

Measuring the Aerotow Box

From the category of answering questions you hadn't thought to ask...

Background

A common training maneuver during aerotow glider training is "Boxing the Wake", also known as "Boxing the Wash". During this maneuver, the glider pilot maneuvers from High Tow to Low Tow and to the right and to the left of the towplane. Doing this in a rectangular fashion results in a flight path that passes over, to the right of, under, and to the left of the towplane's propwash and downwash. The presence of the propwash and downwash can be felt as additional turbulence. This maneuver is used to teach new glider pilots the limits of acceptable tow positions and to teach them why it is preferable to stay outside of the towplane's wash. Additionally, this maneuver is part of the glider practical test.

The Question

For many years I have wondered "Just how big is the Aerotow Box?" I have seen it many times from the point of view of the glider pilot, and the dimensions seemed quite large. However, when observing the maneuver in progress from outside the aircraft, the dimensions seemed quite small. I set out to find a way to measure the actual dimensions.

Measurements

The first measurement was easy. The tow rope is nominally 200 feet long. The challenge was finding a stable platform to measure the angles from.

To define the top of the box (High Tow), consider Figure 1.



Figure 1. High Tow Position

In this picture, we can see two things that can be used to define an angle. The first is that the tailwheel is level with the main gear. That is to say the pitch attitude of the towplane is the same as when it is parked on the ground. The second is that the leading edge of the horizontal stabilizer is lined up with the top of the wing at the root. In fact, the latter concept is used by some instructors to tell their students how to know when they are at the right altitude for High Tow.

Low Tow position is shown in Figure 2.



Figure 2. Low Tow Position

Figure 2 actually shows the glider a little lower than what we will call Low Tow for this paper. We will define Low Tow as when the leading edge of the horizontal stabilizer is lined up with the rear view mirrors (the little bumps just under the stabilizer in Figure 2).

Lateral position at the right side of the box is shown in Figure 3.



Figure 3. Right Side of Box

In this case, the marker is that the tailwheel is superimposed over the left main gear.

Uncertainty Analysis

Uncertainty abounds in this quest, as imprecise assumptions are made to measure angles, and distances of 3 feet are compared to 200 feet. Where exactly on the mirror or the tire do you measure? These are all imprecise since they are viewed from 200 feet away. The analysis is done from the leading edge of the stabilizer, but the tow line is connected at the tow hitch a few feet away. Distances are calculated by ratios of the measured distances, ignoring the fact that this effectively lengthens the tow line. This difference is assumed away by invoking the small angle assumption with angles under 15 degrees. In the end, the uncertainty is estimated to be on the order of 5 to 10 feet, which is still within the dimensions of glider.

Data

On 29 April 2021 Russ Erb and Mike Brooks measured a Pawnee tow plane at Mountain Valley airport.

