THE DEFINITIVE GUIDE TO PROPERLY RIGGING THE WEEDHOPPER WING

By: Dean A. Scott, July 1,2003

Some Background

A typical wing or propeller produces lift when it's at an angle of attack (AOA) between 2 and 15 degrees. At 15 degrees AOA they will stall. So, In order to prevent either one of the plane's wings from dropping due to such a stall condition and causing the plane to dive and roll into a spin, washout is used to stabilize the wing by slanting the tips of the wing upwards at the trailing edge (TE). This slight twist of the wing progressively reduces the AOA out towards the wing tips so that the tips still produce lift even if the root is stalled. With the wing tips still flying and the root stalled, the wings maintain a level attitude and a stall spin is prevent.

A propeller is a good example of washout. Compared to a wing, they have an exaggerated twist with the tips at only a few degrees AOA (pitch) while the root has a far greater AOA. This is because the prop has a greatly reduced radial velocity towards the center, thus requiring an increasing AOA or pitch to produce lift/thrust.

Since the Weedhopper flies at an AOA of 2.4 degrees in level cruise, wing tip washout must be set to at or near level to reduce drag. These instructions explain how to do that. But first, the wing's dihedral, or degree of upward slant as a whole, needs to be set first.

Note: boom down angle, discussed later, does not have any effect on measuring or setting dihedral, so in these setup procedures; you do not have to block up the nose wheel to level the boom.

Finding and Adjusting Weedhopper Wing Dihedral

To find out what you have now, use this "string and protractor method" if you don't have a carpenter's angle finder tool, which you can find for a few bucks at Sears or any home improvement outlet.

1. With your plane on **level** ground, hang a length of thread from the pivot hole of a common, plastic protractor with a nut tied to the other end.

2. Place the straight edge against and parallel with the LE and measure how many degrees either side of the 90 degree mark the thread hangs. The difference between the reading and 90 degrees is your current dihedral.

The factory design dihedral is 7degrees (see Illustration 1). To maintain optimum flight stability and crosswind handling, **do not lower wing dihedral to less than 3 degrees!** Setting dihedral less than 7 degrees is not indorsed, recommended, or advised for anyone not extremely experienced with the Weedhopper Ultralight. Years of GA or other UL experience do not count either. Be safe. Keep it at 7.

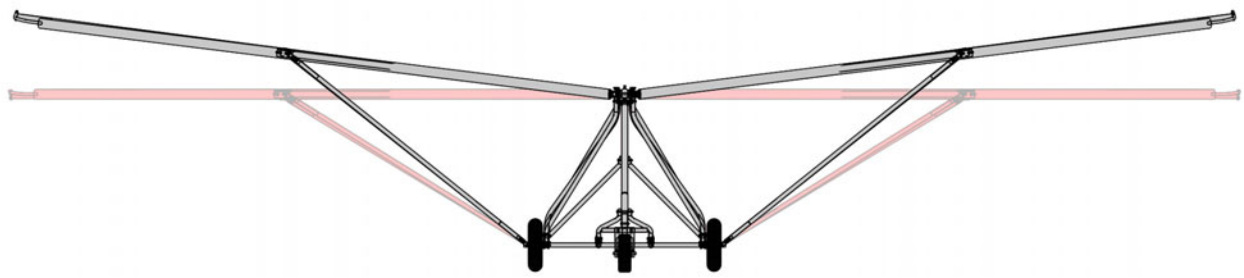

Illustration 1 – Comparison of no dihedral (shaded red) and factory dihedral of 7 degrees.

To set your wing dihedral 7 degrees...

1. Remove leading edge wing struts and prop up the leading edge wing spar tubes at the strut support tang brackets using whatever device or material is on hand until the thread hanging from the protractor reads either 83 or 97 degrees depending on which way the protractor is turned.

2. Mark, cut, and drill the leading edge struts to maintain the angle.

Do not stop now! Whenever the dihedral of the wing is changed or adjusted, SO MUST THE TRAILING EDGE WASHOUT!

Setting The Weedhopper Wing Tip Washout

1. For a Model B:

   Shim the nose wheel to raise the wing's leading edge root bracket **4.5" higher than the trailing edge bracket** (2.8 degrees).

   For all Models C and later:

   Shim the nose wheel to raise the wing's leading edge root bracket **4" higher than the trailing edge bracket** (2.5 degrees).

   Usually the top edge of each bracket is used as the reference point as long as both are rotated level with the boom.

2. Remove the trailing edge wing struts and prop up the trailing edge wing spar tubes at the strut tang bracket using whatever device or material is on hand until the wing tips read level.

3. Mark, cut, and drill the trailing edge struts to maintain this configuration.

The reason for the ½" difference between the model B and all other later models is in the way the wing tip was designed. On the B, the wing tip tube is attached to brackets that are centered on both LE and TE spars, while on later models the tip tube is bolted to the TOP of the TE, remaining centered on the LE in a "slip notch." This gives the C wing tip more washout angle to begin with that is compensated for by reducing the LE/TE setup offset by ½".

