Taming The Taildragger

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A few years ago I read an article in a well-known flying magazine entitled "Real Pilots Fly Taildraggers". The author tried to make a case for this, somewhat tongue in cheek, but it gave me cause to consider the matter at length. Today, with the increasing number of ultralight and homebuilt aircraft coming out in the taildragger configuration it seems appropriate to review the subject of transitioning from a tricycle gear airplane to a taildragger.

First of all let's debunk the myth right off the bat. Handling a taildragger does not require a pilot with superior skills. However, it does require that a pilot learn additional skills which are not needed in handling a trike. Unfortunately, most flying schools, especially conventional schools, use only tricyle geared aircraft for training with the result that new pilots do not learn these skills until it becomes necessary, usually due to an aircraft acquisition. Learning these skills, however, is necessary and the taildragger pilot who does not, will wish he (she) had, someday.

I witnessed a potentially disastrous ground loop at Oshkosh in 1995 which served to convince me even more of the importance of understanding the forces at work when a taildragger is in motion on the ground. A DC-3 had just started its takeoff roll to the left of show centre with a 10-15kt breeze blowing from the direction of the crowd. As it reached show centre it suddenly veered to the right and started off the runway toward the crowd. The pilot immediately shut down the engines and appeared to stand on the right brake and rudder to increase the rate of turn. This resulted in the aircraft continuing the loop through 180 degrees until it began sliding sideways, eventually coming to a stop in a depression about 75 feet from the crowd. Had the pilot chosen to continue to try and correct the heading of the DC-3 after it started to leave the runway, it would most certainly have headed into the crowd with props a-whirling. I do not know what the cause of the ground loop was, it may have been a mechanical failure, but I am sure the pilot knew immediately that the only way to avoid the crowd was to exaggerate the loop and get the airplane side-on to the crowd line. He did it, and the only damage was a collapsed landing gear and bent wing instead of many damaged or dead people.

DC3 came to rest in opposite direction after ground loop.

Consider the geometry of an airplane sitting on the ground. The tricycle geared airplane has the centre of gravity in front of the main gear, otherwise the nose wheel would not stay on the ground. On the other hand the taildragger has its centre of gravity behind the main gear, thus keeping the tail wheel on the ground. Figure 1 shows the relative location of C of G and gear in a taildragger. When they are moving forward with no lateral forces involved one handles as well as the other. When sideways accelerations occur we suddenly have two very different machines.

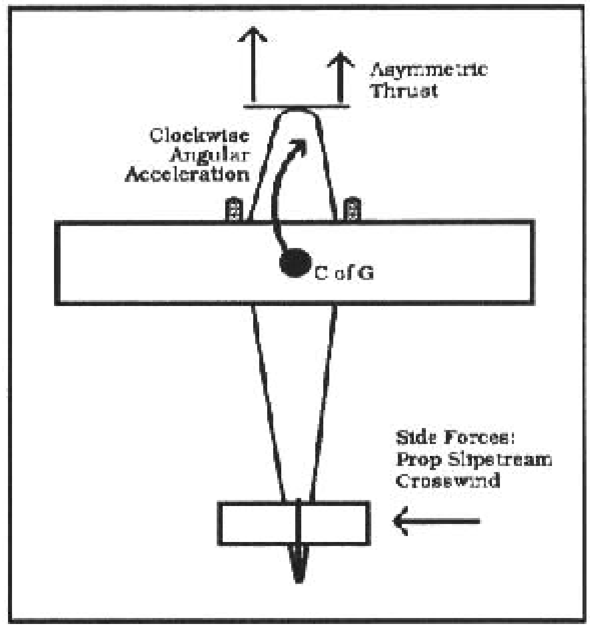

Figure 1.

Think of driving the family sedan compared to a high performance racing car. The family sedan has a very forward C of G as opposed to a racing car that has either a mid-ship or an aft C of G. A high speed turn in a sedan generally results in under-steer, where the front wheels tend to slide forward somewhat while they try desperately to turn the car. The wheels are resisting the turn (stable in angular acceleration). In the racing car the opposite occurs. The aft C of G results in the rear wheels trying to break away and skid out, thereby swinging the nose in the direction of the turn (unstable in angular acceleration). Skilled racing drivers can use this to their advantage to better control the turn while pushing the speed to the limit. However, as we all know, letting the rear wheels get out of control can lead to one or more uncontrolled ground loops.

