



Sharp Landings

mastering the crosswind

eBook

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A good landing is the result of a well flown, stabilized approach. We'll go over the basics for good configuration and stabilized speed control.

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About the Author

Colin Aro is a FAAS Team member with the Reno Flight Standards District Office and has lived in Reno, Nevada for nearly 20 years. He is a commercial pilot and flight instructor rated for single engine airplanes, multi engine airplanes, and gliders. He holds a Ph.D. in Engineering - Applied Science from the University of California, having studied atmospheric chemistry and dynamics. Colin's favorite safety subject is mountain flying - an important topic according to the industry's accident statistics. Colin's past soaring experience in the Sierra Nevada and other mountain ranges, combined with his academic research background offer a slightly different and entertaining viewpoint on this important topic.

Colin enjoys volunteering with the Commemorative Air Force and flying antique aircraft. He currently serves as the squadron commander for the High Sierra Squadron of the CAF in Reno, flying the squadron's N3N-3 and L-19 aircraft. He also flies with the Northern California Beech Boys formation demonstration team.



Introduction

Recently, we published an eBook on mountain flying and a big part of that discussion was mountain weather. The surface winds at mountain airports are strongly influenced by thermal heating and mechanical deflection. These influences quite often manifest themselves as robust vertical convection and shifty, gusting surface winds. Not to imply that mountain airports have a monopoly on crosswinds, but gusty crosswinds are a staple in the afternoons. A healthy practice session of crosswind takeoffs and landings is always time well spent no matter where you fly especially after a winter layoff. In this eBook, we'll look at what goes into a really solid approach and landing especially under crosswind conditions. If you've never learned to fly a tailwheel aircraft, I would highly recommend it. In much the same way that glider and soaring training enhance a power pilot's prowess in the mountains, tailwheel flying hones a pilot's ability in a crosswind because of the tailwheel aircraft's less forgiving nature.



Configured and Stable

The Approach – The Set Up

A good landing is the result of a good approach. As the aircraft is established on final, it should be configured for landing, trimmed, and stabilized. In particular, the airspeed should be stabilized at the proper approach speed. Good speed control is best achieved by flying the appropriate pitch attitude for the desired airspeed. Therefore, good speed control is the result of good attitude control. This is especially true in gusty conditions. Having the aircraft configured and stabilized at the proper speed will go a long way in making the perfect touchdown “automatic”, but don’t be too much of a slave to “stabilized”: The April, 2020 issue of AOPA Pilot has an excellent discussion of aircraft configuration on approach (“Landing like a Pro”, pp. 94-96). This article humorously points out that ‘straight down’ is a perfectly stable approach.



AOPA follows this up with an excellent recent article ‘Finishing Strong’ which breaks down a three-step transition from the air to the ground (October, 2020 AOPA Pilot, pp. 76-83). This material is light on crosswind

discussion - "How has something so simple become so confused?" We hope to expand on the effect of and correction for crosswinds on landing. It truly is a relatively simple skill, and we hope to shed some understanding of it here.

How Fast?

What is the "proper approach speed"? Generally speaking, the approach speed listed in the POH for a typical GA aircraft is $1.3V_{S0}$. Whatever the POH dictates, this is the appropriate speed to be flown on the approach. There may be more than one suggested speed based on configuration and/or desired performance. I cannot stress enough how important it is to fly pitch attitude and not chase the airspeed indicator – especially when it's gusty.

Regarding gusty conditions, it is advisable to adjust the approach speed if the surface winds are gusty. If gusts are present, a good rule of thumb is to add half the gust factor to the approach speed. For example, say the surface winds are at 12 knots gusting to 20. In this case, we have an 8 knot gust factor and would add 4 knots to the approach speed.

Conclusions

In summary, upon establishing the aircraft on final approach, we need to

- Have the aircraft properly configured for landing.
- Have the aircraft stabilized at the proper approach speed, possibly adding a gust factor.

