

Improve Your Approach

by Ben Lanterman

Stop yawing problems that occur during takeoff

HOW TO
DO IT

MY MODELS SEEMED to have developed minds of their own, swerving and weaving all over the runway and often ending up in a ground loop. If you are a good enough pilot that you can fly an airplane down the runway centerline and perform a nice takeoff down the same line, with zero problems, in all conditions, you don't need to read this article. I wrote it for the rest of us.

I have seen fliers at Scale meets try to make good takeoffs but have problems with side winds, slippery runways, and nerves; they could have used help. Then there are those similar to me, who simply don't want to wreck an aircraft. I wanted a device that would help me with this issue with the flip of a switch.

Have you ever taken a beautiful new pride and joy—such as a BF 109—

out for its first flight, feeling great about its potential but trepidatious because you know that it has a bad reputation for takeoff handling? The full-scale airplane had a tendency to put its pilots in danger. Moderate crosswinds against the runway make things even worse.

You taxi the model downwind on the club's nice paved runway, turn upwind, and slowly apply power. As it picks up speed, the aircraft initially starts to yaw to its left. The problem worsens as the tail tries to come up. You expect this, so you keep applying power and right rudder.

But then the model hits a bump or encounters a gust of side wind, and it seems to go nuts. The gust goes away and the airplane's speed increases, and then things get hairy.

It swerves to the right and again to the left, until it finally zigzags all over the runway, maybe even resulting in an excellent example of a ground loop. The wings get scraped and the propeller is missing chunks; it isn't fun.

After several more

Keeping your model straight is as crucial on takeoff as it is on landing. Anyone can do it.





The fleet of smaller airplanes used in flight tests. The two that received the author's "Most Improved" awards are the molded foam Gee Bee (with "NR2100" on the right wing) and the Sig Rascal above its right wingtip.

Gyro Rules to Remember

1. Remember to turn off the HH mode after the model is a wingspan or two above the ground. If you leave the HH mode on and the airplane starts into its first turn away from the pit area, the rudder will go hard over to try to stop the fuselage from turning. Apply rudder input in the direction of the turn to counter the effect.

2. Don't touch the rudder stick at any time during takeoff. Doing so will offset the angle at which the aircraft wants to track down the runway. Cut power and redo the takeoff.

3. When in doubt about what is happening, cut power to the model and think things through.

4. You are allowed to use the ailerons, elevator, and power plant in a normal manner. **MA**

—Ben Lanterman

attempts, you succeed at a wobbly takeoff (which is probably cross-runway into the wind) and finally get a good flight going. After all, the model does fly well.

One might wonder if all flights are going to start this way. The answer is no, but achieving consistent takeoffs and landings usually requires intensive practice with that aircraft or plain luck.

Don't worry; there is another way.

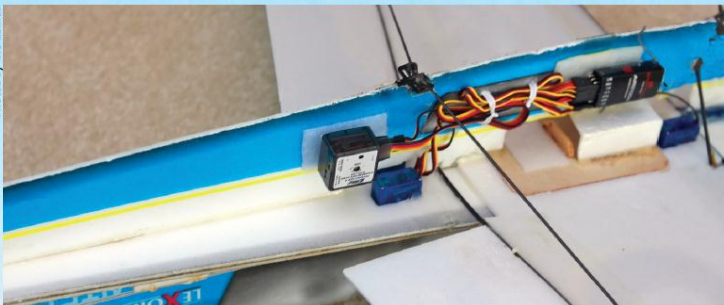
The previous scenario is autobiographical. I have had many of those kinds of takeoffs with some of my Scale and sport models, and it seemed to happen all the time with a recently acquired Messerschmitt Bf 109.

What my squirrely airplanes have had in common is a conventional landing gear setup (sometimes called a tail-dragger). There is usually a small wheel or skid at the tail end of the aircraft.

A degree in aeronautical engineering from Purdue University helped me understand the math behind the reasons why a conventional landing gear setup often results in a wild takeoff, but that is unnecessary. The following description is adequate.

When an aircraft is moving at a moderate speed down the runway, one wheel is suddenly bumped or stopped by a small pebble or chunk of grass. The CG tries to keep going forward but

Photos by the author



The E-flite G110 Micro Heading Lock gyro, shown attached to the side of a typical flat foamie, can be placed anywhere on an airframe as long as the yaw axis of the gyro is parallel to a line that is perpendicular to the airplane's top view.



The additional light weight of the E-flite gyro made no difference in the flying characteristics of these ultra-light models.



Above: The intermediate-size models used in testing. All were reasonably good during takeoff, but adding the gyro removed the need for constant pilot corrections in a crosswind.