Tail wheels on our light aircraft are typically 3-4 inches in diameter and only contact the ground for about 1-2 square inches. There is little ground holding capability and they tend to slide very easily, especially on grass. Added to this is the fact that the aircraft is not in its flying attitude on the ground so that as it moves forward the air moving past the horizontal stabilizer and elevator cause the tail to try to lift, further reducing the effectiveness of the wheel. As the tail wheel loses its effectiveness the rudder should start to become effective in the slipstream. This is nice in theory but in practice there is usually a gap between the speed at which the tail wants to lift and speed at which the rudder really becomes effective.

Once our taildragger is in motion any small lateral force which causes the tail to move to one side of centre will set up an angular acceleration about the main wheel on the same side as the force, and it becomes unstable about the vertical axis. For example, if a crosswind hits the right side of the vertical stabilizer, an angular acceleration is set up around the right main wheel. Since both main wheels are turning freely the left wheel will easily move slightly faster and the right one slightly slower, thus accommodating the rotation. As the C of G moves to the left of centre line (direction of motion) the energy imparting the angular acceleration on the aircraft starts converting to angular momentum. As angular acceleration continues, angular momentum builds and the forward momentum of the aircraft starts to be converted to angular momentum with the pivot point being the right main wheel. If left uncorrected, very soon the angular momentum will be too much for our tiny tail wheel to resist and without a fully effective rudder we find our taildragger actually accelerating into a right turn. At this point we have lost it. The only thing that will save the day is chopping the power and judicious use of differential braking. Of course, if our aircraft is like many ultralights and does not have differential brakes all we can do is hang on and wait for it to come to rest in the hay, facing the other end of the runway.

There are a number of forces that can cause our C of G to move off centre line, a cross wind is only one of them. As we apply full power the prop itself pulls the aircraft to one side or the other depending on the direction of rotation. In the case of a Rotax engine the prop is turning counterclockwise. There are three forces at work here. The first is the torque produced by the drag of the prop which is opposite to the rotation of the prop. Since the prop is rotating to the left the aircraft will want to rotate to the right. It can not rotate while the wheels are on the ground, however, it does have a tendency to turn right as it accelerates down the runway. The second is asymmetric thrust or P-factor. At higher angles of attack and higher power settings the downward moving blade will produce more pull than the upward moving blade. On a counterclockwise rotating prop there will be more pull on the left which will tend to turn the aircraft to the right. Because the taildragger is at a high angle of attack when sitting on the ground it will be much more susceptible to the P-factor than a trike.

The third propeller induced lateral force results from the slipstream of the whirling blades. At high power settings and low speeds (takeoff) the air pushed back by the prop has a corkscrew motion. When it hits the tail it produces an increase in pressure on one side and a decrease in pressure on the other. As luck would have it a counterclockwise rotating prop increases pressure on the right side of the vertical stabilizer and decreases pressure on the left side, thereby "pressuring" the aircraft to turn right. All three of these forces: torque, the P-factor and slipstream, are in the same direction, and are therefore additive. All are trying to turn the aircraft to the right if our prop turns counterclockwise and to the left if our prop turns clockwise.

Perhaps the trickiest lateral force to be dealt with by the first-time taildragger pilot is his or her own heavy foot. Because the low speed response to rudder pedal input is very poor the pilot will begin with heavy inputs. Too much input will impart too much angular acceleration to the C of G, resulting in the aircraft oscillating wildly down the runway as the pilot gets heavier and heavier on what effectively become power-assisted rudder pedals as the aircraft accelerates. Judging the amount of input required is based more on the speed of the aircraft than the amount of correction needed. Getting a feel for this is critical and is the most important part of the taildragger transition. Everyone I have seen take up taildragging has had initial difficulties mastering this exercise, but like everything else in aviation it is just a matter of practice and some judicious coaching from an instructor until the skill is mastered.