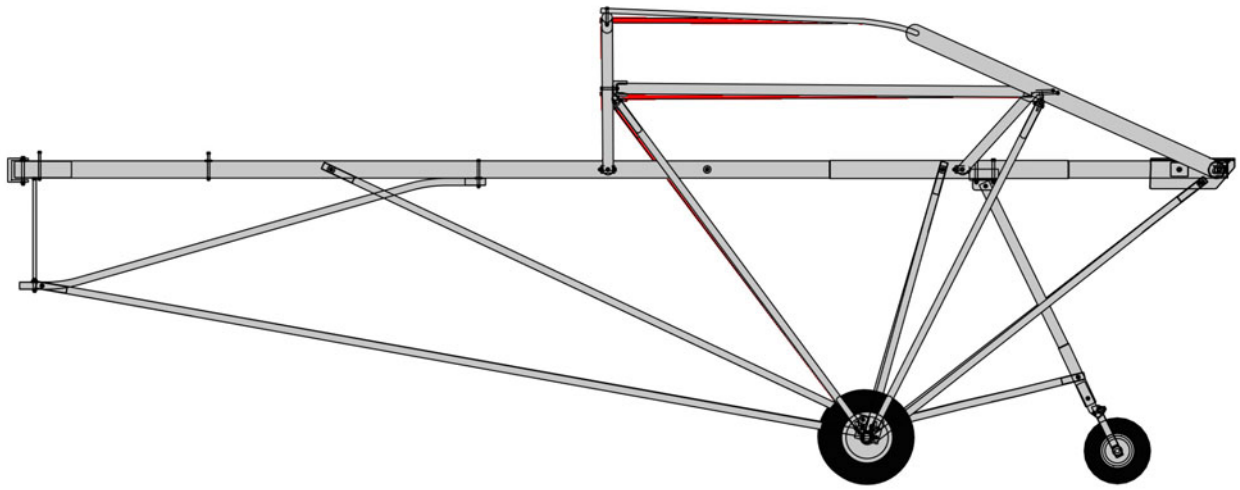

Illustration 2 – Comparison of no washout (shaded red) and a washout of 3.4 degrees.

The wing tip tube for the Model C MUST be bolted to the TOP of the TE in order to create the proper washout and drag characteristics. If it is attached to the bottom (and some have even mounted it centered in a notch in the TE), then more of the wing must be twisted to bring the tips level creating a higher drag component. With the tip tube on top of the TE, a built-in, localized washout of 0.9 degrees* is created and thus less of the wing needs to be twisted by elevating the TE, which means less drag (read that as; go faster).

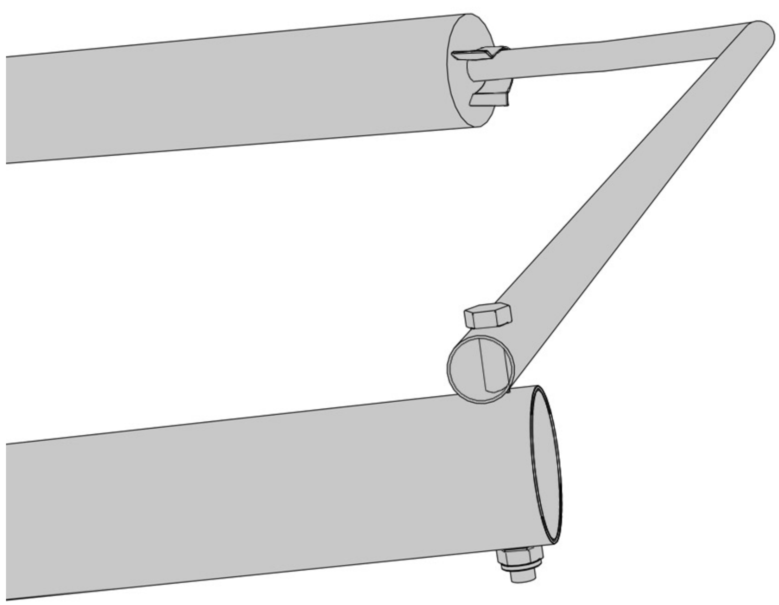

Illustration 3 – Model C wing tip tube correctly bolted to top of trailing edge, creating a built-in washout of 0.9 degrees. *

In preparing the illustrations for this document, I used a digital 3D model of a Model C Weedhopper. It is modeled in real world scale where 1" on the Weedhopper equals 1" in the 3D modeling program. I used the exact same procedures in the program as one would use following these instructions to create tip washout. That is, I rotated the boom so the LE was 4" higher than the TE (2.5 degrees) then rotated the TE spar to set the wing tip tube level again. What I discovered is that the TE only needed ½ (one HALF) degree of rotation to do so. This resulted in moving the very end of the TE upwards by only 1 ½".