Below: The big Junkers Ju 52 (at the bottom) has right-handed propellers; the JR G500T Ring Gyro offered good results. The Bf 109 (at lower left) is a ground-handling nightmare but can easily make long or short takeoffs with the gyro onboard.

can't.

Forces from the propeller (see the sidebar about propeller woes) are there, and the stopped wheel causes the CG to deflect a bit to the side. Then the airplane rotates even more around the restrained wheel.

Unless a tail wheel, a tail skid, or the vertical tail has enough side force to stop the rotation, the fuselage will continue to go around, to the point at which the CG will try to go along the original line of travel, even when the fuselage is sideways.

Since the model is moving slowly, the vertical tail won't contribute enough aerodynamic stabilizing force to stop the turning. If the tail wheel is off of the ground, the situation is worse.

A tricycle landing gear setup doesn't suffer from this problem. The CG in front of the main wheels exerts a stabilizing force, and the nose wheel guides the fuselage.

The worst thing an aircraft with tricycle gear typically does is go crooked when a gust of side wind hits it. However, such an airplane *can* have takeoff problems if the nose gear is set up to be too touchy.

If conditions around the model were smooth all the time and the tail wheel worked effectively against a side force, we wouldn't have a big problem. But any number of small things can trigger the divergence to the unstable yaw condition.

However, the biggest factor for most of us is the massive gusting side wind that seems to come up when we find the rare spare hour or two hour to fly our models.

The Gyro: A Google Internet search of the problem led me to the RC Universe forum, where I found a thread concerning the use of gyros in models. Because these devices are mandatory in RC helicopters, there have been terrific advances in both affordability and capability. The consensus on the thread was that using a gyro on the yaw axis of an airplane could help.

Instructions that come with gyros *do not* recommend them for airplanes. I generally recommend following the manufacturer's directions, but using a gyro heading-hold (HH) mode for the specific purpose of aiding a takeoff seems to work well.

The pilot must remember to turn off the gyro when the aircraft

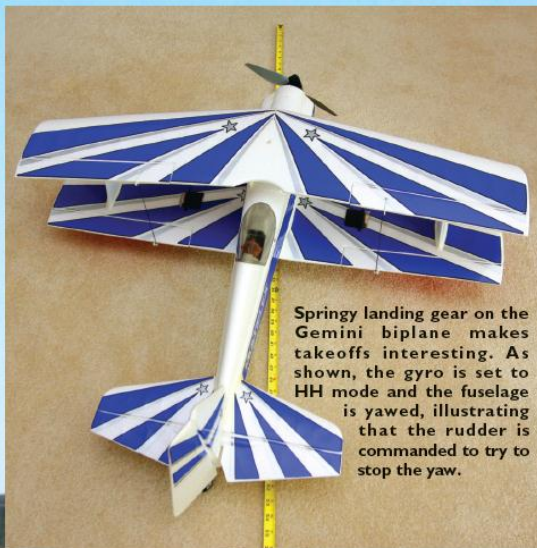
has obtained an altitude of 3-4 feet. At that time the flier takes control of the model.

Luckily for me, and probably also you, I learned that I can use an all-solid-state gyro without knowing a thing about what is inside the little box. I think of the device as a tiny person who senses the airplane's yawing motions during takeoff and instantly gives the rudder command needed to stop them.

The gyro works exactly the way I try to—but a heck of a lot faster and more accurately than I can.

To use such a unit you must first hook it up correctly—and that is relatively easy. A modern gyro has two modes: rate damping (RD) and HH. The RD mode will diminish oscillations in yaw, but it won't necessarily keep the aircraft on the runway.

The HH mode is what we will use for the takeoff problem.



Springy landing gear on the Gemini biplane makes takeoffs interesting. As shown, the gyro is set to HH mode and the fuselage is yawed, illustrating that the rudder is commanded to try to stop the yaw.



The big IMAA-legal Great Planes Super Stearman sometimes made fine takeoffs but could be difficult to keep on the runway with a side wind. The JR G770 3D Gyro gave it a totally different personality on takeoff.

We want our model to go straight down the runway with no corrective input from us.

When the gyro is hooked up and working in the HH mode, you can grab the vertical tail and manually yaw the airplane's body 10°. The result is that the rudder will correct and hold that correction until the original heading is required (that centerline thingy).

The amount of rudder that the gyro gives is proportional to the yaw that the model develops as it goes down the runway. As soon as the main wheels clear the ground, the gyro commands are neither needed nor wanted; by then the vertical tail has more authority to offer adequate directional stability.

I usually turn off the gyro after the airplane has gained a few feet of altitude. The entire takeoff is performed absent of rudder input.

I set two criteria for a gyro: it had to be reasonably inexpensive and work with older analog servos as well as newer digital servos. That was so I could cheaply retrofit some of my older models.