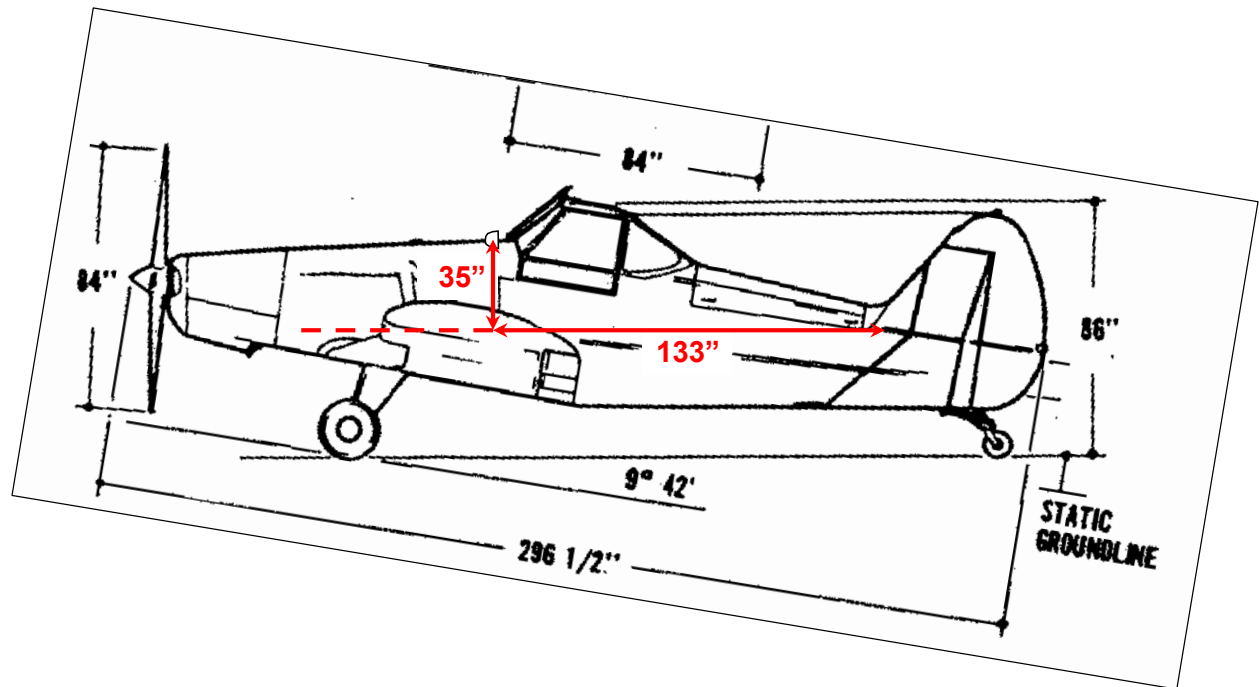


Figure 4. Vertical measurements

As shown in Figure 4, the horizontal distance from the leading edge of the horizontal stabilizer to the mirror was measured along a line from the leading edge of the horizontal stabilizer to the top of the wing at the root (essentially parallel to the ground). The vertical distance was measured from the mirror to this same line.

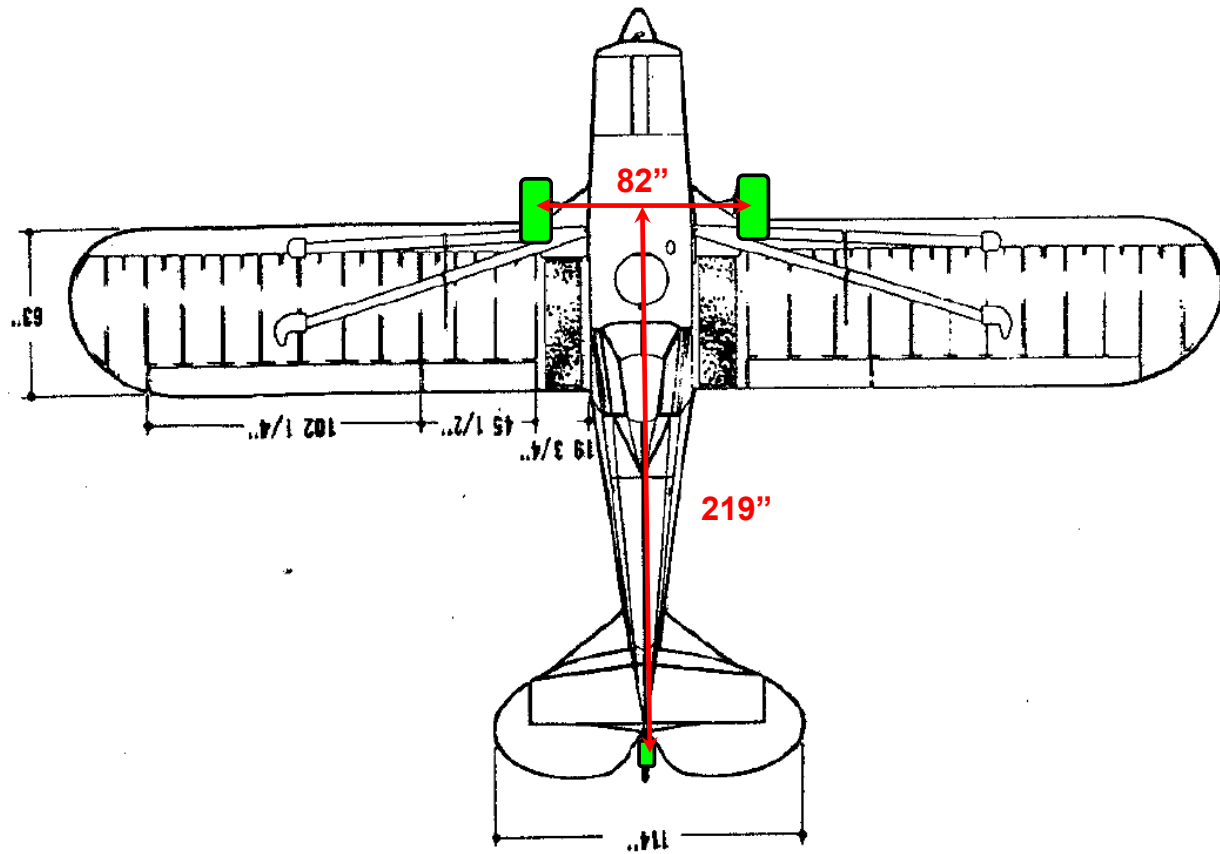


Figure 5. Horizontal measurements

As shown in Figure 5, the distance between the centers of the tires was measured. This was assumed to be the same width as in flight. The distance from the axle of the main gear to the axle of the tail wheel was measured.

Results

Figures 6 and 7 are drawn to scale, with the relative size of the aircraft matching the scale of the distances between them.

