

# The Case for Mode 4 Transmitters, or, "How North America Got It Wrong", or, "How Most of the Planet Got It Wrong"

**Martin Newell**

October 2009

Updated October 2010

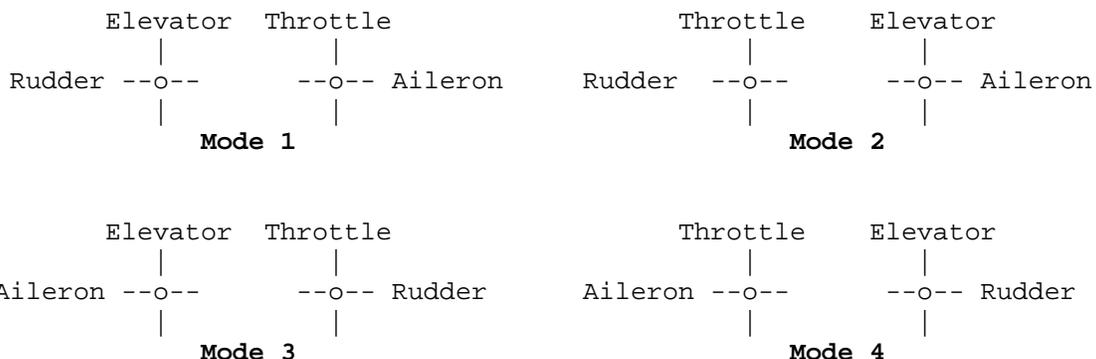
---

The great majority of RC pilots in North America use transmitters set up in Mode 2. This paper sets out reasons why that is a bad idea, and makes the case for using Mode 4. Most of the rest of the world uses Mode 1, which, while better than Mode 2, is still inferior to Mode 4 for most people. If your flying style involves only circuits and horizontal figures-of-eight, with the occasional loop and aileron roll thrown in, the choice of mode is probably not very important. But if you want to learn more advanced aerobatics, read on.

## Modes

So, what are these "Modes"? Transmitter Modes define what movements of the two control sticks control which of the main four control channels, Rudder, Aileron, Elevator and Throttle. The usual response I get when this subject comes up is "What on earth is Mode 4?". I point out that almost everyone who has flown a three channel plane in the US has flown Mode 4 - rudder and elevator on the right stick and throttle on the left. Yet when they get a four channel plane they do a very curious thing - they move the rudder to the left stick and put ailerons on the right stick, which is Mode 2. Why not just add ailerons to the left stick? You might think this would be just a matter of preference, with the choice of where to put rudder and ailerons being somewhat arbitrary. However, it goes much deeper than that.

First, to be really clear, let's define the four modes. In all cases left-right motion of the sticks controls aileron and rudder, and forward-backward motion of the sticks controls elevator and throttle. That leaves four possibilities, for the four Modes.



The difference between Modes 2 and 4 is that aileron and rudder, are swapped.  
The difference between Modes 2 and 1 is that elevator and throttle, are swapped.  
The difference between Modes 1 and 4 is that the entire sticks are swapped.

## Why does the Mode matter?

To understand why the choice of Mode is important, we have to look at what *combinations* of controls are commonly used in flying RC. Perhaps the most demanding form of RC piloting is aerobatics, as practiced in pattern flying and in 3D. These tasks require coordinated, simultaneous use of all four controls. Certain combinations of controls are much more common than others, and some combinations need to be coordinated with each other in specific ways. It is the *ease with which these combinations can be learned and executed* that form the main argument in favor of Mode 4.

The fact that there are so many highly proficient 3D fliers using Mode 2 is a testament to the human brain's ability to learn complex actions and to the perseverance of those individuals. The reason they use Mode 2 is because that's how they were taught. This paper is really aimed at someone starting to learn to fly, or who is moving from three to four channels. For someone already proficient in flying Mode 2, changing to Mode 4 would be very difficult, as would be any change of Modes. I started learning 3D flying to see if this old dog could learn new tricks. The answer is "yes", but it takes longer, and anything that could help the process was highly welcomed. Mode 4 was a major help.

The paper concentrates on fixed-wing aircraft. I know almost nothing about helicopters.

