

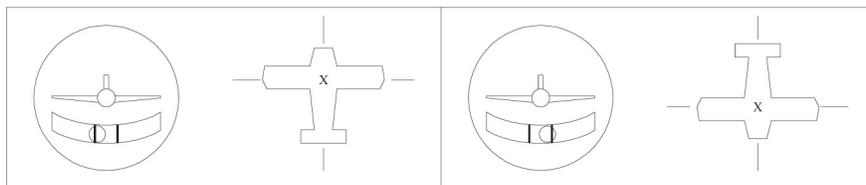
# TECH TIME

## Helpful tips for the Avionics Technician

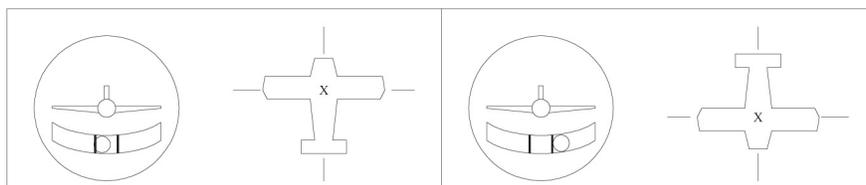
BY AL INGLE

This month we continue our series on autopilot theory and operation by performing a real world inspection of the autopilot as installed in the aircraft. We have previously discussed the ground tests to be performed prior to takeoff but with one omission. This last ground test is to ensure the proper installation and operation of the slip/skid ball in the turn coordinator or turn and bank. One or the other of these instruments is found in most aircraft, and should the aircraft not have such an instrument, there will be a slip/skid ball somewhere in the pilot's primary field of view. Remember the difference between these two devices: the turn and bank is a gyroscopic instrument with its rotor mounted so that the spin axis is vertical, like the wheel of a bicycle and can only sense yaw movements; a turn coordinator is a similar gyroscopic device except the spin axis is tilted at 45° so that the airplane depicted on its face shows both yaw and roll movements.

It is important to ensure the correct mounting of the slip/skid ball because this is the only way to know if the aircraft flies straight and level and in coordinated flight. In other words, the aircraft must be able to hold a heading with the slip/skid ball centered and the wings level as seen by the pilot. To be accurate, however, the ball must indicate properly. The best way to check this is to taxi onto a ramp or open area that is reasonably flat. Find a particular spot on the ramp and stop the aircraft over this exact point and record the displacement, if any, of the slip/skid ball from its centered position. Now taxi forward and make a 180° turn and bring the aircraft back over the exact same spot and stop. Record the displacement again, if any. Examine the two readings and determine if they are equally displaced from the centered position. If for example the ramp is perfectly level and the tires/struts are of equal pressure and all instruments are level, then the slip/skid ball should remain centered regardless of the angle at which you pass over the point of reference. But if the ramp is not level or any other parameters are not equal from side to side *and the slip/skid ball is installed correctly*, then there will be a displacement of the ball from its center *and the distance (magnitude) of the displacement will be the same and in opposite directions*. Given the same circumstances of the aircraft wing not being level with the ground, *a slip/skid ball not installed correctly will give an unequal displacement from center* when the aircraft approaches the chosen point of reference from two opposite directions. This phenomenon is illustrated below:



**Figure 1a. Turn Coordinator properly installed, wing not level with the ground**



**Figure 1b. Turn Coordinator improperly installed, wing not level with the ground**

If the operation of the slip/skid ball is deemed acceptable, the autopilot evaluation may continue in flight. But what if you discover that the slip/skid ball does not indicate a symmetrical displacement from its center during your checks? There is simply no way to know when the aircraft is truly flying straight and level and thus you cannot evaluate the roll portion of the autopilot. It is time to taxi back to the maintenance base for the repair of this device.

We must remember that as aircraft age they undergo maintenance whereby control surfaces are removed, reinstalled and rigged and even major components such as the wing and horizontal/vertical stabilizers are removed and reinstalled. How do you really know if the aircraft was properly aligned during reassembly? You are going to find out with the slip/skid ball, which simply measures the effects of gravity. Without any lateral (yaw) force, this ball rests at the bottom of its race representing coordinated flight. If you think of gravity as a vector pointing downward, in the absence of any yaw, the ball is going to rest at the lowest potential, which is between the two marked lines. Now throw in any slip or skid forces and again think of a vector except now you have gravity being pushed laterally by an amount equal to the slip or skid force. The slip/skid ball is being pulled out of its lowest point by the magnitude of this yaw force. Therefore, to truly measure an aircraft's performance in flight, the ball must be centered in the absence of any yaw forces. See Figure 2 below:

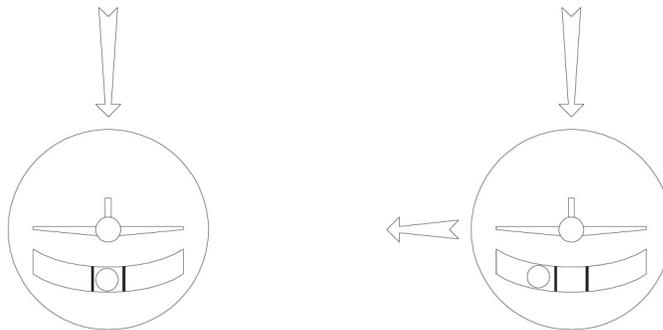


Figure 2. Effect of lateral and gravitational forces

The easiest way to check the slip/skid ball is to remove any lateral forces. On the ground that means simply to level the aircraft. You may consult the appropriate aircraft manufacturer's maintenance procedures to perform this adjustment but a good universal method is through the use of an electronic level. Most aircraft wings are symmetrical in shape and rise from the fuselage attachment point to the end of the wing. This amount of rise is called the dihedral (angle). By measuring the dihedral *at the same distance inboard from the tip of both wings*, one may jack or shift the aircraft as necessary until the angles measured are the same. See figure 3 below:



Figure 3. Dihedral is the upward slant of the wings.

You now have a level aircraft. Adjust the turn coordinator or turn and bank as necessary so that the slip/skid ball is centered within its indices. You may find that there are no elongated holes for the adjustment of the instrument or that the instrument panel has tilted due to worn bushings, or even that the instrument itself is defective. Find the root cause of the imbalance and solve the problem. Having done this you are now ready to fly the aircraft. It is important to remember that much of your autopilot testing has nothing to do with the autopilot, but rather with the airframe itself. We still do not know if the control surfaces are rigged properly, but we are now in a position to determine if they are. Then there is the cable friction and tension to be dealt with. When we are satisfied with all of these details, then and only then can we engage the autopilot and diagnose any resulting symptoms.

Next Month: More autopilots