How AHRS Works

By J. Mac McClellan / Published: Jun 30, 2010

I think the easiest explanation of the difference between a spinning gyroscope and an attitude-heading reference system (AHRS) is that a gyro measures an airplane's attitude while the AHRS calculates attitude.

A spinning gyro remains rigid in space, resisting the forces of acceleration. So the attitude gyro is spinning about a vertical axis and remains vertical as the airplane pitches and rolls around the gyro. That little airplane symbol we see on the face of an attitude indicator is actually remaining stationary relative to the horizon while the airplane — the background of the instrument — moves.

An AHRS uses tiny sensors to measure acceleration, and a fast computer chip analyzes those forces and calculates airplane attitude. By sensing acceleration in all axes, the AHRS can calculate how attitude has changed and thus determine the actual attitude of the airplane at any instant. A fundamental part of the calculation is also track over the ground. A remote flux detector measures the earth's magnetic field, and that magnetic information is applied to the track calculation to determine the compass heading we all see on the PFD.

The complexity of the AHRS calculation and the necessary sensitivity of the sensors in the system are almost impossible for most of us to fully understand. And that such a precise device would be affordable to piston airplane owners is truly mind-boggling.

The first AHRS - though we call it an inertial reference system — was developed by Honeywell and used laser beams to sense acceleration. The laser beams race around a small track reflecting off mirrors in each corner of the loop. Any acceleration deflects the laser beam, slightly changing the frequency of the received light at the end of the loop. The magnitude of the change in light frequency is proportional to the acceleration.

The laser reference is still the gold standard for determining attitude, and the systems work wonderfully and last almost forever, but cost hundreds of thousands of dollars. What made the AHRS price breakthrough possible a few years ago was development of sensors for the automotive industry. The skid- and traction-control systems in a modern car also need very sensitive acceleration sensors, and it was the demand of the auto industry, and its huge volume, that drove down the cost of the essential electronics to help make AHRS available for airplanes of all categories.

Some AHRS also use air pressure changes in the attitude calculation. A change in vertical speed or airspeed as measured by a digital air data computer can help stabilize and refine the attitude calculation, and these systems are called ADAHRS (air data attitude-heading reference systems).

The AHRS used in the G600/500 is the Garmin GRS 77, which is part of the thousands of G1000 integrated glass-cockpit systems delivered over the past several years. It does not use air data in its calculation and can realign itself in flight, which is not necessarily true of all lower-cost AHRS.