## Continuous Rolls

The first maneuvers I attempted that got me thinking about this topic were the coordinated continuous roll, the rolling circle, and the rolling loop. For these three maneuvers the plane should fly in a straight line horizontally, in a level circle, or in a loop, while continuously rolling about its longitudinal axis. All attempts I made to do these maneuvers in Mode 2 ended in disaster. Let's look at why they are hard to learn. In Mode 2 a continuous roll, to the right for example, requires the following actions:

1. Move and hold the left thumb at the required throttle setting
2. Move and hold right thumb to the right (aileron - this sets the roll rate)
3. Move left thumb to the left (Left rudder)
4. Release left thumb and push right thumb
5. Release right thumb and move left thumb to the right
6. Release left thumb and pull right thumb
7. Release right thumb and move left thumb to the left
8. Repeat steps 4 through 7 to continue rolling.

The main thing that is difficult is the out-of-phase motions of the two sticks for elevator and rudder. There is a toy that has been available in the US for many years called EtchASketch. It draws lines on a screen controlled by two knobs, one of which moves the pen left-right, and the other moves it up-down. The motions of the elevator and rudder sticks in a Mode 2 roll are exactly like the motions of the EtchASketch knobs for drawing a circle - something that can be done, but is widely acknowledged to be hard to learn and control. Another difficulty with a Mode 2 roll is keeping and controlling the aileron deflection to achieve a constant roll rate while repeatedly working the elevator up and down on the same stick. Also, maintaining the throttle while working the rudder back and forth is quite difficult. I found my plane would either stop rolling or that I had either increased or decreased the throttle, because of all the other unrelated activity going on on the same stick.

Now let's look at a Mode 4 continuous roll:

1. Move and hold the left thumb at the required throttle setting
2. Move and hold left thumb to the right (aileron - this sets the roll rate)  
You can now forget about the left stick
3. Move right thumb to the left (left rudder)
4. Rotate the right thumb in a circle around the center - push, right, pull, left, ... repeatedly.

To compare with EtchASketch again - this is like drawing a circle with a pencil - much, much easier. Moreover, since the left stick, throttle and aileron, hardly moves at all, it is much easier to maintain constant throttle and aileron, or to make minor adjustments to these controls if needed.

Of course, in both Mode 2 and Mode 4 you have to coordinate the rate of movement of the sticks with the rotation of the plane. The difference between a straight roll, a rolling circle to the right or left, and a rolling loop is largely in leading or lagging the plane's roll with the stick motions. This is quite enough to think about without having to worry about getting the phase between rudder and elevator correct. In Mode 4 that part is automatic.

For a right roll, the right thumb rotates to the right, or clockwise. For a left roll it rotates left, or counter-clockwise. Very natural.

## Vertical Hover

This maneuver is controlled mainly by the rudder and elevator, to maintain the plane pointing vertically upwards. This tends to require small, rapid movements of the rudder and elevator, like balancing a stick on your finger. The throttle is adjusted to maintain altitude, and the ailerons are used to either counteract a torque roll, or to force a roll. These tend to be slow adjustments. As with the continuous roll, having a rapidly changing control on the same stick as an unrelated slowly changing control tends to make it difficult to maintain the slow control.

Again, hovering in Mode 2 can, obviously, be learned, but there is nothing very natural about it. Consider what it takes in Mode 4. There are two main orientations - hovering "canopy-in", where you are looking at the top of the plane, and hovering "wheels-in", where you are looking at the underside of the plane.

**Canopy-in:** Holding the transmitter horizontal, consider the right stick to "be" the vertical fuselage of the plane. Now just move the stick in the direction you want the plane to tilt, as if you were holding the plane's nose, for example:

To make the plane to tilt away from you, push the stick away from you.

To make the plane to tilt to the right, push the stick to the right.

If the plane drifts away and to the left, pull the stick towards you and to the right to counteract it. And so on.

The relative amounts of rudder and elevator come out correct automatically by the direction in which you deflect the stick, whereas in Mode 2 getting that balance is not automatic. This is sometimes called "flying the nose" because the plane reacts as if your thumb was on its nose.

