Many, if not all, turbine jet pilots today use onboard stabilization systems in one form or another.

Flight Stabilization Basics

THREE-AXIS STABILITY FOR FIXED-WING RC

BY **KLAUS RONGE** FLIGHT PHOTOS BY **SAL CALVAGNA, RICH URAVITCH & DAVID HART**

THREE-AXIS STABILIZERS or gyros specifically designed for fixed-wing airplanes are a relatively recent innovation. These amazing little black boxes help the aircraft to fly stable around its three axes: roll (aileron), pitch (elevator), and yaw (rudder). Prior to their development, modelers often used single-axis gyros designed for RC helicopters in airplanes, usually on the rudder. Multiple-axis stabilization required multiple gyros and was a chore to install and set up. Today's three-axis stabilizer units have a small footprint that can be installed in aircraft of virtually any size. There are also ready-to-fly planes that come with these units preinstalled as well as receiver/stabilizer combinations in one unit.

Today's onboard stabilizers are versatile and can be a great aid to pilots of all skill levels. They make learning to fly much easier and less stressful, and also allow experienced pilots to fly more comfortably in wind conditions that would otherwise ground them. They also help tame those squirrely tail-dragger planes that are a handful to tame. Despite their widespread use, there still seems to be some confusion and misconceptions regarding the use of three-axis stabilizers. Some pilots feel as if they are relinquishing control, while others think of them as autopilots. I have also talked to pilots who have expressed their dislike, claiming the plane doesn't fly correctly. I suspect that, in most of these cases, the gyro was improperly set up or the pilot had unrealistic expectations. A basic understanding of how these stabilizers function and their features will help ensure success at the field.

It will also help you choose the gyro best suited to your intended purpose and your budget, of course. Gyros vary widely in price and features, and it is not possible to list every feature available here. The principles on which they operate are universal, however, as are some key features discussed here.

STANDARD AND HEADING HOLD MODES

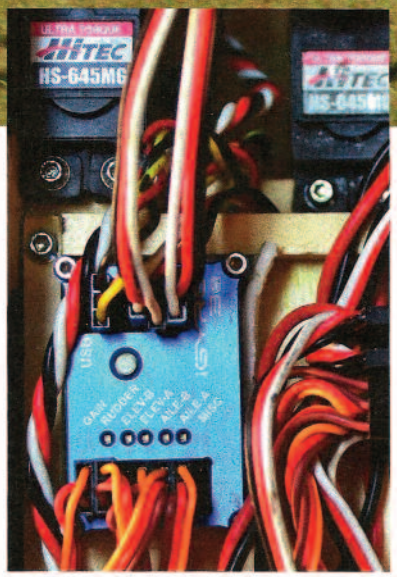
All but the most basic gyros have two principal modes: Standard/Rate and Heading Hold (also known as "3D AVCS"). Typically, the pilot can toggle, in flight, between modes using a transmitter switch. Gyros with only one mode operate in the Standard mode.

A gyro operating in Standard (or Rate) mode will sense a deviation or upset from the airplane's flight path and provide an opposing control deflection—the higher the rate of rotation, the larger the correction (hence, the name "rate"). The gyro makes no attempt to return the plane to its original heading but merely dampens any deviation. The easiest way to visualize this is to use an RC helicopter as an example. Consider a heli in a stationary hover that is hit by a wind gust from the side. The heli will try to weather-vane into the wind, which the gyro senses as a rotation around the yaw axis. The gyro will send a command to the tail rotor to stop the rotation, but the heli will have rotated to some degree and will be on a new heading.

In essence, the gyro gives the airplane a bigger feel with improved tracking and fewer and less severe oscillations due to the wind. Sport and aerobatic pilots often find the smoother flying characteristics and improved tracking allow them to concentrate on perfecting their maneuvers. The gyro will not make their loops any rounder or compensate for a crosswind as the plane still goes where the pilot points it.

Stabilization systems have also been

When it comes to WW II tail-dragger warbirds, onboard stabilization greatly improves ground handling and smooths out flight performance.



This is the installation of the PowerBox iGyro 3e in Sal Calvagna's Ki-43 "Oscar." To operate properly, the onboard flight stabilization unit must be installed properly and lined up with the airplane's centerline and direction for flight.

a boon to scale modelers. Tail-draggers, especially World War I and WW II fighters, have notoriously poor ground handling, especially on the takeoff and landing rolls. A gyro can tame that tail as well as improve the peculiar flight characteristics of some scale models. Turbine pilots have relied on gyros to achieve the ultra-smooth and arrowlike precision flying you may have seen. Another benefit is the reduced likelihood of an unintentional tip-stall. While it offers no miracle cure, a gyro can turn a mediocre-flying model into a pretty-good-flying model and a good one into a great one.

