What's All The Flap About?

Flaps are so much more than simply those large surfaces hanging from the wing trailing edges

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Bill Cox

The approach looked edgy from the start. Then, it got worse. We watched the accident unfold before us from the tall grass, 9,000 feet up in the jagged crest of the Sierra Nevadas. The United States Forest Service (USFS) strip was only 1,800 feet long, leaving little margin for error. If conditions were good and you did everything right, it wasn't that challenging, but winds across the high terrain of 14,505-foot Mount Whitney, a mere 19 miles away, could change in an instant.

On that day, conditions weren't optimum, and the pilot wasn't doing everything right. The temperature was a moderate 60 degrees, light-jacket comfortable. Trouble was, that was well above what it "should" have been. It was far too warm for Tunnel Meadows' elevated runway. We had arrived in a Maule a few hours before, and I calculated the density altitude (DA) at almost 11,000 feet, a major challenge for any normally aspirated airplane.

Now, it was even hotter, and the air was thinner.

The flaps were fully deployed as the airplane made the steep descent to the short dirt runway. Even for an amateur eye, the approach looked a shade long, and as the airplane slowly descended, it became obvious that it was also too fast.

Fortunately, or so we thought at the time, the pilot realized his mistake and applied full power to go around. Unfortunately, "full power" at this elevation was only about 50%, easily enough to keep the Skylane flying with no flaps, but not nearly enough to do the job with full flaps adding drag.

We watched in amazement as the huge barn-door flaps remained stubbornly full down, and the airplane staggered uncertainly. It held its own for a few seconds, then gave in to the inevitable laws of physics. The Cessna contacted the runway nose high with a vicious sink rate, splayed its main gear far to the sides, then collapsed the left main and nose gear before sliding to a stop in a cloud of dust.

"Hell of a short-field landing," said the pilot standing next to me as we both dashed across the meadow toward the wrecked airplane, both breathing heavily in the thin mountain air.

There had been no fire and no cockpit intrusion. The tough little Skylane had done its job. Neither the pilot nor his girlfriend suffered more than bruises, but the airplane was heavily damaged.

Sadly, the FAA commonly identifies the misuse of flaps as a probable cause of many landing accidents. Pilots often misunderstand the use of flaps, both during takeoff and landing. Flap abuse is more common during landing than takeoff, since some airplanes don't use any flaps for departure, whereas landings nearly always demand deployment of the aft-wing, stall-reduction devices.

Some larger airplanes require flaps for every takeoff and landing, however. If you've ever watched the deployment of flaps, slats and spoilers from an airliner during approach, you can appreciate that the big birds need all the aerodynamic help they can get during landing. Should the crew fail to position the high-lift devices in the proper configuration for either landing or takeoff, the airplane may simply stall or refuse to fly.

Pilots rarely question the function of flaps in either mode, though most aviators understand that deployment of flaps imparts an artificial expansion of wing surface, usually a little for takeoff and a lot for landing.

The questions pilots most often ask about the use of flaps are: At what setting do flaps begin adding more drag than lift, and how should they be deployed for short takeoffs and landings? Conversely, how should flaps be retracted—a few degrees at a time or all at once? Finally, how should flaps be deployed during gusty wind conditions?

Flaps were designed to allow airplanes to land slower, safer and on less runway without compromising lift for cruise by adding significant drag. Early tests with the first primitive high-lift devices proved that flaps add maximum lift for the associated drag when deployed somewhere between 9 and 15 degrees. On most airplanes, that coincides with one-quarter to one-third flaps. These days, max flaps usually equals about 30 degrees. Some older airplanes and a few STOL models use as much as 50 or even 60 degrees for max performance takeoffs and landings.

Flap designs vary from the extremely simple to the remarkably complex. Again, the airlines utilize extreme flap positions, not only for departure and a wider stall margin on landing, but also to assist in aerodynamic braking on the ground.

As the name implies, the plain flap is the least complex, a simple, hinged surface comprising usually 30% to 50% of the inboard wing trailing edge that deflects by electrical or hydraulic power.

Split flaps are mounted fully beneath the wing and deploy without modifying the top wing surface. These are mounted on a variety of aircraft, such as the AT-6 trainer and some Cessna twins.

The Fowler flap is perhaps the most common on high-speed aircraft, though it's also a fixture on many general aviation models. This is perhaps the most complex and labor-intensive flap, employing a track system that allows them to translate aft as they extend down.

All these types offer the same advantages and fly by basically the same rules. Flaps make the job of departing or arriving at a short runway considerably easier and safer.

As mentioned above, actuation systems may vary from electric to hydraulic or even manual. Pipers with the old manual flaps typically reach the optimum deflection (9% to 15%) at the first notch, and the majority of Cessnas also use this deflection for the first programmed position.

Beyond 14 degrees of flaps, drag begins to exceed lift in a big way. The principal application of major flap settings is a short-field approach, though many pilots regularly employ full flaps on every landing. In fact, however, the use of flaps of any kind becomes far less critical as runways become longer and allow greater margin for error.