**Canopy out:** Consider that the right control stick is attached to the tail of the plane, and that you are balancing the plane on the top of the stick. Now move the control stick just as if the plane really was balancing on its tail, for example:

If the plane falls away from you, push the stick away to re-balance the plane.

If the plane falls to the right, push the stick to the right to re-balance the plane.

And so on. Again, very natural. Most people can balance a stick on their finger, so they should find Mode 4 wheels-in hovering very easy. This is sometimes called "flying the tail" because the

plane reacts as if your thumb was supporting it on its tail.

## **Inverted Flight**

In inverted flight the actions of the throttle and ailerons remain the same as for normal flight, but the rudder and elevator controls are reversed. In Mode 2, each stick has one control reversed and one normal. In Mode 4 the left stick remains normal, and both controls on the right stick are reversed. For me this is easier to remember, rather than trying to remember which of the two controls on each stick is reversed and which stays the same, as you have to for Mode 2. In a way similar to hovering, you fly the nose of the plane when it is approaching you, and fly the tail when it is going away, and the main controls for doing this are both on the right stick, in Mode 4.

## **Benefits of Mode 2**

Some people say that Mode 2 is better because the right stick acts like the joystick in a full-sized aircraft. While this is true, I believe it is irrelevant. Friends of mine who fly both RC Mode 2 and full-sized planes tell me that the experiences are quite different. Maybe if RC pilots used foot pedals and separate throttle levers, and had seats that always oriented them in line with the aircraft, there might be a case. But when Bleriot came up with the configuration of joystick and foot pedals used today, it is unlikely that he was thinking about optimizing the controls for rolling circles and hovering. Besides, most of us don't fly full-sized aircraft anyway.

Another argument in favor of Mode 2, at least in the US, is that you can fly other people's planes and they can fly yours. Again, this is true, and is a valid argument. However, if more transmitter manufacturers would provide the facility for switching Modes, as some already do, this would be a non issue. For me this is actually a benefit. I hate flying other people's planes ever since I smacked a friend's plane into the trunk of a tree, pretty much wrecking it, the plane, not the tree. So now I have an excuse not to fly other peoples' planes, because they are not set up in Mode 4. But if I want someone else to fly my plane, I just switch my Multiplex transmitter to Mode 2 and hand it to them.

What about three channel throttle, elevator and aileron planes, or elevon planes? Here I don't think there is much to choose between Mode 2 and Mode 4. Now the ailerons play a more active role and it could be argued that they would do better on the dominant hand, Mode 2 for righties. At the same time some pylon racing people have told me they have the aileron on the left stick (Mode 4) to maintain a good separation between the bank and yank phases of a pylon turn.

It has been said that focusing on rolls, hovering and inverted flight is biased, and surely there are other maneuvers for which Mode 2 is better than Mode 4. I am yet to find them.

Perhaps the biggest case for Mode 2 is that it is what most people in the US have learned from others, and changing to any other convention would be difficult to do.

## **What about Mode 1?**

The difference between Mode 1 and Mode 4 is that the entire sticks are swapped. Because of this, Mode 1 enjoys all of the benefits of Mode 4, except one. The rapidly-changing controls for rolling or hovering are the elevator and rudder, so they should be assigned to the dominant hand. Most people are right-handed, so Mode 4 is better for them. Left-handed people would do better with Mode 1.

## **What about Mode 3?**

I can find no redeeming properties for Mode 3.

## **Conclusions**

Mode 4 makes the common combinations of control movements needed for aerobatic and 3D flying much easier to learn and execute than they are in Mode 2. Using Mode 4 I can now fly a range of 3D maneuvers, and while they are by no means as good as what I see teenagers doing, I enjoy them. Left to Mode 2 I think I would have given up on 3D, as I have seen many others do. If you are familiar with Mode 2 you should probably stay with it. But if you have only flown two or three channel planes with rudder and elevator on the right stick, you might give some consideration to staying with Mode 4 and putting the aileron on the left. Try it first on a simulator. I think you will prefer it.

One final point, many leading F3A pilots use Mode 1, including World Champion Quique Somenzini. Maybe there's something in this issue of choice of mode, and Mode 4 may be best of all.