Landing on Porpoise

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In my last article in this space, we discussed the perils of wheelbarrowing, and the ensuing potential loss of directional control, and or ‘ground loop’. There we showed that the lateral stability of the tricycle-gear airplane goes negative (divergent) if there is too much weight on the nose gear during the takeoff or landing roll. Here we will develop the idea a bit further, and expose another, related landing fault in the too-much-weight-up-front category: landing ‘on porpoise’.

The porpoise is a landing fault that occurs, like wheelbarrowing, when the pilot allows the aircraft to touch down at too great an airspeed. The difference in the set-up is the sink rate. While a wheelbarrow will develop if the pilot ‘rolls it on’ at too high an airspeed, the porpoise is initiated typically with a similar excess speed combined with a substantial sink rate.

The downward velocity at impact causes the nose gear to compress and then rebound (like the spring that it is). The upward rebound causes the aircraft to pitch up, increasing the angle of attack. The mains will contact slightly after the nose gear, and they will also compress and rebound. This will tend to stop the pitch-up motion, but at an angle of attack much higher than at the initial contact. Given that the airspeed is above stall, the increased angle of attack results in a large increase in lift. This new-found lift combines with the rebound from the main gears and ‘launches’ the aircraft back up into the air.

If left to its own devices, the aircraft will then fly a semi-ballistic arc at the trimmed angle of attack. It will reach a peak altitude at a minimum airspeed, and then go ‘over the top’ and begin an increasing rate of descent back towards the runway at increasing airspeed. If the pilot does not intervene, the next impact will be at an angle and descent rate similar (or slightly less than) that of the first impact. The aircraft will execute another ‘skip’ off the pavement, and continue through a series of arcs of gradually decreasing height interspersed with impacts of similarly decreasing severity, until the oscillation dies out altogether.

Unfortunately, few pilots understand the dynamics of oscillating systems. They try to ‘fix’ it, and, in so doing, usually make things worse… much worse.

The uninformed pilot will usually react at the top of the first arc; they will see the excessive height over the runway, combined with a frighteningly low airspeed. Having been repeatedly cautioned about the dangers of stalling, they will apply forward elevator to reduce the altitude and increase the airspeed.

Sadly, this is exactly the *worst* response to a porpoise. Down elevator at the top of the arc pitches the airplane down at a point when it was already pitching down on its own. The net result is to increase the down-angle and airspeed at the next impact.

These translate into a more violent nose gear contact, a faster and higher pitch up, and a larger (not smaller) arc on the next cycle. The next peak altitude is higher, with a lower minimum airspeed at the top; the pilot may then be tempted to pitch down *more* the second time, and the third impact and arc will be more violent still.

This pilot's attempts to 'correct' the porpoise actually make it worse. Where the natural response would have been a gradually decreasing oscillation, with these pilot inputs the result is a divergent PIO (pilot-induced oscillation). The altitude of each arc—and the vertical velocity of each impact—are both greater than that of the previous cycle.

The end-game of the porpoised landing usually comes at the third or fourth impact; the violence of the porpoise is greater than the nose gear and structure can tolerate. The nose gear fails, and the aircraft slides to a very sudden stop.

The good news is that rarely are there any injuries in such an accident. The bad news is that blocking a runway in a mangled airplane is a good way to attract news helicopters and become instantly famous.

There are two ways to deal with the porpoise: prevention and cure. Prevention is better, so we will take that first.

Like the wheelbarrow, the porpoise can only occur if the pilot allows the airplane to contact the runway at too high an airspeed. The high airspeed corresponds to a shallow angle of attack, and hence a low pitch attitude, such that the nose gear will contact the ground before, or more firmly than, the main gears. Thus, if we 'hold it off' until the airspeed has decreased to something at or near the stall speed, the porpoise cannot occur. During the float, it is best to apply a continuously increasing backpressure, such that it is just sufficient to keep the aircraft from sinking onto the runway, but not great enough to cause a 'balloon' (unintended climb). When the aircraft runs out of airspeed, it will stall onto the runway at or near full up elevator. In this condition, the nose gear does not make contact with the runway, and thus the porpoise cannot occur.

If we make the error of letting the aircraft sink onto the runway well above the stall speed, we may get a wheelbarrow (low sink rate) or a porpoise (high sink rate). The best way to fix a porpoise is to apply full power, pitch to the go-around attitude, and GO AROUND. If the available power is insufficient to stop the descent before the second impact, in the go-around attitude the aircraft will take that hit on the main gears, which is the safest way to do it. From there, execute a normal go-around procedure; fly the pattern, and come back for a new approach and landing—this time held off to a speed at or near stall before allowing the aircraft to touch down.