- Have the pitch attitude trimmed for the appropriate speed, especially in gusty conditions.

If the approach is stabilized with the correct airspeed, attitude, and configuration then a good landing and rollout are very nearly an automatic result of the properly flown and stabilized approach.

As for stabilized, I personally like to hold my crosswind slips to landing *relatively* early on final - other instructors whom I respect immensely believe the opposite: crab into the wind until the flare and add the slip at that point because the crosswind component will change as you descend to the runway.

And to bring the dreaded "taildragger" into the discussion: we will discuss the prospect of estimating crosswind component based on the aircraft's crab angle. In my humble opinion, the only good argument for wheel landing a taildragger is when the crosswind is unknown. It is better to run out of control authority and execute a go-around with the mains firmly on the ground as opposed to minimum controllable airspeed a few feet off the runway.

The remainder of this eBook will focus primarily on proper crosswind correction during landing. Loss of control is our primary source of accidents in the landing phase and for short final/touchdown/rollout a large factor here is proper crosswind correction and control. The major issue with landing in a crosswind is, of course, the aircraft's crabbed flight path when the longitudinal axis is aligned with the runway centerline. In the next chapter we will add a discussion of crosswinds and crab angles in preparation for slips-to-land.



The Effect of a Crosswind

In chapter one, we talked about the keys to a good approach to landing – being stabilized at the appropriate speed, attitude, and configuration. Moving forward, we'll add discussion of crosswinds and how to appropriately compensate using crabs and slips. Let's begin by looking at the effect of a crosswind on an aircraft's flight path. Consider an aircraft heading due north with a 10 knot wind 30 degrees to the left of heading (Figure 1)

Of course, we analyze vectors by using simple trigonometry to break them into components, in this case headwind and crosswind components. Figure 2 shows the resulting component vectors: This 10 knot crosswind 30 degrees off of the aircraft's nose has the effect of a 5 knot direct crosswind (crosswind component) and an 8.6 knot direct headwind (headwind component).

If we were landing in this wind condition, we can immediately see that crosswinds are not all bad: this one slows our groundspeed by almost 9 knots leading to a slower touchdown speed. However, we will also be drifting to the right at a speed of 5 knots. Bear in mind that 1 knot is about 100 feet per minute and 5 knots (500 feet per minute) is about 8 feet per second. Left uncorrected, this rate of sideways drift will have you off into the weeds after only 10 seconds or so even on a very wide runway. This is certainly quite a noticeable drift rate for a crosswind component with the strength of a gentle breeze. Ultimately, we are not pointed in the same direction we are flying and this will cause problems on touchdown even if we do stay out of the weeds.

Figure 1

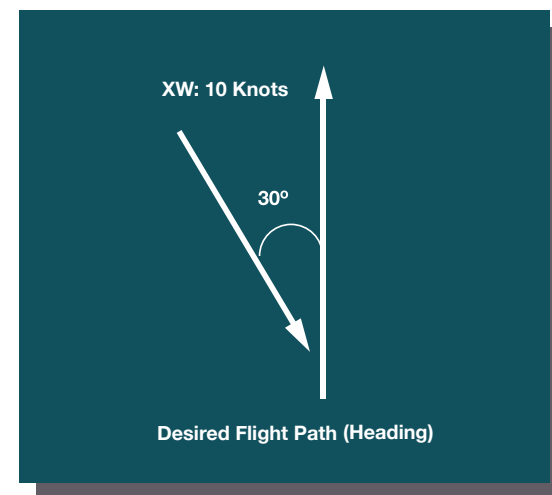
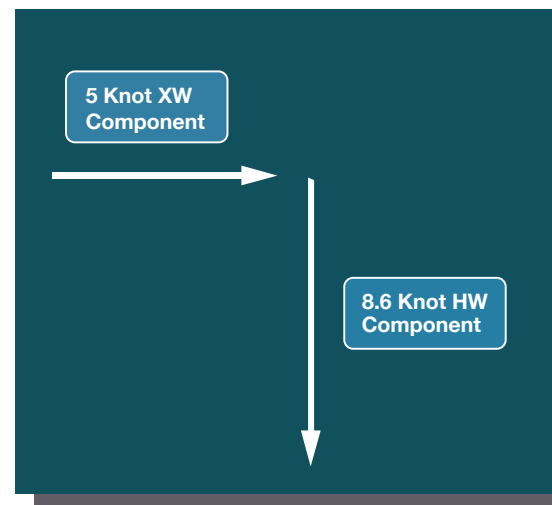


