—HANDS-OFF FLIGHT CONTROL—

A major purpose of initially learning hands-off flight control is to enable pilots to understand the techniques of fingertip control input. They will find properly trimmed flight allows satisfactory performance within the aircraft's design limits and is much easier and safer.

—PHYSIOLOGY OF MANUAL CONTROL—

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Year after year, stall/spin events account for a disturbing number of general aviation accidents. According to the Air Safety Institute's Nall Report, "failure to maintain airspeed" appears as a proximate or contributing cause in roughly 40 percent of the fatal accidents. This statistic persists in spite of stalls, stall recovery, and stall prevention having been taught — ad nauseam — to virtually every candidate for every certificate, rating, flight review, insurance checkout, and type certificate over the last half-century, or more.

Someone once defined insanity as "doing the same thing over and over and expecting a different result." It is the opinion of this author — a long-time flight instructor — that the results demonstrate that we in the flight instruction profession are not giving our customers an adequate methodology for dealing with this problem. Specifically, we do not provide a sufficiently clear and effective means of preventing unintentional stalls. This article is an attempt to define such a methodology.

Central to the problem of the prevention of unintentional stalls is a general misunderstanding of how and why an aircraft will stall. Too often, we hear discussed the aircraft's stall speed; in fact, the aircraft stalls if, and only if, the wing exceeds the critical angle of attack. That this will occur at a particular speed is only true given a closely defined set of conditions. Any stall speed is only valid at a particular combination of weight and load factor; the critical angle *of attack does not change as long as the flap configuration is constant.*

A second poorly understood concept is the issue of trim and stability. Pilots tend to think that the aircraft trims to an airspeed; this, also, is only true under particular circumstances. The static stability of an airplane tends to drive it back to a trimmed angle of attack. This will correspond to a particular airspeed only under steady-state conditions.

The stability of the aircraft can be used to the pilot's advantage with regard to stall prevention. In a nutshell, let go of the controls. Once releasing the controls, the aircraft will return to the trimmed angle of attack (regardless of the airspeed) within a little more than a second. Most aircraft will not trim to an angle of attack that exceeds the critical angle of attack; thus, with very rare exception, an aircraft loaded forward of the aft center of gravity limit cannot be stalled in hands-off flight.

Unintentional stalls, then, occur when the pilot applies enough backpressure on the yoke to overcome the natural stability of the aircraft, leave the trimmed angle of attack, and exceed the critical angle of attack. It would seem, then, that we could eliminate unintentional stalls by warning pilots to avoid applying excessive backpressure.

One would think this would work. History tells us, however, that it does not. Discovering the reason for this paradox requires bringing some outside knowledge into play. In particular, I find it helpful to consider the 19th century contributions of German anatomist and physiologist Ernst Heinrich Weber (1795-1878), and his student, physicist and philosopher Gustav Theodor Fechner (1801-1887).

These two scientists developed the theory of perception, defining the "just noticeable difference (JND)," or, in other words, the minimum change in a stimulus required to trigger perception.

With regard to pressure stimulus (such as force on the yoke), the JND is a change of approximately 14 percent of the pressure already present. Today, the relationships they defined are referred to as the Weber-Fechner law, or the W-F law. It is common knowledge in physiology but, unfortunately, not so well known in aviation.

Several features of the W-F law are important to flight operations. First, any stimulus (yoke pressure) which is constant will fade from perception over a short time. A pilot who is flying in an out-of-trim condition will soon lose the ability to perceive that he or she is applying any elevator pressure at all. The out-of-trim condition becomes the new zero; the pilot cannot trim it off, because they do not perceive that it is there.

Second, a constant stimulus (i.e., steady backpressure to compensate for being out-of-trim) will elevate the just-noticeable-difference. If the pilot is holding a constant 20 lbs. backpressure, the minimum pressure change he or she can feel on the yoke is now 2.8 lbs., in any direction.

Every attempt to make a "small" input will become a "small" input plus 2.8 lbs. of additional pressure that the pilot has no way to know he or she is applying. The result is over-controlling; small, precise inputs are impossible.

Also, the pilot will tend to make unintended inputs, in pitch and roll, across a 5.6 lb. "dead spot" in his or her perception. This can be especially vexing when the pilot is attempting to accomplish non-flying tasks, such as reading a chart, or dialing a radio frequency; he or she will apply an unknown and unintended input up to the limits of the JND.

A pilot flying in this manner is much more at risk of inducing an unintentional stall. Too many pilots are in the habit of flying the aircraft with large control pressures, far away from the trimmed angle-of-attack. The elevated JND makes it easy to apply the control forces accidentally that are necessary to overcome the stability of the aircraft and drive it to and past the critical angle of attack.

What can we do?

To avoid the unintentional stall, we need to develop the habit of flying the aircraft in trim and hands off. An airplane which is in trim and flown hands off is (with rare exception) impossible to stall. The natural (static) stability will drive it to and hold it at the trimmed (not stalling) angle of attack; flying hands-off ensures the pilot will not force the aircraft away from the trimmed (not stalling) condition.

Getting into a perfectly trimmed condition is not always as easy as it sounds. For most pilots, it requires a change in the way we touch *the controls. Due to the physiology, it is virtually impossible for pilots to trim an aircraft precisely if their hands are still on the yoke.*

Trimming, then, requires that we trim the aircraft to the limits of our perception (trim off the pressure), and then let go. Only with the hands off the yoke can we observe the change in pitch attitude and vertical speed, which is the clue to the remaining out-of-trim condition that existed below our ability to perceive.

