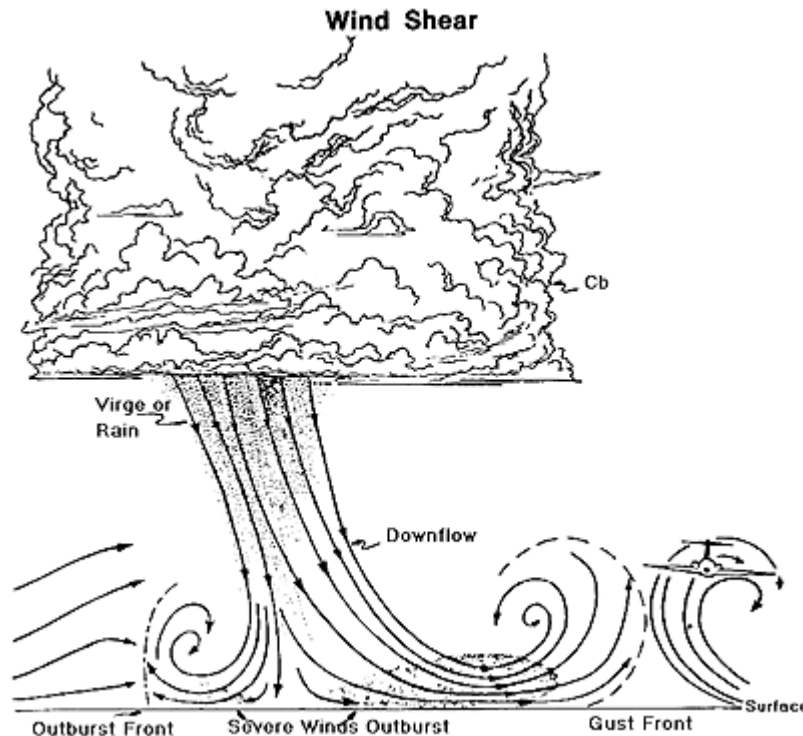




FAA Pilot Education Pamphlet Reprints

Wind Shear



"Tonto 55, final controller, how do you read...?" "55, loud and clear." This has been a good flight thought the Instructor Pilot (IP) as the pilot in front smoothly and efficiently transitioned to the Ground Controlled Approach (GCA) final. I enjoy being an instructor on days like this.

"Tonto 55, begin descent. Slightly above glide path, on course. Seven miles from touchdown."

He's really smooth on this GCA, just a little trouble getting down to the glide slope.

"Slightly above glide path, on course. Five miles from touchdown." "Slightly above glide path, on course, wind 050, 10 kts. Cleared to land Runway 05. Four miles from touchdown."

This approach is not taking much thrust. Maybe they tuned up the engines last night.

"On glide path, on course. Two miles from touchdown."

"Slightly below glide path. One mile from touchdown."

"Going well below glide path. Well below glide path."



Wow, the bottom dropped out of this approach. Add power. "I've got it!" Light burners, light!

"Tonto 55, to low for safe approach. Climb immediately! Contact departure."

"Did we hit those lights? Uh, GCA, Tonto 55, on the go. Going Tower."

"What happened?"

"What happened, indeed? How could two experienced pilots let themselves get so far behind the aircraft that they crash into the approach lights on a perfectly clear day? A few years ago the answer would have been a simple "pilot error." Everyone would shake their heads and go on as usual. Now, thanks to increased research and experience, we are more aware of complex problem of wind shear.

What is wind shear? Wind shear is a change in wind speed and/or direction over a short distance. It can occur either horizontally or vertically and is most often associated with strong temperature inversions or density gradients. Wind shear can occur at high or low altitude. This article will discuss only low altitude wind shear. There are four common sources of low level wind shear: Frontal activity, thunderstorms, temperature inversions, and surface obstructions.