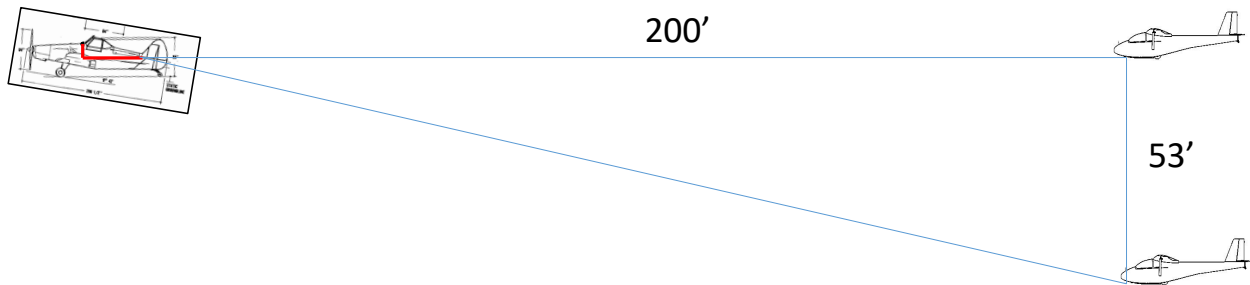


Figure 6. Vertical Displacement

Using similar triangles and the distances shown in Figure 4, the difference in altitude between High Tow and Low Tow is approximately 53 feet.

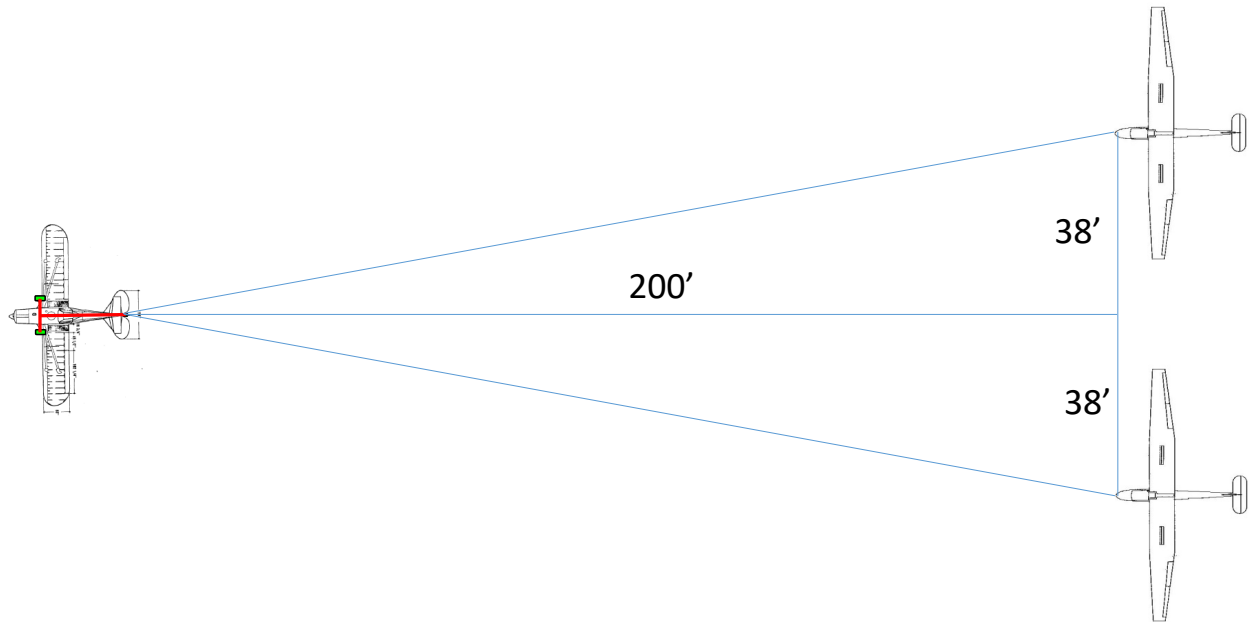


Figure 7. Horizontal Displacement

Using similar triangles and the distances shown in Figure 5, the lateral displacement for either side of the box is approximately 38 feet. It would appear that the inner wing will still pass through the downwash of the towplane. This can be slightly perceptible, especially with very long wing spans while going up or down the side of the box.

Another Question You Didn't Bother To Ask

Yes, the tow pilot can tell where you are in the box, even though he can't see you in the mirrors once you leave the High Tow position. Since the tow pilot is working to maintain a constant heading and pitch attitude, as you go from High Tow to Low Tow, the tow pilot has to push forward on the stick to compensate. When you move out to the right, the tow pilot adds right rudder to maintain heading. As you swap to the left side, the required rudder swaps with you. Of course, this assumes you are maintaining proper tension in the tow line.

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 3 May 2021