As you can see from Illustration 2 above, the difference between no washout and a 3.4 degree, tips level washout is not very significant visually. Anything more and you will increase drag unnecessarily.

Boom Down Angle

With dihedral and washout set, be sure that the boom is sloping down **minus 2** degrees while resting on level ground. **The length of the nose wheel strut adjusts this angle.**

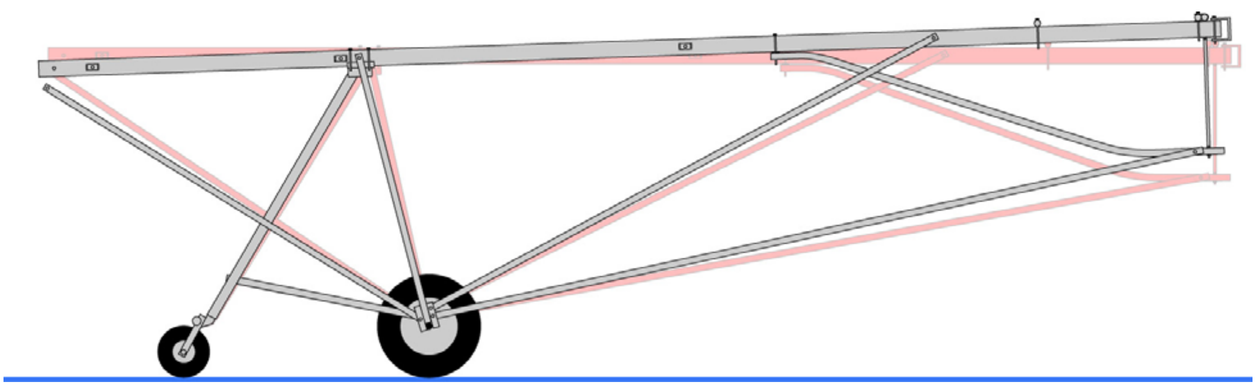

Illustration 4 – Comparison between level boom (shaded red) and negative 2 degree down angle boom.

Why is this important? Because, the down angle creates a zero lift wing AOA when taxiing on the ground and most importantly kills all lift as soon as the front nose wheel touches the runway when landing, preventing the possibility of either wing continuing to fly (producing lift).

Without this zero or slightly negative AOA, the situation becomes just like an unstable wheelbarrow. Landing speeds with a nose wheel and only one main gear on the ground and one wing still lifting the other wheel up **will** dump you over on your nose like an overloaded wheelbarrow. The reaction time and control input response delay basically prevent you from being able to do anything about it. It just happens so fast you may not even have time to kill the engine before you say, "Good-bye, Mr. Prop!"

You have been warned!

In Conclusion

Rigging your wing will most likely result in the best performance possible out of your Weedhopper by reducing drag to the design minimum with a properly set washout, resulting in increased speed and fuel economy. The following chart compares washouts for the B and C to one without washout and dihedral, giving AOA details for each.

A Comparison of Various Wing Tip Washouts
Based on a Wing Angle of Attack Stall of 15 Degrees

No Washout – (cross-wind competition for extremely experienced pilots – DO NOT attempt!)					
	Setup	**Washout**	**Drag**	**Angle of Attack**	**Condition**
Root	0 degrees			15 degrees	stall
Compression	0 degrees			15 degrees	stall
Wing Tip	0 degrees	0 degrees	0 degrees	15 degrees	stall
Model C Factory Washout – (setup = LE 4” higher than TE, then set wing tips level)					
	Setup	**Washout**	**Drag**	**Angle of Attack**	**Condition**
Root	2.5 degrees			15 degrees	stall
Compression	1.2 degrees			13.8 degrees	lift
Wing Tip	0.9 degrees*	3.4 degrees**	3.4 degrees	11.6 degrees	lift
Model B Factory Washout – (setup = LE 4.5” higher than TE, then set wing tips level)					
	Setup	**Washout**	**Drag**	**Angle of Attack**	**Condition**
Root	2.8 degrees***			15 degrees	stall
Compression	1.4 degrees			13.6 degrees	lift
Wing Tip	0 degrees	2.8 degrees	2.8 degrees	12.2 degrees	lift

* The tip tube is ¾” higher on the TE compared to being centered because the diameter of the TE is 1.5” and half of that is ¾”. Thus, the angle of the tip tube with all things level can be determined by the simple trigonometric formula: arcsin(0.75” / 48”) = 0.9 degrees (48” being the chord width of the wing tip).

** Total washout angle includes built-in washout of 0.9 degrees + root offset of arcsin(4” / 92”) = 2.5 degrees for a total of 3.4 degrees, where 92” is the distance between LE and TE bolt hole centers.

*** Model B offset angle of 2.8 degrees equals arcsin(4.5” / 92”).