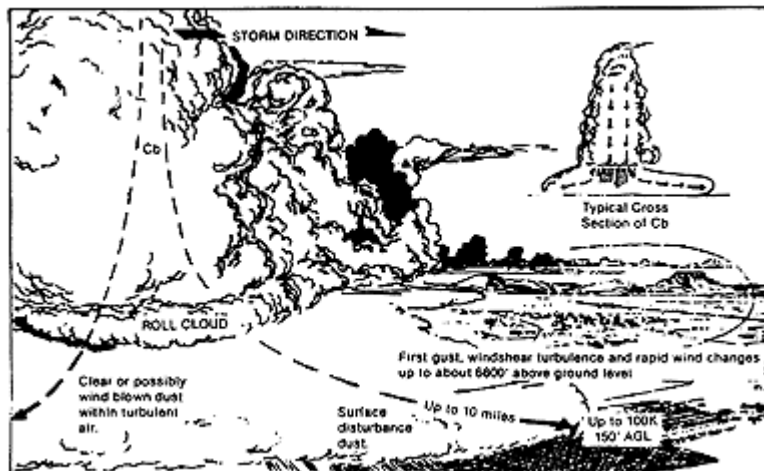


Figure 1 First Gust Hazards

Frontal Wind Shear

Not all fronts have associated wind shear. In fact, shear is normally a problem only in those fronts with steep wind gradients. Like so many things in weather, there is no absolute rule, but there are a couple of clues: (1) The temperature difference across the front at the surface is 10 degrees F (5 degrees C) or more; and (2) the front is moving at a speed of at least 30 knots. You can get clues to the presence of wind shear during the weather briefing by checking these two factors. Ask the briefer, and if they are present, be prepared for the possibility of shear on approach.

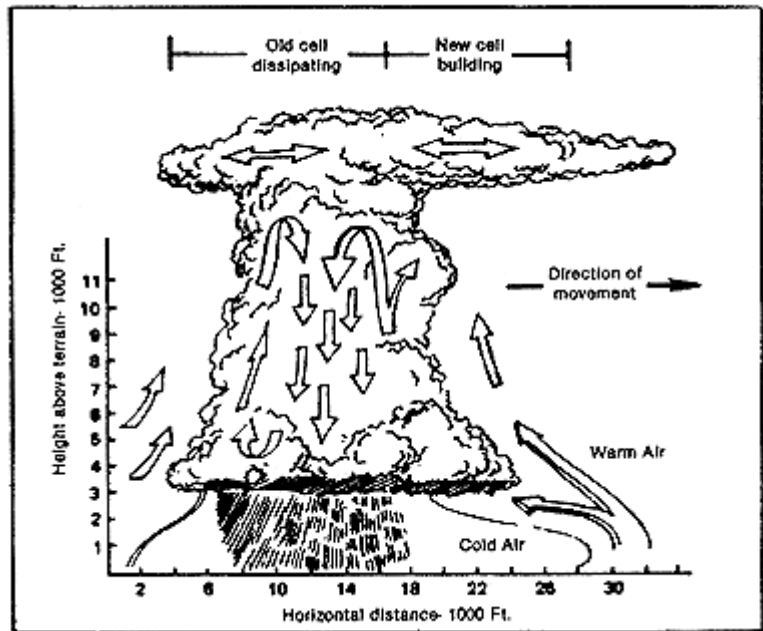


Strong downdrafts from a dissipating thunderstorm cell spread horizontally as they approach the ground. This wedge of cold air provides a lifting force on surrounding warm air which may be sufficient to initiate formation of new thunderstorm cells.

Thunderstorms

Wind shear is just one of the many unpleasant aspects of thunderstorms. The violence of these storms and their winds are well documented. The two worst problems outside actual storm penetration are shear related. These are the "first gust" and the "downburst." Most everyone has seen the rapid shift and increase in wind just before a thunderstorm hits. This is the first gust.

The gusty winds are associated with mature thunderstorms and are the result of large downdrafts striking the ground and spreading out horizontally. These winds can change direction by as much as 180° and reach velocities of 100 kts as far as 10 miles ahead of the storm. The gust wind speed may increase as much as 50 percent between the surface and 1,500 feet, with most of the increase occurring in the first 150 feet. The implications for a shear on approach in such a case are obvious.



The other wind problem mentioned earlier, "the downburst," is also downdraft related. It is an extremely intense localized downdraft from a thunderstorm. This downdraft exceeds 720 feet per minute vertical velocity at 300 feet AGL. The power of the downburst can actually exceed aircraft climb capabilities, not only those of light aircraft but even as is documented in one case, a high performance Air Force jet.

The downburst is usually much closer to the thunderstorm than the first gust, but there is no absolutely reliable way to predict the occurrence. One clue is the presence of dust clouds or roll clouds or intense rainfall. It would be best to avoid such areas.

Temperature Inversions

Pilots who have flown in the Southwest or in Southern California or Colorado are familiar with this weather pattern. Overnight cooling creates a temperature inversion a few hundred feet above the ground. This, coupled with high winds from what is known as the low level jet, can produce significant wind shears close to the ground.

One particularly bothersome aspect of temperature inversion shears is that as the inversion dissipates the shear plane and gusty winds move closer to the ground. In some areas of the



Southwest a 90 degree change in direction and 20-30 knot increases in surface winds in a few minutes are not uncommon. Obviously, such a shift would make an approach difficult at best.