Figure 2



OK, standby for some simple trigonometry: the crosswind component is calculated by multiplying the wind speed (10 knots in this case) by the sine of the crosswind angle (30 degrees in this case). I promise, that's all you need to know. The sine of 30 degrees is 0.5 and so the crosswind component is

$$0.5 * 10 \text{ knots} = 5 \text{ knots}$$

There are a few rules of thumb that will help you estimate crosswind components to within a knot or two. As noted, the crosswind

component for a 30 degree crosswind is half (exactly) the total wind velocity. This increases to about 70 percent of total velocity (approximately) at 45 degrees of crosswind and 87 percent at 60 degrees. So, for crosswinds 30 degrees or less, you can assume the crosswind component to be 25 – 50% of the total wind speed (the closer to 30 degrees, the closer to 50%). More than 35 degrees and you can conservatively expect the component to be 70 – 100% of the total wind speed (the farther past 45 degrees, the closer to 100%).





Landings aside, Figure 2 shows us that left uncorrected, the crosswind will drift the aircraft to the right of the desired course at a rate of 5 knots. The obvious way to correct for this is to “crab” or angle the aircraft’s flight path into the wind. The FAA even gives us a formula (“angle to parallel”) to quantify how much the aircraft’s heading needs to be angled in order to maintain flight path:

$$\alpha = 60(\delta)/D$$

where δ – crosswind component

D – airspeed

α – crab angle

This leads to a striking coincidence if the aircraft’s speed is 60 knots (not *too* far off the approach speed of many light GA aircraft): the equation reduces to

$$\alpha = \delta$$

That is, at 60 knots, the aircraft’s crab angle in degrees is roughly equal to the crosswind component in knots. At 120 knots, the crab angle is half the crosswind component and so forth. Not only does this give the pilot another way to estimate crosswind component (in the absence of a weather reporting station, no less), it shows us that even with a modest 5 knot crosswind component we’ll have approximately a 5 degree crab angle for a typical light GA aircraft. That’s a 5 degree difference between the direction the aircraft is pointed and the direction it is travelling. Crab angles are effective in maintaining ground track, but in terms of transitioning from the air to the ground, we still have some more work to do. Being pointed in a direction different than the direction of travel is a sure fire recipe for directional control problems upon touchdown. Especially if you’re flying a dreaded taildragger!

In the next chapter, we will discuss the forces on an aircraft in turning flight and apply this knowledge to crosswind slips to land.

Turns and Slips

In the previous chapter, we looked at the effect of a crosswind on the aircraft's flight path and the correction of that effect through the use of a crab angle. In both cases, the aircraft is pointed in a different direction than it is tracking. Therefore a crab angle is useful in correcting an aircraft's ground track but useless for a crosswind landing due to the obvious potential for directional control problems.

