
# Descent Performance Testing

## Timing a climb in reverse

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LAST MONTH WE FINISHED EXplaining how to reduce the sawtooth climb data and determine the steepest angle climb speed, $V_X$, and the associated climb angle and climb gradient. This month we'll tackle descent performance, and if you're thinking a descent is nothing more than a climb in reverse, you're basically correct.

How to get the best descent performance from your airplane might be something you discuss while cruising toward your destination. Bantering with your co-pilot or passenger is a good way to—BAM!

The engine quit. Now what? One thing's for sure. This is the wrong time to wonder what your airplane's best glide speed is. A better time is your next flight, and determining your airplane's glide performance is easier than the climb performance testing we've detailed over the past few months.

An airplane's climb rate depends on how much power the engine-propeller combination can deliver beyond that required for level flight. More excess power produces faster climb rates. Climb angle depends on how much excess thrust your powerplant can deliver. The bigger the difference between the thrust available and the thrust required (drag), the steeper your airplane's maximum climb angle will be.

In an engine-out glide, no power or thrust is available. You're coming down, but how you come down can make a big difference in how quickly you reach the ground and how far you can travel in the process.

With climb performance we're interested in the fastest rates and steepest angles, but the opposite is true with descent performance. We want to know our airplane's slowest descent rate and shallowest descent angle (which occur at different airspeeds) because these maximize our engine-out endurance and range.

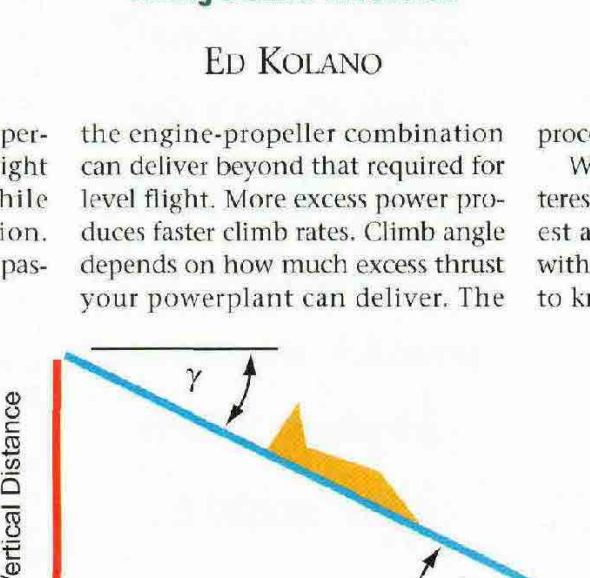


**Figure 1**

### Angle Size Matters

Figure 1 shows a profile view of our example airplane's engine-out descent. The smaller the flight path angle (γ, pronounced gamma), the bigger the ratio of horizontal distance to vertical distance, or the shallower the flight path angle, the farther you can glide for a given altitude.

During a glide forces act on our airplane just like they do during every other phase of flight, except there's no thrust after the engine quits. That leaves lift, drag, and weight as the only forces, and Figure 2 shows these forces with a little trigonometric extra. The weight arrow (W), which always points down regardless of the airplane's direction or attitude, is a dashed line, and the weight components (the trig sine and cosine functions) are solid arrows that are parallel to the lift (L) and drag (D) arrows. By using these parallel weight components we can see the relationship between the forces more easily.

Our airplane is in a constant-airspeed descent. Because it is not accelerating either by changing airspeed or maneuvering, all the forces acting on it must balance. If we look separately at the forces acting perpendicular and parallel to the airplane's flight path, we have

$$\text{Lift} = \text{Weight} \times \cos(\gamma)$$
$$\text{Drag} = \text{Weight} \times \sin(\gamma)$$

We used the same Greek letter $\gamma$ in Figure 2 that we used in Figure 1's flight path angle because $\gamma$ represents the same engine-out flight path angle in both figures. Now let's rearrange the two force equations.

$$\text{Weight} = \frac{\text{Lift}}{\cos(\gamma)}$$

$$\text{Weight} = \frac{\text{Drag}}{\sin(\gamma)}$$

We now have two expressions for weight, so let's set them equal to each other.