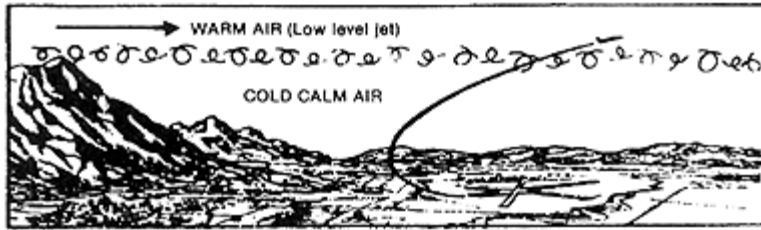


Figure 3

Turbulence at boundary between calm, cold air and a low-level warm air jet stream.

Surface Obstructions

This is usually thought of in terms of hangars or other buildings near the runway. The sudden change in wind velocity can seriously affect a landing. (Large hangars are a good example.) But there is another type of obstruction.

Some airfields are close to mountain ranges, and there are mountain passes close to the final approach paths. Strong Surface winds blowing through these passes can cause serious localized wind shears during the approach. The real problem with such shear is that it is almost totally unpredictable in terms of magnitude of severity. A pilot can expect such shears whenever strong surface winds are present.

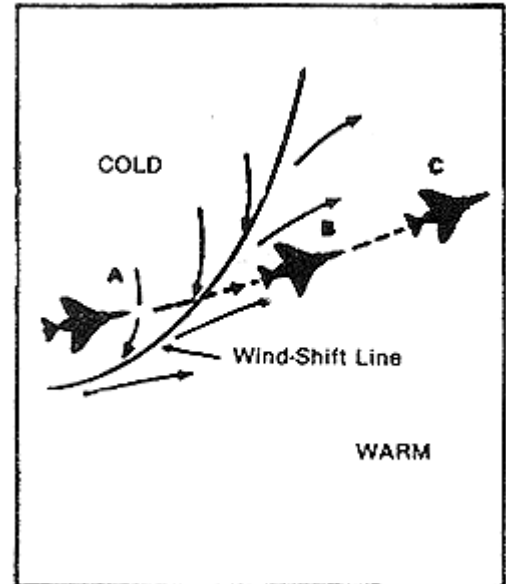


Figure 4



Types of Wind Shear

Wind shear can be divided into horizontal and vertical shears. Although both components can affect an aircraft simultaneously, it is easier to discuss each separately.

Horizontal shear occurs when the flight path of an airplane passes through a wind shift plane. Figure 4 shows how such a penetration would appear as an aircraft crosses a cold front.

The other type is the one most often associated with an approach. The vertical shear is normal near the ground and can have the most serious effect on an aircraft. The change in velocity or direction can drastically alter lift, indicated airspeed (IAS), and thrust requirements and can exceed the pilot's capability to recover.

Wind shear in its many forms can, in a matter of seconds, change a routine approach into an emergency recovery.

This has been a brief look at the kinds of wind shear and their sources. Now let's look at the affects of wind shear on an aircraft, pilot techniques for coping with shear, and new developments in forecasting wind shear.

Wind shear is an abrupt change in direction and/or velocity of wind; the shear can be horizontal or vertical and is associated with frontal activity, thunderstorms, temperature inversions or surface obstructions.

An aircraft is affected by the change in wind direction/velocity because the aircraft motion relative to the ground is also changed by the wind.

Suppose the aircraft is stabilized on an instrument landing system (ILS) approach and encounters a shear which results from a decreasing head wind. In such a case, there is transient loss of airspeed and lift causing the aircraft to descend. The pilot must compensate for this loss of lift. The critical factor is whether there is sufficient altitude to complete a recovery. In Figure 5 the shear occurs at an altitude high enough for the pilot to complete the recovery (just past the final approach fix, for example).

As the aircraft passes through the shear level, airspeed and lift are lost. The aircraft starts to sink and drops below the glide path. The pilot sees this as a deviation and corrects with increased pitch and power. Very often the correction is too large, and the aircraft overshoots the desired airspeed and glide path. However, since there is sufficient altitude to correct, the pilot is able to land safely.

Figure 6 illustrates the situation where the shear encounter is farther down glide path. Reaction time is more critical. Again, the initial reaction of the aircraft to the shear and the pilot's correction are the same. But, in this case, if the pilot overcorrects and the aircraft goes above the glide alope and airspeed increases sufficiently, there is insufficient altitude to recover, and the aircraft may land long and hot.