Landing in a Crosswind

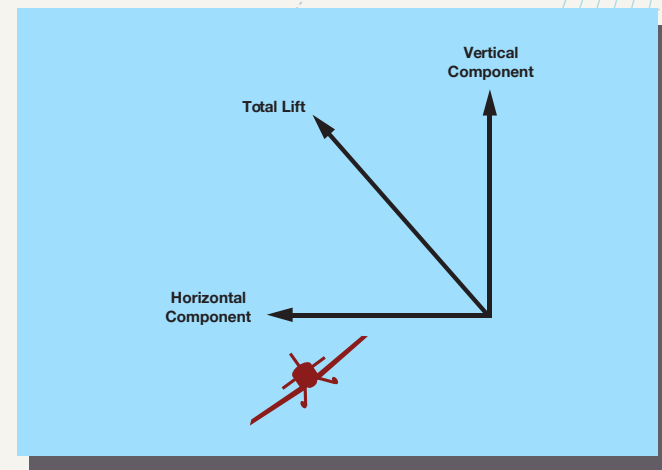
Obviously, the key to successfully negotiating a crosswind landing is to point and fly in the same direction as we approach the runway and transition to the ground. This helps immensely with directional control and avoids placing an excessive side load on the landing gear. Doing so requires the pilot to correct for crosswind drift WITHOUT a change in heading! The solution: the horizontal component of lift, the force that turns the aircraft...let's digress a bit.

Turning Forces on an Aircraft

When the aircraft is banked, the lift vector is tilted and no longer directly opposes gravity. It has a vertical and horizontal component – the vertical component directly opposes gravity while the horizontal component is the force that turns the aircraft. Figure 1 illustrates the situation: the vertical and horizontal components

add together to equal total lift. The vertical component of lift opposes gravity, so it has no direct bearing on the turning of the aircraft. Its only effect is to keep the aircraft in level flight. Figure 2 depicts this – the force acting on the aircraft, the horizontal component of lift, deflects the flight path in the direction of bank. This produces a curved flight path in the direction of the horizontal component – a turn.

Figure 1





Rudder – What is it Good For?

As we know, the horizontal component of lift turns the aircraft – so what does the rudder do? The rudder coordinates flight. Too little or too much rudder results in a slip or a skid. Another way to describe a slip or a skid is that the aircraft's heading change is too slow or too fast for the bank angle. Again, in both cases we're not pointed where we're headed, but this time we can take advantage.

We are more interested in the case of a slip, where the heading change is too slow for the bank angle. If the pilot goes as far as to use opposite rudder, there are moderate bank angles for which the heading change can be reduced to zero. This gives the pilot a horizontal force to oppose the crosswind component WITHOUT a change in heading – exactly what we were looking for. NOTE: the aircraft is slipping and therefore NOT in coordinated flight. That's OK; we're doing it on purpose! The aircraft is pointed in the same direction as it is travelling. See Figure 3.

With the aircraft on short final, the transition from crab to slip is made establishing the conditions in Figure 3. At this point, the aircraft's longitudinal axis should be aligned with the aircraft's flight path and the runway centerline in preparation for roundout and touchdown. Because the aircraft is slipping (and therefore producing extra drag) some power may be needed to compensate for the increased sink rate. Moving forward, this series will conclude with a discussion of roundout, touchdown, and rollout.

Figure 2

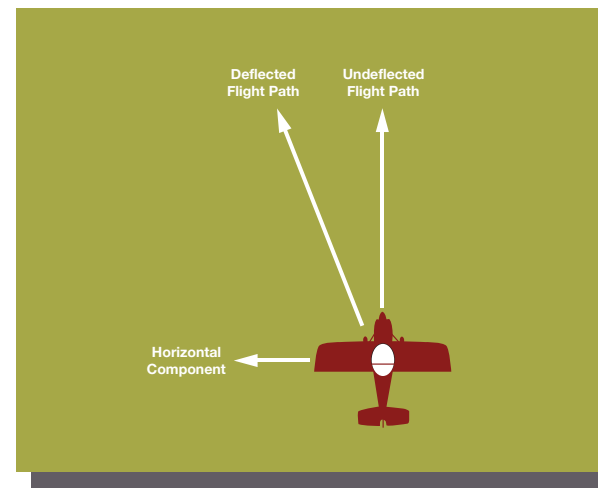
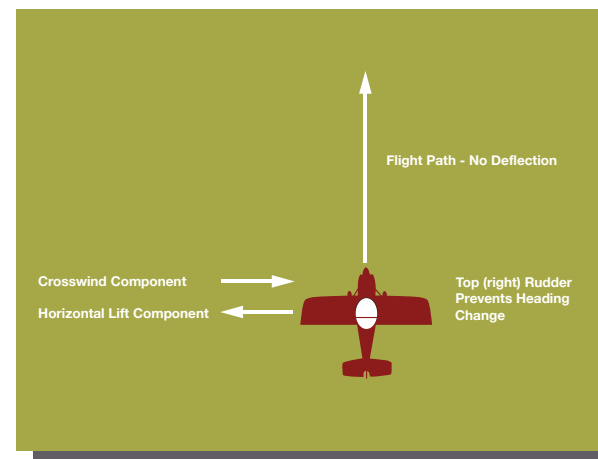