Heading Hold mode has various names depending on the manufacturer and is a more aggressive form of stabilization. The gyro will not only correct the momentary rotational movements as does a rate gyro but also sense how far the plane has deviated and return it to its original heading. The transmitter sticks no longer control the servos directly but, rather, tell

STABILIZER QUICK-START GUIDE

It seems as if it's human nature to ignore instruction manuals, but setting up a gyro requires careful reading and understanding of the manual. Specific steps must be followed to the letter to program them properly, and they vary by manufacturer. Some gyros have provisions for using a programming card or computer interface for easier setup. Below are some universal steps for gyros.

- **AIRCRAFT SETUP.** Proper plane setup is even more important when using a gyro. Mechanically set up the control throws and directions using the best practices; place the clevis farthest out on the control horn and closest in on the servo arm that gives the desired control throw. Some gyros do not tolerate any subtrim, but it is best to keep it to a minimum in any case.
- **EXPONENTIAL.** Since the gyro is attempting to counteract movement about the aircraft's axis, it behaves somewhat like expo. To get the same feel, the expo may need to be reduced. Flight testing will be required to determine the best setting for your flying style.
- **SERVOS.** The servos will be working constantly, which demands a lot from them. Gyros are the most efficient when coupled with high-speed servos of adequate torque. Digital servos are ideal (some manufacturers require them), while a servo that is too slow can render the gyro unusable. Use the best servos you can afford to achieve the best performance from your gyro.
- **GYRO MOUNTING.** Mount the gyro on the aircraft centerline as close to the center of gravity as possible. Use the supplied double-sided tape (usually shock-absorbing) to mount it to a firm, solid surface, paying attention to the gyro's orientation. Excess vibration can cause gyro inefficiency, forcing you to reduce the gain. If using a nitro or gasoline engine, verify that the gyro can be used as some are designed for electric aircraft only.
- **GYRO OPERATION.** Verify that the gyro direction is correct. A simple way to do this is to tilt or raise the aircraft along an axis and check that the control surface moves in the same direction. To check the roll axis, raise the right wing panel quickly; the right aileron should move up. For the pitch axis, raising the tail should move the elevator up. Moving the tail to the right should result in the rudder moving to the right. Check all the control surfaces in both directions, and change the gyro direction as needed.

When it comes to flying in competition, the Fokker Triplane has notoriously poor ground-handling characteristics. Today, three-axis stabilization systems are a must-have if you're going to compete in RC scale.

the gyro the required rate and direction of rotation.

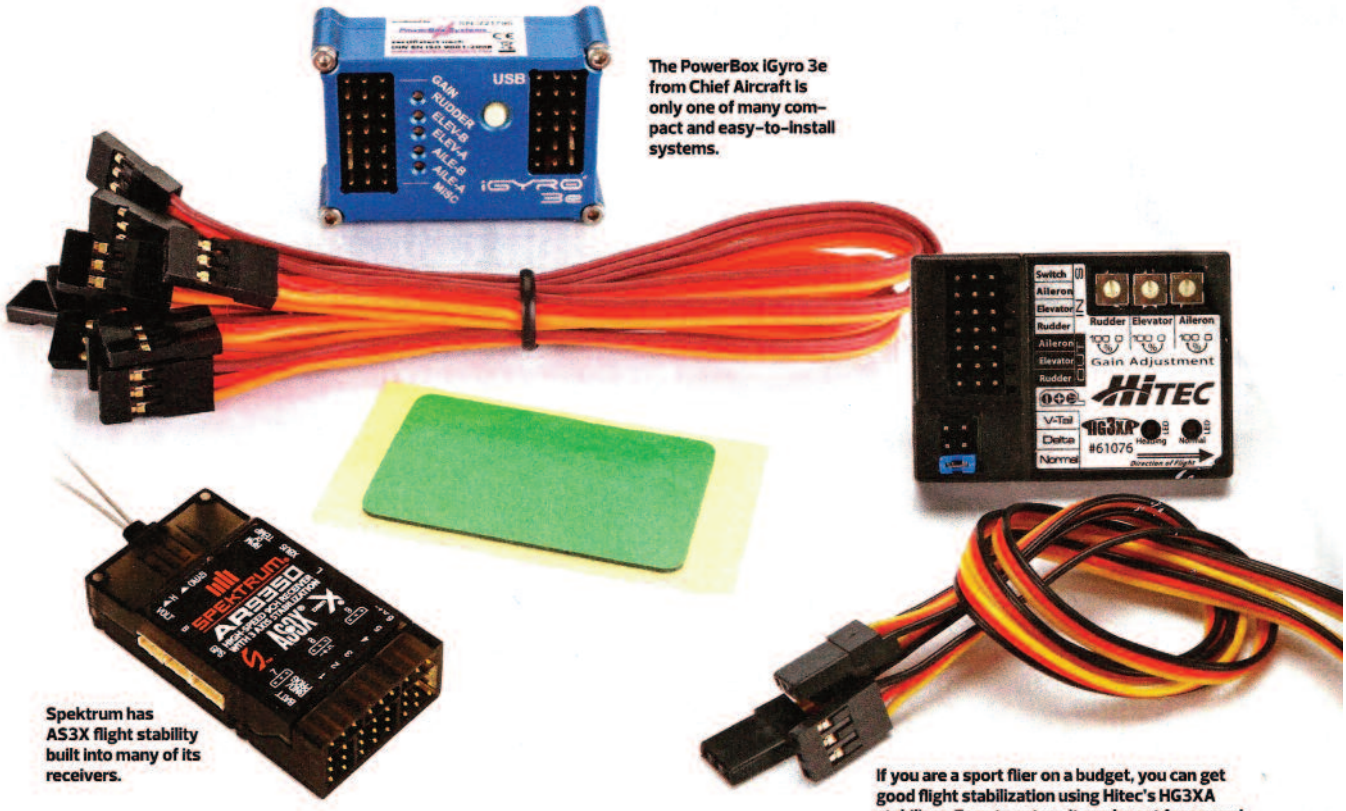
In this mode, the gyro will attempt to keep the plane locked in the attitude commanded by the pilot. Using the hovering heli example, the gyro will sense the rotation about the yaw axis, stop the rotation, and return the tail to its original position. In an airplane, if the pilot enters a hover and turns on Heading Hold, the gyro will keep the plane locked in the hover with no input by the pilot. Aspiring 3D pilots may find this mode useful in learning difficult new 3D maneuvers. It is especially helpful in harrier maneuvering as well as hovering and performing the torque roll.