You should consider the total investment in the aircraft, compare it with the cost of the gyro, and determine whether or not making the modification is worth it. The cost is worth it for me, because now my takeoffs look professional and I have reduced the chance of breaking a favorite airplane.

The two most expensive gyros I tested were an older JR G500T Ring Gyro (I believe it was \$200 at the time of purchase) and a JR G770 3D Gyro (\$190 from Horizon Hobby). The least expensive unit was the E-flite G110 Micro Heading Lock Gyro (\$65 from Horizon Hobby).

These products worked well with both analog and digital servos. I moved the JR gyros in and out of various airplanes, but I have purchased many of the E-flite gyros.

Other makes of HH gyros probably work as well, but I couldn't afford to test them all. Those I tried have worked well for this series of tests, and they remain in the models shown in the photos.

The Test Setup: I used a JR 12X transmitter and all varieties of Spektrum receivers. The only requirement for those was that they had a fifth channel available for remote gyro control.

I conducted all of the flights from a slick asphalt surface. That is the worst case from a ground-looping standpoint, because it makes it easier for the tail wheel to slide sideways.

To ensure that my test results were not flukes—limited to one airplane or gyro combination—I used the three gyro types in 20

Propeller Woes

Put your hand in a pail of water and stir it until you have a spinning mass of water. Now stop your hand and hold it flat to block the spinning water. You can feel a large force. This is essentially what happens when the spiral propwash (SP) hits the vertical tail of a model.

Spiral means "in a rotating motion" and propwash is the air that the propeller blows toward the rear. So we have a spiraling mass of air moving to the rear of the airplane: a small tornado.

With the power plant in front, the tail in back, and the power plant turning clockwise as viewed from the back, the SP has an opportunity to hit the fuselage.

With no vertical tail, no side force is generated when the SP hits the fuselage.

When we stick a vertical tail on top of the fuselage in that mass of rotating air, we get a force on the left side of the vertical tail. The result of that force on our aircraft is a yawing moment that wants to force the nose of the model to the left.

Factors that will result in a higher SP are more power, bigger propeller, and high rpm. Factors that make the SP more effective are a bigger vertical tail and a slow-moving airplane.

The result is that we need to input right rudder immediately upon power application for takeoff. There is little we can do about the effect of SP; it is simply a negative part of a model configuration that is otherwise is great.

The propeller produces P-factor. A propeller moving through the air with no angle relative to the air has zero P-factor. If the axis of the power plant is tilted upward, such as in a tail-dragging airplane with conventional landing gear running along the ground, we develop P-factor.

The up-going propeller blade (on the left side of the aircraft) has a lower relative angle of attack than the down-going propeller blade (on the right side of the aircraft). This means that the right side of the propeller "disk" produces more forward thrust than the left side. The result is a left-yawing moment on the model.

A higher-power motor or engine, a bigger propeller, and a higher angle of attack of the airplane give us a larger P-factor, and we need more right rudder to counter it.

Gyroscopic Effects: As the aircraft accelerates down the runway, the propeller blast on the horizontal tail lifts the tail wheel off of the ground, leaving the model free to pivot in yaw on the two main wheels.

As the propeller blast lifts the tail, it forces the rotating propeller (which is now a big gyroscope) to change its pitch angle (because it is attached to the motor shaft). Also known as "gyroscopic procession," that effect further increases the need for corrective rudder input.

The gyroscopic effect applies a yawing moment to the aircraft that tends to swing the nose to the left. The magnitude of the gyroscopic torque depends on the mass of the propeller, the rpm of the propeller, and the pitch rate of the fuselage.

Heavy propellers plus high rpm plus rapid pitch rates equals large gyroscopic effects and major left-yawing tendencies. A large-scale World War I model with a big propeller that starts out at a hefty angle with respect to the ground will have a much larger gyroscopic effect. **MA**

—Ben Lanterman



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airplanes of all sizes, weights, and landing gear configurations.

The models, shown in the photos, range from a light foam indoor aerobatic model (flown outside in the wind), to the large Junkers Ju 52 (spanning 94 inches with a 15-pound flying weight), to the huge Great Planes Super Stearman.

The gyro is mounted in the aircraft so that the yaw axis of the device (see instructions) is parallel to the yaw axis of the model. The yaw axis of the airplane is a line that goes through its CG and is perpendicular to the model when it is held level. The gyro does not have to be positioned on the aircraft CG.

However, it does need to be mounted so that vibration from the airplane engine or motor will not shake it apart. I recommend using Velcro to attach the gyro to a light-plywood base. Glue that base to a piece of thin foam, and use Velcro to attach the foam piece to the model. This provides double insulation from power plant vibration and allows the gyro to be easily moved if necessary.