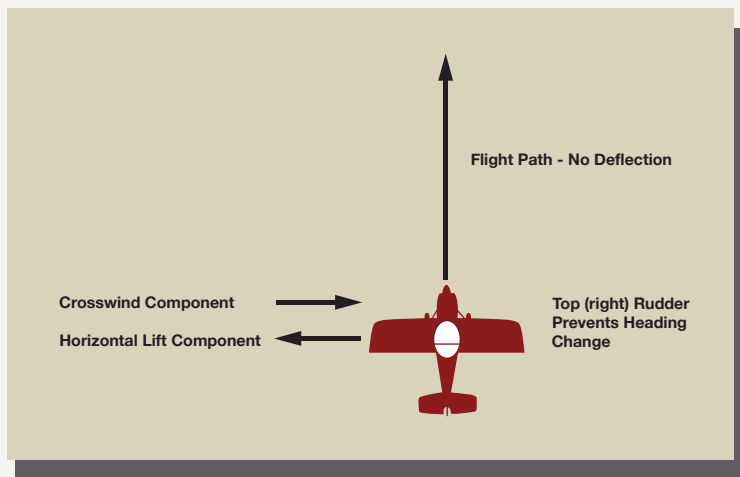
Figure 3



Touchdown and Rollout

Well, here we are on short final with the aircraft in a slip to correct for the crosswind component.

Figure 1



We have successfully used the horizontal component of the lift vector to zero out the crosswind component of the wind – the aircraft is pointed in the same direction it is moving, the longitudinal axis is aligned with the runway centerline and we are ready to make the transition to the ground.

As the aircraft enters the roundout phase, we level off just above the runway and decelerate for touchdown. As the aircraft decelerates, the lift produced by the airfoil diminishes (we wouldn't touch down

otherwise!) and therefore the horizontal component of that lift will diminish. As a result, the cross-control application will have to increase in order to compensate. This means more aileron and more cross rudder leading up to touchdown.