Once observed, the change should prompt the pilot to pitch (with the yoke, not the trim) back to the desired pitch attitude and rate of climb, trim slightly against the error, and try again. Only when the aircraft will stay at the desired pitch attitude and vertical speed for five to 10 seconds in hands-off flight can it be considered to truly be in trim.

Once in trim, the pilot should endeavor to avoid violating that trim. That is, "if it ain't broke, don't fix it." Said another way, the pilot should not touch the yoke unless there is presently an error in pitch that needs correction. If the airplane is doing what it should, there is no need to touch it!

All transitions in airspeed, power setting, and configuration will induce some trim change. Immediately address any change in the trimmed condition to bring the aircraft back to the desired trim. Once regaining the trim, maintain it by flying hands off to the maximum possible extent.

It is important to realize that the oft-repeated advice "use a light grip" is, unfortunately, a misnomer. Another principle of physiology, the grab-and-grip reflex, makes this so.

Under stress, the reflex induces us to unconsciously grab hold (of the yoke) and grip with increasing pressure. Over time, the light grip will invariably escalate to the famed white knuckles condition we see so often, and create all of the same problems as an out-of-trim condition.

Thus, when a pilot does have to make a control input, it is important to avoid setting up a grip condition; it is better to touch the yoke, rather than to grip it. Use the minimum pressure required to achieve the desired correction, and then go back to hands off.

If you've developed the uneasy feeling that this methodology involves a radical change in the way we fly, you would be correct. It requires discipline, thought, and practice to achieve truly in-trim and hands-off flying skills, but the rewards are worth it: better stall resistance, smoother ride for the passengers, more precise control of the aircraft, and lower pilot workload.

—HANDS-OFF FLIGHT—

To enable understanding how an aircraft is controlled consider that the aircraft was designed and built to fly. The pilot only inputs control, steering to specific headings and altitudes to accomplish a particular flight.

During ground operation, initial precise control input to the rudder can be done by wiggling the pedals back and forth as deliberate over control while learning the input feel for maintaining the taxi lines. Wiggling controls for precision is actually inputting too much control and immediately removing it by the reversing.

A sample initial flight will be to begin flight from start of taxi to landing roundout only touching the control wheel when changing elevator trim. This is accomplished by using normal flight procedures of pre-flight, engine start, taxi, and engine run-up.

Prior to takeoff, the elevator will be set at an expected Vx indicated-airspeed or other required lift-off indicated-airspeed. With clearance to takeoff, the power is set and brakes released. Steering is done normally with rudder input.

The aircraft will accelerate and upon reaching the indicated-airspeed as set with the trim, it lifts off, acceleration ceases, and climb begins at the trim-set indicated-airspeed.

Rudder input is continued for directional control toward a distant visually acquired target. Aileron input will not be used unless unusual conditions require more control than available with yawing by rudder. This yawing procedure also allows a new student to quickly become aware of the kinesthetic sensing through the seat.

When established in climb and clear of any obstacles, a slight push on the elevator control will allow acceleration and re-trim to Vy as a climb indicated-airspeed for this flight.

The flight will continue climbing until approaching a desired altitude at which the elevator is again gradually pushed to coordinate leveling at that altitude. The aircraft will now be accelerating to the desired cruise indicated-airspeed. Gradual power reduction will coordinate the thrust to this cruise indicated-airspeed. You are now cruising in level constant indicated-airspeed flight…still not touching the control wheel. Probable minor adjustments as necessary to attain the specific cruise criteria.

Additional understanding of flight control requires being aware that the aircraft flies at an angle-of-attack which means the direction of thrust is slightly above the direction motion. This results in a small thrust component-lift at the engine attachment…essentially, a fifth control which causes pitch change with thrust change.

Throughout this flight, the elevator control is touched only to coordinate with thrust for changing indicated-airspeed. All level turn and climb maneuvering in this condition is by rudder yaw and coordinated thrust.

Descent is different. When reducing thrust from level flight, there is reduced thrust component-lift which is part of the elevator trimmed condition so allows some acceleration. Now throughout all descent for constant indicated-airspeed flight, it requires coordinating the elevator trim with any thrust change.

Visual sighting of the runway end as relative to a spot on the windshield (like sighting a gun at a target) and maneuvered to be kept unmoving is a collision course to the landing area.

If using the control wheel for maintaining a precise approach course, again the technique of wiggling the control wheel with fingertips allows learning the feel for that precise control.

—SUMMARY—

It should be noted when maneuvering with minimum or no manual control-wheel input, it is virtually impossible to stall the aircraft.

In the event of inadvertent IMC or any condition losing visual flight reference, turning loose the control wheel and with reference to a turn instrument, it is possible with rudder-only control to make a safe one-eighty turn and fly out of the conditions or with added thrust to climb to regain visual reference.

For precise idle-thrust and engine-out approaches use visual reference by sighting through a spot on the windshield aimed at the landing spot and keeping it unmoving, a collision course.

In high altitude flight conditions, avoiding control wheel input limits in-flight maneuvering to the existing conditions thereby avoiding stall but requires understanding of the prevailing much reduced thrust performance available from the machine.
A local Instructor using these techniques has found Students can be proficient for safe flight control to solo within five hours and completion of PPL requirements within thirty hours.

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