$$\frac{\text{Lift}}{\cos(\gamma)} = \frac{\text{Drag}}{\sin(\gamma)}$$

If we divide both sides of this

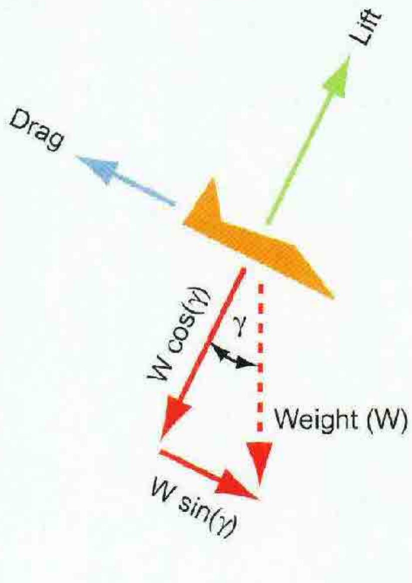


**Figure 2**

equation by drag and then multiply both sides by cos ($\gamma$), we get

$$\frac{\text{Lift}}{\text{Drag}} = \frac{\cos(\gamma)}{\sin(\gamma)} = \frac{1}{\tan(\gamma)}$$

We finished the last equation by substituting the trig tangent func-

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tion (tan = sin/cos). From trig tables or a little experimenting with a calculator you can see that the smaller the angle, the smaller the tangent of that angle. Looking at the last equation, the smaller the tan ($\gamma$), the larger 1/tan ($\gamma$) will be.

In Figure 1 we showed that the smaller the flight path angle, the farther the glide distance. Reversing that, we achieve the greatest glide distance when the flight path angle is smallest, which means the tan ($\gamma$) is smallest, which means 1/tan ($\gamma$) is largest, which means lift/drag is largest. So it makes sense that the maximum engine-out glide distance occurs when the airplane is flown at its maximum lift-to-drag ratio (L/D).

Most of us don't have a flight path angle or L/D indicators in the cockpit, so how can we find the airspeed that yields the smallest flight path angle? Well, speed is simply distance divided by time. So let's redraw Figure 1 in terms of speed. Figure 3 shows the relationship between our airplane's true airspeed, vertical speed, and the same engine-out flight path angle, $\gamma$.

$$\sin(\gamma) = \frac{\textit{Vertical Speed}}{\textit{True Airspeed}}$$

We can measure vertical speed and record observed airspeed during the flight test. If we record the outside air temperature and pressure altitude, we can convert observed airspeed to true airspeed (assuming we've already performed our airplane's airspeed calibration). Then we have everything we need to determine the flight path angle. Our engine-out glide test boils down to flying several glides at different airspeeds and determining which airspeed yields the smallest flight path angle.

The flight path angle depends on true airspeed and, therefore, pressure altitude. If you fly the same observed airspeed at two different altitudes, the true airspeed will be faster at the higher altitude. Fortunately, you don't have to worry about memorizing which true airspeed to fly when the engine quits. We know that the shallowest flight path angle

