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 test flight. In preceding articles we performed a comprehensive ground check and learned how to check the Turn Coordinator's slip/skid ball and adjust as necessary. **Do not forget the small screwdriver, other tool(s) and documentation needed when in the air. It is embarrassing and inconvenient to be forced to return for these items. Plan ahead!**

Climb after takeoff to a safe altitude where you are above the clouds and in smooth air. It is important to do this so that subtle symptoms can be sensed that would be otherwise be masked by any turbulence. Typically this is at least 2-3000' above the ground. The aircraft should be flown at maneuvering speed unless there is an overriding reason to do otherwise. Maneuvering speed (V_A) is the speed at which the aircraft controls can be fully and abruptly deflected without imposing loads in excess of structural limits. Above this speed it is possible to damage the aircraft. Avoid at all times approaching the stall speed or redline. Your margin of safety at these speeds cannot be justified and there is no reason to be in such situations.

Level at the selected altitude and trim the aircraft for hands-off flight with the autopilot off. Holding the control wheel, lean inward so that your head is in the middle of the cockpit, observe both wing tips and adjust the ailerons until the wings are at the same point on their respective horizons. Now check the Turn Coordinator's slip/skid ball and verify that it is centered in the indices. If it is not centered, adjust the rudder trim until these conditions are met. If you do not have rudder trim, you must land and adjust the rudder trim tab. Take extra time to insure it is adjusted in the proper direction. If the ball is to the right of the indices, you must apply right rudder in flight to correct. Therefore, to make the rudder move right the trim tab must be deflected left. The corollary is the slip/skid ball out of the indices to the left, requiring left rudder to correct and right deflection of the trim tab. This procedure has applications for the other control surfaces as well.

Now that you have the wings level with the horizon and the ball centered, let go of the yoke (ailerons), and the aircraft should fly straight and level. Should the aircraft bank consistently right or left, you may have a wing wash misalignment problem. *Wing wash* is the differing angle of attack between the two wings that corrects for P factor, but only at one speed. Aileron trim is used to correct for the imbalance by either manual adjustment in the cockpit, or set with trim tabs on the ground. Again you may have to land and adjust the trim tabs until the aircraft flies straight and level. Lastly, after meeting these conditions, you want to insure that the ailerons in level flight are parallel with the flaps and wing tips. Otherwise there is additional drag and a misalignment in the airframe somewhere. An airframe technician must correct a problem such as this.

You are now finally ready to test the autopilot. With the aircraft trimmed for level flight, press Flight Director (FD, if applicable), then engage the autopilot in attitude (ATT) and altitude hold (ALT) modes. Center the HDG bug for reference only (do not select HDG mode), and monitor the aircraft heading for long-term drift. After flying for several minutes adjust the roll null trimpot for minimum heading change.

While in the ATT and ALT modes, overpower the roll clutch by forcing the aircraft into a 30º right bank and then releasing the yoke to determine if the clutch has sufficient authority to bring the aircraft back to level flight. Repeat this procedure for overpowering in a 30º left bank. Regardless of the direction, there should be no difference in performance. If there is a difference, it may be due to P factor and a weak clutch. The servo clutch must have adequate authority to return the aircraft to level flight symmetrically or the problem must be found.

This test is continued in the pitch axis with the autopilot in ATT mode (ALT *off*). One caution regarding the trim system is in order here. When applying an input to the pitch axis (pushing or pulling on the

yoke), after a few seconds delay and depending upon the autopilot, you are going to induce a trim action. The longer the trim runs in response to your pushing or pulling on the yoke, the more the aircraft is out of trim when you release the applied pressure to the yoke. *In this scenario you are placing undue stress upon the aircraft and putting your safety in jeopardy.* Therefore, to test the pitch portion of the autopilot, first place one hand on the trim wheel so that you can sense when the trim servo is being actuated, then overpower the pitch servo by applying downward pressure on the yoke until the aircraft is in a 5-7º dive, then release the yoke as soon as you feel the trim running (approximately 3 seconds, varies by autopilot model and type of aircraft). You are checking to see if the servo clutch has sufficient authority to bring the aircraft back to level flight and that the autopilot has positive stability. Repeat the same test except by pulling on the yoke, causing a 5-7º climb, and release as soon as trim action is felt with the other hand.

The autopilot response must be damped such that the aircraft returns to level attitude within one cycle. What we desire, in technical terms, is a damped sinusoid. Figure 1 below shows a properly damped, *converging* maneuver while Figure 2 shows an unstable, *diverging* maneuver.

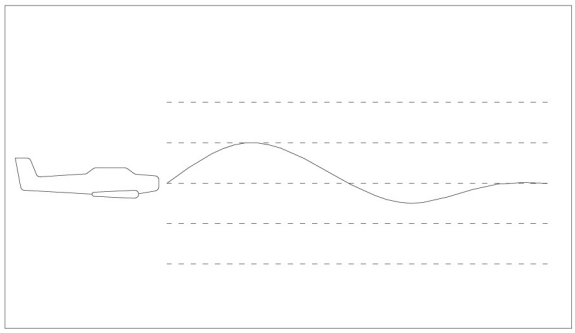

Figure 1 Proper *converging* maneuver.

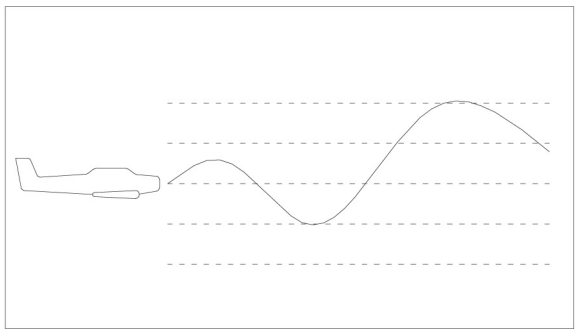

Figure 2 Improper *diverging* maneuver.

Autopilots that do not dampen within one cycle may have any number of problems including almost any part of the system i.e. gyro, computer (defective or misaligned), control linkages, servos, clutches, etc. An autopilot that satisfies the tests described to this point is residing in a good airframe with its fundamental loops properly adjusted and operational. Next month we add command signals to modify these fundamental modes.

In the June issue of Tech Time, a mistake was made regarding the testing of the trim system when the aircraft is on the ground. The responses described were those observed when the aircraft is in *flight*. Lets review *ground* trim functional checks again.

With the gyros erect (as applicable to the autopilot), hold the yoke in the neutral pitch position and engage the autopilot in its default mode (typically attitude hold, pitch and roll). Now apply forward pressure on the yoke and after a delay of several seconds, the trim should begin to run *trim up*. This is because the pitch is trying to oppose your downward pressure and this is being sensed by the trim system, which tries to help by trimming up. Likewise, when applying back pressure on the yoke (against the effects of gravity), the pitch servo tries to reduce it and after several seconds have elapsed, elicits a downward trim action.

In summary, the trim should move in the direction *opposite* the yoke input, after some seconds delay. Special thanks to alert reader Jim Mills for bringing this error to our attention.

Next Month: More autopilots