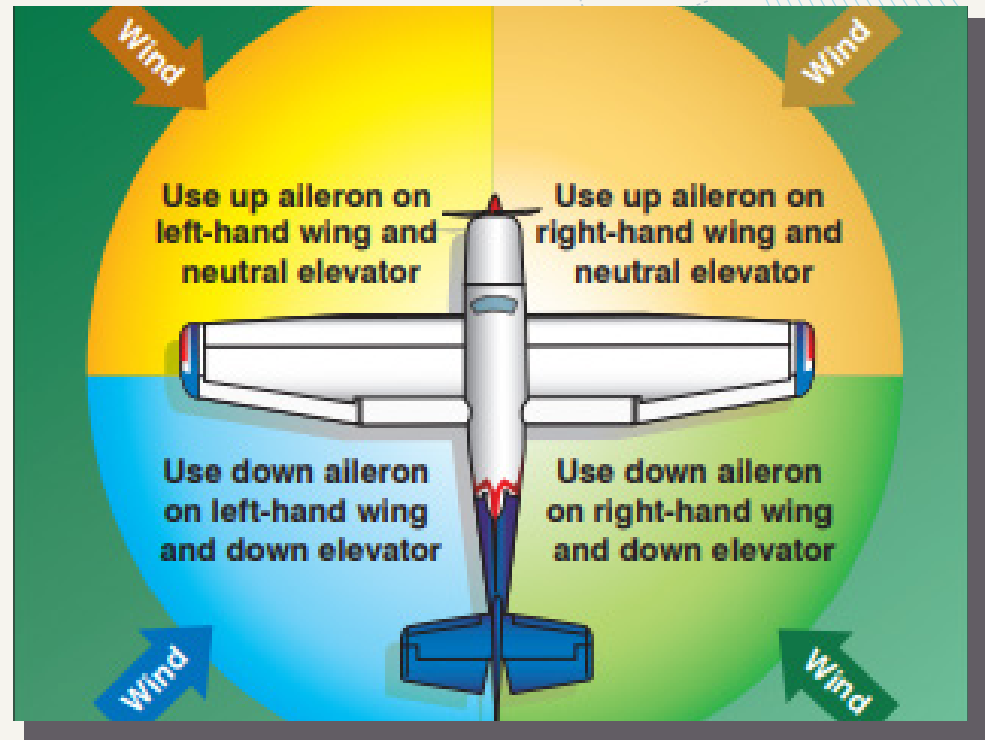
Due to the increasing cross-control during the roundout, it is expected that the upwind wheel will be the first to touch the runway. This is where crosswind correction is most critical – the moment of touchdown. Done properly, the upwind wheel touches first – this sets us up for a few common errors that lead to the dreaded ground loop, especially in a tailwheel aircraft. First, notice that with the upwind wheel grounded and the downwind wheel still in the air, the brake you would need if the aircraft were to weathervane is the one that is still in the air! Correcting for a weathervane by “turning away from it” or in any way putting that downwind wheel on the ground just aggravates the situation. The only way out of this situation is proper technique: Point the lift vector (ailerons) into the wind and keep the airplane going straight with opposite rudder. We are crossing the controls intentionally. This may feel a bit counterintuitive to the student pilot as it feels like “turning further into the problem”. This is an intuition that must be trained away initially and revisited during recurrent training. If we run out of control authority during the maneuver, the crosswind exceeds the aircraft's capabilities, a go-around is called for, and it is time to consider a different runway.



As the speed bleeds off and the downwind wheel contacts the runway, a common error is to give up on that crosswind correction. The rollout phase as the aircraft decelerates to taxi speed is still ripe for side loads and the dreaded ground loop. FULL cross-control correction should be applied at this point. This is actually a natural extension of the roundout phase: as cross-control application increases during the roundout phase it stands to reason that we should go to FULL correction as the aircraft touches down and rolls out. Doing so makes directional control significantly easier and keeps us out of trouble.

As the aircraft decelerates to taxi speed and exits the runway notice that the proper crosswind landing technique places the controls exactly as the FAA recommends for taxiing in windy conditions (see Figure 2).

Upon exiting the runway, we are now taxiing and can begin positioning the controls as Figure 2 suggests. Remember: what this figure is telling us is climb and turn into the wind, dive and turn away from the wind. There is a saying within the tailwheel community: "You're not done flying until the airplane is tied down". All pilots would do well to adopt this advice. I have given occasional mention to tailwheel flying starting at the outset when I likened its effect on landing skill to soaring skills and mountain flying. If you've never flown tailwheel, give serious consideration to doing your next BFR or WINGS phase in a tailwheel aircraft. It will increase your awareness of certain aspects of your crosswind landing technique and sharpen your skills. A fringe benefit is that tailwheel aircraft can be a lot of fun to fly, so beware – you may find yourself hooked. Remember that if you've ever dreamt of wiling the afternoon away in an open cockpit Stearman, you're gonna need a tailwheel endorsement when the opportunity comes along.





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