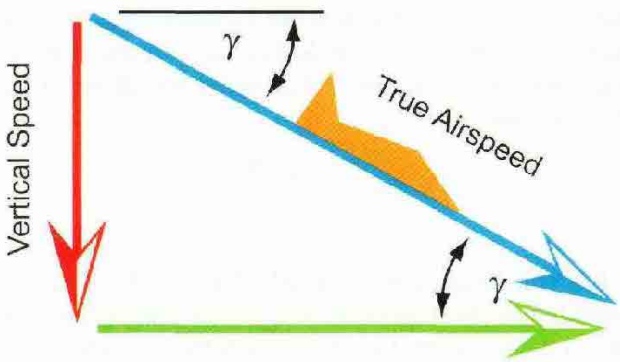



**Figure 3**

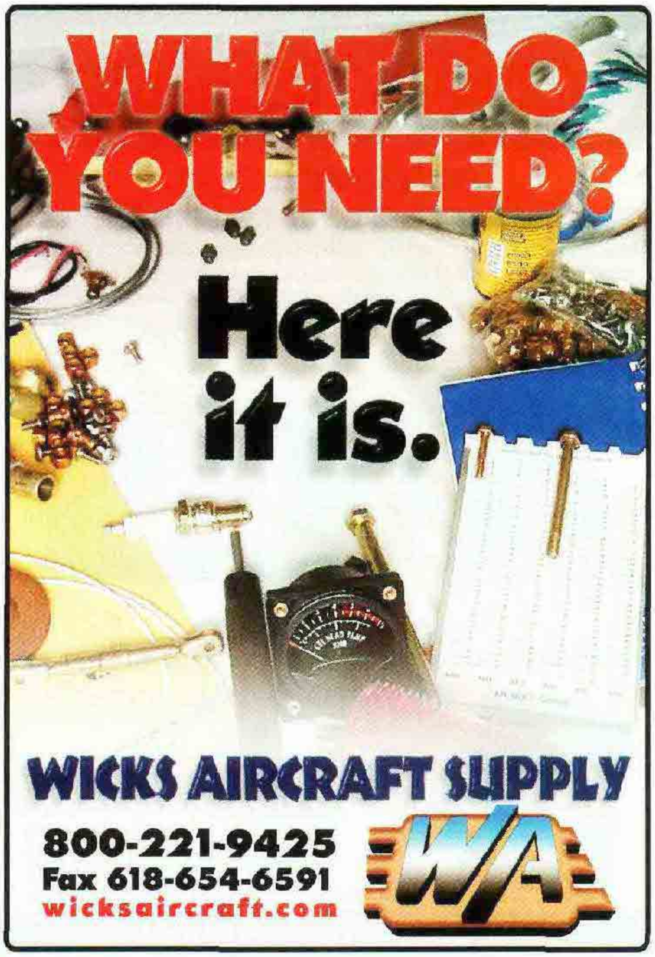
and maximum engine-out glide range occurs when the airplane flies at its maximum L/D. The maximum L/D occurs at a particular angle of attack. Flying the airplane at any other angle of attack will reduce its engine-out glide range. This fundamental statement is why you can't stretch a glide.

You probably don't have an angle of attack indicator in your cockpit, but that's okay. By determining the optimum observed airspeed from flight testing, you're indirectly determining the maximum L/D angle of attack. To achieve this angle of attack all you need to know—and fly—is the observed airspeed at which it occurs, because this optimum engine-out observed airspeed is valid for all altitudes. At higher altitudes your optimum engine-out observed airspeed will result in a faster true airspeed and descent rate, but you'll still be getting the maximum range possible. Because the best glide performance observed airspeed does not depend on altitude, you can perform the flight test at any safe altitude.

When your engine quits, the propeller may windmill. If you performed the tests with the engine at idle power, your actual engine-out glide range will probably be less than your test results indicate. If your propeller stops completely when the engine quits, and you performed your tests with idle power, your actual range will probably be better than your results indicate. Performing the glide tests with idle power makes safety sense. The resulting optimum glide speed should still produce the maximum glide range possible.

We didn't mention weight when discussing the previous flight path angle equation because an airplane's glide performance does not depend on its weight. It will come down faster when it's heavier, but it will travel just as far as when its weight is less *if* you fly at the maximum L/D.

But lift and drag depend on airplane weight, so the maximum L/D airspeed depends on airplane weight. You can handle this a couple of ways. You can test at your airplane's maximum weight and test again at its minimum weight and interpolate to find the maximum L/D









glide speed for weights that fall between these two extremes. Or you can use the following formula to adjust your plane's maximum L/D airspeed for different airplane weights:

$$V = V_{TEST} \times \sqrt{\frac{W}{W_{TEST}}}$$

V is your plane's maximum L/D airspeed when your airplane weighs W pounds. $V_{TEST}$ is the maximum L/D airspeed determined from your flight test, which was performed when your airplane weighed $W_{TEST}$ pounds. Or you can test at an airplane weight about halfway between its minimum and maximum weight and use the resulting maximum L/D airspeed for all weights. Flying a few knots faster or slower than the maximum L/D airspeed may not significantly affect your glide range—it depends on your plane's glide characteristics, and we'll show how to check this next month.

#### Flight Test

The flight test is a series of idle-power descents that you time so you can determine the rate of descent. Fly each test in the series at a different airspeed, and during the data reduction you'll determine which airspeed produced the shallowest flight path angle. Simple.

Begin your test planning by selecting a test altitude that's high enough to reach a landing field should the engine actually quit. Then specify an altitude block through which you'll time your descent—500 feet should be enough for the glide characteristics of most homebuilt airplanes.

You'll need data cards, like the example in Figure 4 (following page), with target test airspeeds and columns for the actual test airspeeds, altitude blocks, elapsed time, and comments. Notice the order of the target airspeeds in Figure 4. We're intentionally starting in the middle of the glide airspeed envelope and working our way toward the extremes as we gain experience, comfort, and familiarity with the test airplane's glide characteristics.

