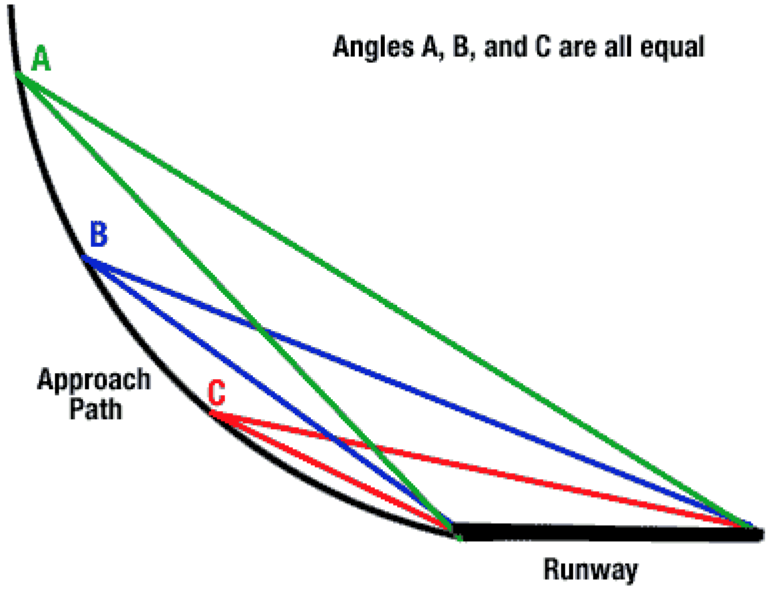

Figure 6: If the pilot keeps the visual angle subtended by the runway constant, the approach path will be an arc.

Now let's look at Figure 6. This shows (although exaggerated for clarity) what happens when a pilot flies an approach to a runway and keeps the visual angle of the runway constant. The approach path will be on the circumference of a large circle centered over the approach area. This means that the descent to the runway will be too steep at first and will flatten out as it gets closer to the runway. As a matter of fact, the Boeing researchers found that the typical descent on a black hole approach, if continued to touchdown, would result in a landing (impact?) two to three miles short of the runway. Although the circular path is clear in the illustration, it is imperceptible to the pilot flying the approach.

Although research has not yet discovered why pilots tend to keep the visual angle of the runway constant under black hole conditions, they have discovered that the condition is universal. You WILL be fooled if you try to conduct a long, straight-in approach over featureless terrain using only out-the-window references. There is no amount of training or practice that will make this illusion go away. Just like the visual illusions we looked at earlier, you know what the answer is, but your perceptions lie to you repeatedly. As you have seen, these false perceptions can be overwhelming. The only defense you have is awareness and avoidance.

Some conditions make the black hole effect more pronounced. Be alert for the illusion when you observe these conditions:

- An airport that is on the near side of a brightly lit city with few or no terrain features or lights between you and the airport. The brightness of the city lights will give the impression that they are closer than they are.
- An airport that is on the coast or in very sparsely settled terrain such as deserts and wilderness areas. This is the classic black hole scenario. Los Angeles International landing to the east and Salt Lake City landing to the south are classic examples.
- A night with extremely clear air and excellent visibility. One of the things we use to judge distance is the normal hazing that distance provides. When the air is extremely clear, this lack of hazing makes things appear much closer than they really are.

Coping with the black hole illusion

Since you know what sets you up for the black hole illusion, what can you do to keep from being sucked in? The most obvious is to avoid long, straight-in approaches. The black hole illusion disappears within two to three miles of an airport so the most obvious thing to do is to fly to the airport at a known safe altitude and then descend and fly a normal traffic pattern.

We said earlier that reference to the flight instruments will not help in a black hole situation and that is true for a quick reference to the attitude indicator, airspeed indicator or altimeter. Nothing there will be immediately suspicious. If you study the VSI, however, you may notice a larger than normal rate of descent, but that may not be apparent. You need to do a little analysis to see the whole picture. A three-degree descent -- 300 feet per nautical mile -- is the normal landing descent. If you see more than that, you should be suspicious. However, what in the cockpit measures descent angles? Your airspeed indicator and VSI do. For that three-degree descent, your rate should be five times your ground speed. If you're doing 120 knots across the ground, your rate of descent should be about 600 fpm. If you don't know your ground speed, using your indicated airspeed will be close enough to keep you out of trouble. Of course, to use this formula for a descent to the runway, you have to know how far you are from the runway. DME, GPS, or good old-fashioned pilotage should be able to tell you that.

There are many other theories about factors that may contribute to the black hole illusions. Some are more believable than others, but the thing you MUST believe is that if the conditions are right, you can be fooled by the black hole illusion and the only way to keep from getting sucked in is to analyze what you see out the windscreen and be aware that you, too, can be fooled. Seeing is not believing.