The drill is taxiing back and forth on the runway at varying speeds until it starts to come. The first reaction is to over correct as mentioned. However, on the second pass the tendency will be to under correct, so be prepared to pull the power and brake as soon as the nose points toward the side of the runway. And do not go fast enough to lift the tail on the first couple of passes. On many aircraft the transition from tail wheel and rudder control to rudder-only control can leave you with significantly reduced control for a short time.

It is essential to develop a "feel" for the movement of the tail and to correct NOW, before the C of G gets control. In most taildraggers you will not be able to see over the nose with the tail wheel on the ground. There will be a natural tendency for trike pilots to force the tail up too soon in order to see ahead. Don't. You need to keep the tail on the ground until the rudder starts to become effective, although in many well designed taildraggers you can simply let the tail lift on its own when it is good and ready. But don't take my word for it - consult your operators manual and follow the manufacturer's instructions in this regard. However, while the tail is on the ground you will have to use only your peripheral vision to keep track of where you are relative to the sides of the runway. Pretend you are doing a soft-field takeoff in a trike.

In a trike you have learned to depend on visual clues to tell you what to do with your feet since you are likely sitting at the C of G. In the taildragger you are sitting behind the C of G and with practice you will eventually be able to feel the tail movement before you can detect it visually. Once you reach this stage you are in control. Now you can react quickly with small inputs and keep the tail on centre line without the risk of your C of G taking control. Quick, small rudder inputs are the key to keeping your taildragger in line.

Up to now you have probably been having some difficulty turning around at the end of the runway. When flying out of a grass strip you are quite often faced with having to do tight turns at the ends of the runway. Most of the grass strips I've been to are no more than 50 feet wide and they usually do not have a turnaround area at the end. In an ultralight taildragger without differential braking this can be a little nerve racking.

Above I discussed how the C of G being behind the main wheels results in instability in lateral rotation during forward motion. In other words, when the taildragger is moving forward any deflection of the C of G from the line of motion develops into an angular acceleration around the opposite main wheel. We looked at how best to control this and keep our airplane accelerating in a straight line.

When taxiing, however, we can use this to our advantage to execute a tight turn in much the same way a race car driver uses the instability in his aft C of G car to do a controlled skid around a corner at high speed. The technique is really very simple but it takes practice to keep it under control. First, it is important to always turn into the wind if you have a crosswind component. That way the wind will assist by pushing on your vertical stabilizer in the direction of the turn for the first half, thereby accelerating your turn. In the second half it will be pushing against the direction of turn and will provide angular deceleration to help stop your turn. Turning away from the crosswind will have the opposite effect, making it more difficult for you to stop or control the turn.

Enter the turn at a moderate taxi speed leaving enough room for your tail to swing around without hitting lights or markers that might be at the end of the runway. Apply a burst of power just as you apply full rudder. You want enough power so that you feel the tail just start to swing out, but not more. (Using differential braking, if you have it, at this point will greatly reduce the amount of power required.) As you swing towards the half way point you will feel the rate of turn start to increase. A terrifying, out-of-control feeling will overcome you as the side of the runway passes in front of the nose. Here's where you need fortitude. Keep the power on a little longer because you'll need some of that prop wash over the rudder to stop the turn smoothly. As you pass the three-quarter point apply opposite rudder and start to decrease the power. Let the aircraft go a little more than 180 degrees so that you can move back to the centre-line before stopping.

It sounds easy but don't be fooled. Take it real easy the first few times and don't be afraid to stop, get out, and finish your turn by hand. There is a fine line between a successful turn and going off the runway, and it all depends on the amount of power applied and for how long. With practice, though, you will eventually be able to turn that taildragger on a dime, with or without brakes.

Now that we can turn around we are ready to takeoff. I always stop my turn on the centre-line but at about a 20 degree angle to it. Then I do my final in-cockpit check and take one last, good look down the runway to be sure it's clear. Once you start the take-off roll the runway will be out of sight for a while. It's now critical to monitor the sides of the runway with your peripheral vision. Don't look out one side and then the other, monitor both at the same time so that you can detect a sideways movement early. Since I discussed at length above the techniques for keeping the tail tracking straight at this point, I won't elaborate again. However, we do have some choices to make at this point in our take-off roll.