Normal, or non-3D, flight should always be done in the Standard mode to avoid unwanted and unusual fight characteristics. In Standard mode, the servos will return to center when the sticks are released. That's not so in Heading Hold mode; the servos may not return to center as the gyro tries to hold the last commanded attitude.

The Heading Hold mode locks the plane in the attitude set by the pilot.

SPECIAL FEATURES

Some gyros feature a Beginner mode, which limits the bank and pitch angles. This helps eliminate overcontrolling and subsequent loss of control common to newcomers. One of the most challenging aspects in the early stages of flight training is learning to give the proper control response with the airplane flying toward you. The Beginner mode gives student pilots time to sort this out without the constant need for bailouts. The best way to learn to fly is to receive instruction from an instructor at the local club, but this may not be feasible for everyone. A docile trainer equipped with this type of gyro gives the pilot a fighting chance. Also, flight training with an instructor can be less stressful with a gyro-equipped



The PowerBox iGyro 3e from Chief Aircraft is only one of many compact and easy-to-install systems.

Spektrum has AS3X flight stability built into many of its receivers.

If you are a sport flier on a budget, you can get good flight stabilization using Hitec's HG3XA stabilizer. Easy to set up, it can be set for normal, V-tail, and Delta-wing aircraft.

FLIGHT TESTING

Time spent fight testing and setting up the gyro will ensure optimal performance from the plane. Because aircraft vary in weight, size, control response, and a host of other factors, you'll need to program unique settings. Here are some tips that apply to all gyros.

- Allow the gyro to initialize after turning on the plane, per the manufacturer's instruction. The gyro may not function if the plane is moved or disturbed during the initialization process.
- At the field, double-check the control-surface direction as you normally would (with the gyro off). Turn on the gyro and verify that it is functioning properly and giving the correct commands when the aircraft is rotated about the various axes.
- Periodically check that the gyro is still securely mounted to the airframe. A loose gyro will cause havoc in the air.
- Perform the initial takeoff with the gyro off, if it has that capability. Once at a comfortable altitude, switch it on and be ready to turn it off at the first sign of trouble.
- Fine-tuning the gyro gain may require numerous flights. The gain can be thought of as the degree of response to a disturbance. A low gain setting results in little dampening, while a high gain results in a rapid response. If the gyro gain is set too low, the gyro will not be utilized to its fullest potential with little dampening. If the gain is set too high, the plane will oscillate or hunt. Start with a low gain setting and test-fly the plane. If there is no oscillation, turn up the gain slightly and perform another test flight. Repeat this process until oscillation is experienced. Back off the gain and verify that there is no more oscillation. Depending on your personal preference, you may want to further fine-tune the gain setting.

trainer as well as giving the post-solo pilot increased confidence.

There are a few occasions in the past where I could have used a Panic Button feature. Some stabilization systems include a panic or return-to-level function. When activated by a button or switch on the transmitter, the plane will return to straight and level flight no matter what attitude it was in when the panic button was activated. This is obviously great for beginners, but even experienced pilots may find it useful on occasion when a case of the "dumb thumbs" strikes.

BOTTOM LINE

Flying a gyro-equipped model is a difficult experience to put into words. Just as with dual rates and exponential, gyros are a pilot aid that increases the enjoyment of flying RC airplanes. Perhaps one day, we will wonder how we ever flew our models without them.