The case in Figure 7 is the most serious. When the altitude of the encounter is too low to effect a recovery or the shear itself is sufficiently strong to overcome the aircraft performance, the aircraft lands short.

A decreasing tail wind has the opposite effect. When the aircraft crosses the shear plane and loses the tail wind, lift increases and the aircraft climbs above the glide path. As in the head wind case, the pilots reaction can mean an overcorrection. The worst case here is the one similar to Figure 6. There the overcorrection leads to a transition to below glide path, but without enough altitude to correct. This is the classic high sink rate, hard landing.

The most hazardous form of wind shear is that encountered in thunderstorms. The severe, sudden wind changes can exceed the performance capabilities of many sophisticated aircraft. There have been numerous documented cases of aircraft mishaps directly related to encounters with thunderstorm wind shear.

The best way a pilot can cope with a shear is to: (1) Know it is there; (2) Know the magnitude of the change; and (3) Be prepared to correct or go around.

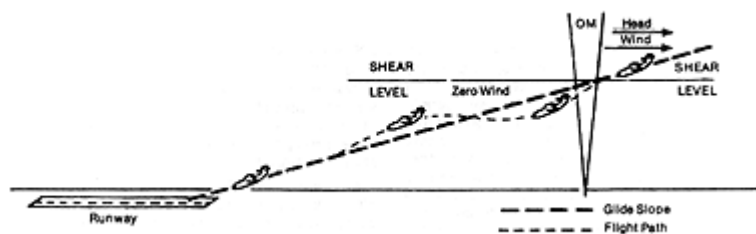


Figure 5
Moderate Shear-Altitude sufficient to effect recovery

1. Loss of indicated air speed is equivalent to shear value.
2. Lift is loss, aircraft pitches down, drops below glide slope.
3. Pilot applies power to regain speed, pulls the nose up and climbs back to the glide slope.
4. Probably overshoots the glide slope and target air speed but recovers and lands without difficulty.

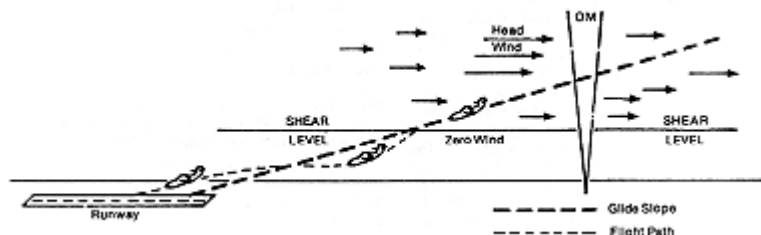


Figure 6
Moderate shear-at altitude where over-corrections results in long landing or overshoot.

1. Loss of indicated air speed is equivalent to shear value.



2. Lift is lost, aircraft pitches down, drops below glide slope.
3. Pilot applies power to regain speed, pulls the nose up to climb back to glide slope. Nose up trim may have been used.
4. When airspeed is regained, thrust required is less than required for previously existing head wind.
5. Thrust is not reduced as quickly as required, nose-up trim compounds the problem, airplane is climbed back above glide slope.
6. Airplane lands long and fast.

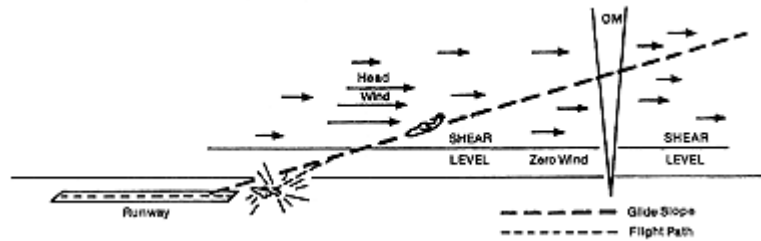


Figure 7

Shear of sufficient magnitude and at an altitude too low to effect recovery.

1. Loss of airspeed is equivalent to shear value.
2. Lift is lost, aircraft pitches down, drops below glide slope.
3. Pilot applies the power to regain airspeed, pulls nose up to climb back to glide slope, engine spool-up requires time.
4. Aircraft is in high drag configuration, altitude critical, increase in angle of attack produces only a slight or momentary increase in lift accompanied by a tremendous increase drag as the maximum value of the lift / drag ratio is exceeded. The result is a momentary arrest of the descent with decreasing airspeed followed by a large increase in an already high descent rate.
5. Pilot's only hope is to pull on the yoke and push on the throttles.
6. Pilot action is too late, aircraft crashes short of the runway.

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