After you're safely airborne and ready to begin testing, set your altimeter to 29.92 and it will display pressure altitude, which we'll need later for our true airspeed calculations. Establish an idle-power descent above the top of your test block. Trim carefully. The quality of your data depends on maintaining the test airspeed within a knot or two. Achieving this tolerance is not as difficult as it may sound, but flying in calm air with a distinct visual horizon is a must.

Begin timing as you pass the top of your test block. Keep an eye on the outside air temperature and record it near the midpoint of the altitude block. Stop timing as you descend through the bottom of the test block.

| Test Order | Observed Airspeed [Target] | Observed Airspeed [Actual] | Start Press Altitude | End Press Altitude | Elapsed Time | OAT | Remarks |
|---|---|---|---|---|---|---|---|
| 1 | 100 | | 3750 | 3250 | | | |
| 2 | 80 | | 3750 | 3250 | | | |
| 3 | 110 | | 3750 | 3250 | | | |
| 4 | 70 | | 3750 | 3250 | | | |
| 5 | 120 | | 3750 | 3250 | | | |
| 6 | 65 | | 3750 | 3250 | | | |
| 7 | 130 | | 3750 | 3250 | | | |
| 8 | 140 | | 3750 | 3250 | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

**Figure 4**

While you're climbing back up for your next test at a different airspeed, record the first test's elapsed time and outside air temperature and any qualitative comments. If the airspeed wandered between two knots slow and two knots fast several times during your timing, make a note about it. If the airspeed was dead-on, but you made a lot of flight control inputs, note that. These qualitative comments can help explain why a data point doesn't fall in line with the other points during your data reduction. Reviewing the quality of your last test immediately afterward helps you decide whether the quality is good enough. If you have any doubts, repeat the test.

Repeat this glide test for every test airspeed on your data card. When your testing is complete, make one last check of your data before returning to the airport. Find the airspeed that produced the least elapsed time. Now look at airspeeds faster and slower than that speed. These should have longer elapsed times.

We already mentioned the importance of maintaining a constant airspeed while timing. Equally important is the smoothness of your flight control inputs. If you see the airspeed starting to wander, it's better to make tiny, smooth corrections than to aggressively yank the plane back on speed. Aggressive or large control movements create drag that can contaminate your results.

If you find yourself perfectly stabilized a few knots off your target speed as you descend through the top of the test block, that's okay. Just fly the test at the stabilized airspeed. During the data reduction, we're going to use these data to create a plot. The important thing is to have a bunch of tested speeds spanning the airspeed range rather than the exact target airspeeds.

### By the Numbers

1. Set 29.92 in your altimeter.
2. Establish a constant-airspeed, idle-power descent above the top of the test altitude block. Trim.
3. Start timing as you descend through the top of the test block.
4. Note the outside air temperature near the midpoint of the test block.
5. Stop timing as you descend through the bottom of the test block.
6. Record the test airspeed, elapsed time, outside air temperature, and qualitative comments as you climb back up for the next

test.

7. Repeat Steps 2 through 6 until you have flown all target airspeeds.
8. Reset your altimeter to the local setting before returning to land.

Think safety first. Don't bury your head in the cockpit for prolonged periods. Clear the area below before beginning each test, and check the airspace ahead during each climb between tests. Don't try to fly the test using the artificial horizon or the vertical speed indicator. These instruments are too coarse for good results. Use the real horizon to maintain the pitch attitude necessary for the test airspeed. If the airspeed begins to wander, make a tiny pitch attitude adjustment by referring to the horizon; don't chase the airspeed indicator with the control stick. This external reference also helps you see and avoid other airplanes.

Don't forget about your engine. A series of full-power climbs and idle descents puts a lot of thermal stress on your engine. Keep an eye on engine temperatures and other "health" parameters.

There are too many flight test stories of the simulated event actually occurring during the test. Choose a test area where you can easily glide to a safe landing should an actual engine failure occur.

There you have it—the why and wherefore of engine-out glide testing. Next time we'll use the data acquired during glide tests in the Young Eagles RV-6A to illustrate the data reduction. When we're finished, we'll not only know the airplane's best glide speed, but we'll also show how gliding off-speed reduces glide distance.

Thanks to everyone for sending your comments, questions, and suggestions. The address is Test Pilot, EAA Publications, P.O. Box 3086, Oshkosh, WI 54903-3086 or *editorial@eaa.org* with TEST PILOT as the subject of your e-mail.