The gyro has two plugs that go to the receiver: one goes into the rudder channel and the other goes into Channel 5. The auxiliary channel switch is used to change the gyro from its HH mode to its RD mode (or off altogether). The rudder servo plugs directly into the gyro.

Following the instructions, the HH limit (gain) is set high (approximately 100%) and the RD gain is set extremely low (roughly 10%). Because the low RD gain effectively turns off the gyro, the

transmitter auxiliary switch is used to turn the HH mode on and off. You will have to determine what works using your radio and gyro instructions.

Set the stick trim sliders to neutral and rudder subtrim values (if available) to zero. Use rudder pushrod adjustments to mechanically zero the rudder position. Make sure that the rudder operates freely and correctly.

To make initial settings for the gyro gain, turn on the transmitter with the auxiliary switch set to the gyro RD mode position. Turn on the receiver and gyro, letting the model remain still for 15-20 seconds; this will let the gyro initialize. Then switch on the gyro HH mode.

You might see the rudder drift slightly or drive to the extremes of throw. Switch back to the RD mode and use the rudder stick trim sliders to adjust the rudder drift direction to be opposite of the observed drift. Then switch back to HH and observe the rudder action.

Repeat this process until you get a nice zero-drift setting in HH mode. Switch back to the RD mode and check to make sure that the mechanical setup is still giving you a zero rudder position, and adjust the mechanical zero if necessary.

Now you must determine the direction of the gyro correction. That is easy to do.

In HH mode, if you yaw the airplane to the left, the rudder should be driven to the right as it responds to the yaw. If the rudder deflection is going the wrong way, use the small switch on the side of the gyro to reverse it.

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If the rudder-angle change is equal to or more than the applied yaw angle, the aircraft is in a good starting place. An exact angular response can be fine-tuned later, but I have found that it is noncritical.

Flight Testing: In preflight setups, the only practical difference in the gyros I have worked with is that the more expensive JR versions are stable with respect to keeping settings from day to day. I haven't had to adjust anything since the first setup. The E-flite gyro is much more inexpensive, and with that apparently comes a small amount of positional instability from day to day.

The practical meaning of that to me, as a pilot, is that before each flight I need to check to ensure that the rudder holds neutral position when the gyro is switched to HH. If the rudder starts moving slowly when it is set to the HH mode, it can be adjusted with a click or two of rudder trim.

I have made the HH drift check a part of my normal preflight checklist, so it is not a big problem. I like the E-flite gyro so well that I have 18 airplanes with one in each.

My initial taxi-only trials involved using small park flyers in a corner of an empty parking lot. On a day that had wind speeds gusting up to 18 mph, I made the

taxi runs so that a full crosswind was available.

I gave each airplane a bit of power and allowed it to run approximately 150 feet with the tail always on the ground. I did that with the gyro on and off.

It was interesting to watch the rudder work to counter the wind gusts. A model that normally would have been blown all over the parking lot was following straight lines.

I moved the next tests out to the Boeing's Phantom Flyers field in Saint Charles, Missouri. The club has a good asphalt runway with a white stripe down the center (which always seemed to be jeering at me before).

During the corn-growing season, when the wind is from the north, a terrific rotor is caused by the wind spilling over the corn. It hits the runway area as a rotating crosswind.

We flew aircraft after aircraft with consistent results, regardless of wind direction or airplane configuration, exercising such variables as P-factor, spiral propwash, gyroscopic effects, tire spacing, etc. Both slow and fast takeoffs were made to try to mess up the "gyro on" takeoffs, and none did.

The device in HH mode consistently guided the models to make good takeoffs. Some airplanes took off straight but with evident oscillations, some were straight but moved sideways a bit as the wind blew them, and other takeoffs were straight. The results have been uniformly positive with the HH gyros I have tested.

A great thing about using a gyro is that if the nose gear is set incorrectly, the tail wheel is bent, or a landing gear part gets bent on a bad landing to the point where the aircraft would normally veer off to the side during takeoff, the device can still adjust the takeoff. The model will be directed to take off straight down the runway, although the body might have an apparent yaw angle.

The only exceptions to airplanes going reasonably straight down the runway were light models in a hard side wind. The fuselage would point down the runway and try to be parallel to the centerline, but the hard side wind would blow the whole airplane sideways. But it was better than the ground loop that normally took place.

Conclusion: The modern RC gyro with HH capability is a great tool to use to help almost any model configuration attain better takeoffs and landing approaches. All airplanes I tested certainly improved; ground-looping monsters were turned into well-mannered aircraft.

The Bf 109 now makes reasonably fine takeoffs, with no pilot input needed. A video showing some of my comparisons between having the HH gyro off and on, including in the Messerschmitt, is shown on YouTube. I made sure that the side winds were extraordinarily high, to ensure that the benefits of the HH gyros were exercised to the max. **MA**

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