As we start to roll at full power the asymmetric thrust starts to pull to the right (assuming a Rotax turning the prop counterclockwise), and the slipstream is pushing our tail to the left. As we gain speed and the tail lifts, the asymmetric thrust will start to decrease but the right torque rolling force will become more effective. Add to this any crosswind component we might have and keeping the tail straight becomes a constantly changing challenge as we pick up speed.

We will want to keep the tailwheel on the ground until we are sure we have enough rudder authority. There may be a temptation to hold the tail down all the way up to lift-off but I don't advise this if there is some crosswind component. It would be like trying to combine short-field technique with crosswind technique, which is unnecessarily complicated if not required. Once the tailwheel breaks ground contact you will have to input more rudder, then fine tune the rudder inputs as asymmetric thrust decreases and the rudder becomes more effective with increasing speed.

Although the main wheels have not yet left the ground, you are essentially flying because the aircraft has freedom of movement in pitch and yaw. This is why taildragger takeoffs are so much different than on tricycle gear. Now you have to maintain straight and level "ground-flight" until you reach rotation speed. Once there, a gentle tug on the stick and you are in the air and the aircraft is in its element. The handling differences between a taildragger and a trike suddenly vanish.

Eventually you will have to land and make another transition between air and ground. At least at this stage of the flight the power is at idle so you don’t have to contend with the angular rotational forces of asymmetric thrust, slipstream and torque. If there is no crosswind component then it's a piece of cake.

Landings can be made in one of two ways. You can reverse the take-off procedure by flairing into a level attitude and letting the main wheels settle first, then gradually lowering the tailwheel as speed bleeds off. I don't know why, but in taildragger lingo this is called a "wheel" landing. Perhaps it came from the early days of aviation when tail skids were common rather than tail wheels. This has the advantage of good runway visibility through to contact. The disadvantage is that you still have a "ground-flight" stage prior to the tail settling which may require lots of rudder work in crosswind conditions.

I prefer the more traditional three-point landing technique. This requires that you flair into a level attitude and gradually pull back on the stick in order to keep the aircraft just off the ground. Once you reach the normal on-the-ground attitude, hold it until all three wheels settle at the same time. The advantage of this is that you immediately gain tailwheel control, plus you contact the ground at a lower speed - ideally at the stall. The disadvantage is that you have to transition to using your peripheral vision for maintaining centre-line as you increase you attitude for touchdown. But having done lots of taxiing before we went flying, we should be good at using our peripheral vision by now - right!

In either case, once you are on the ground do not let up on the tight rudder control. Even though the aircraft is slowing down under idle power, the same angular acceleration forces are at work and letting the tail drift too far before correcting will result in the same opportunity for a ground loop.

The above notwithstanding, read your aircraft operators manual carefully. Some manufacturers will clearly spell out the best take-off and landing methods for their particular aircraft. Depending on the design, some tails will lift at very low speeds whereas others will have to be pulled up. Some manufacturers recommend only two-point touchdowns while others will recommend the three-pointer. Obviously you should use the techniques recommended by the designer, at least until you have lots of experience with the airplane.

One last cautionary note. If you are flying ultralights or very light aircraft you will most likely do you first taildragger flying from a grass strip. Your first landing on a paved runway will give you a bit of a shock. At first you might think the extra friction of the tail wheel on the pavement will make it easier to control, but since you are use to the wheel sliding around on the grass it will feel like the wheel is stuck to the pavement with glue. You will find your feet have suddenly become very heavy on the rudder pedals and if you aren't very careful it may ruin your day. I would suggest a wheel landing for the first occasion in order to keep the tail wheel off the pavement until your speed is minimized. And before taking off again do a little taxiing to get the feel of it all over again.

Handling a taildragger on the ground and through air to ground transitions is most definitely different than handling a tricycle geared aircraft. It is not necessarily more difficult but it does require the learning of different skills. Even the handling differences from model to model are more pronounced in taildraggers than trikes. So when it comes time for you to move to a taildragger, read, get some dual, and take the time to get lots of ground practice before venturing skyward. I also strongly recommend not flying with a crosswind of any kind for the first five hours. But don't shy away from taildragging. It’s a great way to fly and it definitely keeps your skills sharpened.