Cause and Effect

Most glider pilots really want to understand why the glider acts the way it does in all modes of flight. After all, understanding why something works helps us to get the most out of our flights. So when it comes to encounters with turbulent winds close to the ground most pilots want to know if the glider is reacting to a vertical gust (thermal or downdraft) or a horizontal gust (wind gradient or shear). It is especially important when you encounter a downdraft or negative wind shear. In one case the glider will pitch nose up and in the other it will pitch nose down. In both cases the pilot will notice an increased descent rate. Let's look at events in detail and see why the wind shear event is so dangerous.

I'm pretty sure we have all had the experience of cruising along on a nice day when we run straight into a thermal. We make a split second decision and decide it's not worth circling in so we continue on in cruise flight and quickly exit out the other side. While our thoughts are probably on other things, like checking for traffic, keeping the speed constant, and looking for the next thermal marker, there are a couple of things about this encounter we should notice.

When we first entered the lift we felt that surge in the seat of our pants and noticed that the nose pitched down as the glider started to accelerate. When we flew out of the thermal the glider pitched nose up and started to slow down. A small amount of stick pressure stopped these pitch variations but why did they happen in the first place?

Some of you already realize that the pitch changes are being caused by changes to the glider's Angle of Attack (AOA) as it enters and leaves the thermal. Entering the thermal, the AOA increases and the glider pitches nose down as it tries to maintain its trimmed AOA. Exiting the thermal, the AOA decreases and the glider pitches nose up, for the same reason. Notice that the pitch change occurs first followed by the airspeed change.

Flying into a downdraft is exactly the same as flying out of the thermal. The glider will experience a decrease in AOA, the nose will pitch up and the glider will slow down. It doesn't matter if this happens at 2,000 ft, 200 ft or 20 ft, the physics are the same. The glider will pitch nose up and slow down.

The cause is the change in AOA due to the glider entering an airmass that is moving vertically in relation to the glider. The effect is the glider making an airspeed change in response to this AOA induced pitch change.

Contrast this with what happens when you encounter a horizontal gust.

As we all know, close to the ground the winds can be quite gusty and they can change directions and/or speed quite rapidly. These gusty winds show up as rapid and unpredictable changes in the gliders airspeed. Let's define a negative wind shear as a sudden decrease in airspeed due to a decreasing headwind component or an increasing tailwind component.

In contrast to the air, the glider is much heavier and it tends to follow Newton's laws of motion. Consider the case where the glider is flying along at 60 kts into a 20 kts headwind and at 100 ft AGL the wind suddenly quits. The reason for this sudden wind speed change isn't impor-

Table 1

	Initial airspeed 60 Kts		Initial airspeed 70 Kts	
Speed Decrease	Lift Produced	% loss	Lift Produced	% loss
0	1500		1500	
-5	1260	16.0	1293	13.8
-10	1042	30.6	1102	26.5
-15	844	43.8	926	38.3
-20	667	55.6	765	49.0

tant, we just accept for a minute that it did. In this case the glider pilot sees a sudden decrease in airspeed, going from 60 kts to 40 kts in an instant.

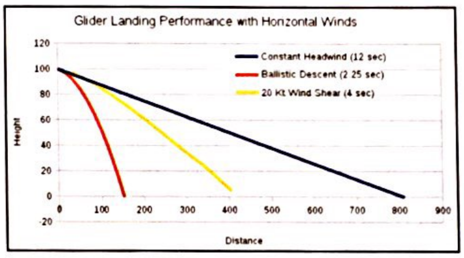
When this happens the glider is suddenly unbalanced, the amount of lift the wings are producing no longer equals the weight of the glider, and the glider pitches nose down and begin to accelerate down a steeper flight path. The pilot also feels the glider start to fall as gravity takes over and starts pulling the glider down the new flight path. Table 1 shows the magnitude of this loss of lift and the glider reacts to this just as Newton predicted. If the lift does not return, the glider will follow a ballistic path and strike the ground about 2.5 seconds after encountering the shear.

Fortunately for us, the glider has wings and they still work. The glider is not just falling, it is making a steeper glide path, thus raising the AOA quite rapidly. In addition the glider is pitching nose down in an attempt to recover the lost airspeed. These two actions cause the wings to produce more lift and within 0.5 second the glider should be under aerodynamic control, but it is flying dangerously slow at just over 40 kts.

Being a safe pilot, you want to accelerate back to your original 60 kts airspeed, but the only way you can do this is to pitch the nose down and use our gravity engine to pull you forward down the steeper flight path.

Let's say you want to recover that lost 20 kts of airspeed in 4 seconds. To do so you would need to lower the nose 15 degrees below the horizon and it will take you 90 ft of altitude to get this airspeed change. Looking at figure 1 you see that you are now 4 ft above the ground and 50% short of your intended landing spot.

Figure 1



The cause is a sudden change in airspeed due to an encounter with a negative wind shear. The effect is a sudden drop in airspeed followed by a pitch down motion as the glider begins to accelerate.

In both cases the gliders descent rate increases; how much depends on the strength of the downdraft or the magnitude of the airspeed change. In addition the pilot may be faced with the task of recovering the lost airspeed, if he was flying too slow in the first place, and diving is the only option he has.

If flying at the proper approach speed, divebrake deployment, and flight path on final approach, you should be able to compensate for some if not all of this shear by closing the divebrakes and slowing to best L/D speed. Then evaluate the situation to determine if a new aim/touchdown point is required to safely complete the landing.

So, the next time you are on short final in gusty conditions be sure and thank your instructor for insisting that you use the appropriate approach airspeed and glide slope to deal with the wind shear you might encounter!