All airplanes benefit from partial flaps during any phase of flight that demands maximum lift. Some pilots might conclude that means takeoff. Not necessarily. The effect of flaps on takeoff and climb performance depends on the wing's airfoil and other aerodynamic factors.

If you must generalize, it's probably true that most of the time, flaps will help you get off a runway sooner. What happens after that will depend on piloting technique and the operating procedures for each individual airplane.

A peripheral question sometimes asked by pilots is when to deploy flaps for a short-field takeoff—prior to the beginning of the roll or near the expected rotation point? Some instructors argue that the airplane should be totally configured for takeoff before the throttle goes forward, and for many pilots, that's probably sound advice. This simplifies the job of transitioning from ground to sky, a process that can be pretty busy for new pilots and old pros alike.

If the runway is short and you're flying behind manual flaps deployed with a Johnson bar, be cautious about any sudden application. Manual flaps can have so much leverage, they can make it too easy to deploy, partially because the pilot can transition from a clean underwing to partial or full flaps almost instantly, and it's possible to overshoot the proper position. On some airplanes with excellent pitch authority, that can cause a pitch change you may not be ready for.

(Once, while flying a company Seneca II with manual flaps out of a short grass strip in Fort Atkinson, Wis., I was a little intimidated by all the tall corn at the end of the runway. I got too enthusiastic in my flap application and overshot the setting to two notches rather than one. This was equal to 25 degrees. The mains lifted off immediately and tried to pitch the airplane onto its nose wheel. Only a very abrupt rotation kept the front wheel from burying itself in the grass.)

The question of how to raise flaps generally centers around whether they should be "dumped" or "milked." The former method eliminates all lift and drag as quickly as possible, handy if you need to transfer all the airplane's weight to the wheels for braking. The latter is more graceful and allows a more gradual reduction in both lift and drag.

Here, my preference is to always milk the flaps up, but respected aviation author John Hoyt, in his classic text, As The Pro Flies, suggests there are circumstances in which dumping flaps is appropriate or even desirable. If you're flying at maneuvering speed or higher, Hoyt writes, "The rule of always raising flaps slowly may be good policy for the novice, but expert pilots know their airplanes and fly accordingly…. When we want to be up and away promptly, we dump the flaps, apply power and hardly realize that we've raised the nose slightly, thereby providing lift to replace the lift we lost when the flaps went up."

One rule some pilots use for retracting flaps at speeds above 1.3 Vso is to retract them one degree for every knot in excess of that speed. If the airplane stalls at 50 knots, for example, and you'd normally approach at a speed of 65 knots, and you have 10 degrees of flaps extended, you can start bleeding them up when the airspeed reaches 66 knots. If the airspeed is 75 knots, you can dump the full 10 degrees without a lift loss that you can't counter with pitch.

Some airplanes do better in gusty winds than others, especially those with relatively high wing loading, and many pilots have long been confused about the use of flaps when winds are variable. A few years back, the FAA contributed to the confusion by changing its position and suggesting that full flaps should always be used in any headwind. Hoyt suggests that when flying in gusts more than half the stalling speed of the airplane (25 knots for the airplane above), flaps should be no more than half the wind velocity, in this case about 12 degrees or one notch. If stall is 50 knots and wind gusts are reaching 30 knots, use no more than 15 degrees of flaps.

In lesser winds, most pilots will choose to use full flaps for every landing, not just because the FAA recommends it, but because what happens slowest is usually easiest. It's best to wait until you have the runway made to extend the last notch, however. Full flaps add considerably more drag than lift and steepen the approach angle, as our Skylane pilot learned to his dismay several paragraphs back. That may be just what you want if you need to land short and stop quickly.

Once you're on the ground, another common question is when to retract flaps. Again, some instructors shudder to think of pilots doing anything other than controlling the rollout after touchdown. The primary concern on retractable gear airplanes is that a pilot will accidentally grab the wrong lever and retract the gear on the ground.

Raising the flaps soon after touchdown may be to your advantage, assuming you can tell one lever from the other. This will transfer more of the airplane's weight onto the main gear and allow earlier braking action. It also will help avoid foreign object damage (FOD) damage to the bottom surface of the flaps at unimproved airports. Apply brakes with the flaps fully extended, and you may only succeed in flat-spotting the tires as the wings may be developing just enough lift to keep the rubber barely in contact with the runway.

Flaps don’t always have the same effect on all airplanes. A few designs pitch up with flap deflection, while most pitch down. Some airplanes don’t gain much lift from extending flaps, while other, especially the high-wing Cessnas, realize a major reduction in stall speed and a dramatically steeper glide path.

The overriding rule is generally the same as with instrument flying, “Slower is usually better”…within limits. That means using flaps for virtually every landing.

Overall, flaps offer pilots the advantage of slowing down the world. With more time to make decisions, a pilot can do a better job during those two critical moments of transition to and from the Earth.