SPOILERS

NASA

FOR GLIDEPATH CONTROL

Is direct lift adjustment coming for lightplanes?

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Sailplane and airline pilots are worlds apart, but they have at least one thing in common: they're spoiled. In addition to the three basic flight controls, their aircraft also are equipped with a fourth set of control surfaces: spoilers to destroy lift.

It may seem like heresy to suggest that a pilot kill lift when every fiber of his flying muscles has been exercised to preserve it. But too much of a good thing can be dangerous, and lift is no exception.

A spoiler is any device used to interrupt the smooth flow of air over an airfoil. The most common is the plate-type as on the Twin Otter, above. An excellent example is found on Boeing jet transports. Anyone who has sat in the aft cabin of a 747, for example, probably has seen these "barn doors" pop up from both wings within a second or two of touchdown. The massive wings seem to come apart as the large, hinged "boards" swing 60 degrees forward. When not in use, they lie flush and unobtrusive against the wing's upper surface.

Not as popular are the plug- or interceptor-type spoilers, which are wholly contained within the wing. When deployed, they rise through narrow, spanwise splits on the wings' upper surfaces to spoil the flow of air. Lift is lost.

According to Vic Saudek, a soaring historian, spoilers were developed in the mid-1930's. Sailplanes had become so aerodynamically clean that pilots of that era were having difficulty landing within the confines of a runway. Overshooting was common, and spoilers were devised to increase sink rates and minimize floating beyond the touchdown target.

The first sailplane to sprout spoilers seems to have been the German Rhönsperber (circa 1936).

Spoiler development took another step forward during World War II. Needing additional gliders for training, the Army removed the engines from numerous two-seat airplanes and replaced these with a third pilot (to maintain the required center of gravity). *Voilà:* three-place gliders to which spoilers were added.

Shortly after the war, some of these aircraft were reconfigured with engines. The result was a small fleet of rag-wing taildraggers equipped with spoilers. But then came a bureaucratic snag: an attempt to have the hybrid machines approved by the CAA (FAA's predecessor).

Certification proceeded smoothly until a government inspector, whose name is mercifully unknown, tried to use spoilers as if they were flaps. The result was a pranged machine, a severely bruised ego and a profound declaration that "spoilers don't belong on airplanes." Unfortunately, this attitude prevailed, and the development of spoilers for general aviation came to a

NASA is experimenting with glidepath-control spoilers on a de Havilland Twin Otter to test their feasibility on light wing-loaded STOL transports. Results show that spoilers "can be applied beneficially to general aviation airplanes."

screeching halt.

In recent years, however, NASA dipped into its petty cash drawer to fund two research projects to determine, in part, the feasibility of applying spoiler technology to light airplanes.

The first involved equipping a Beechcraft Musketeer with spoilers that were modulated by throttle movement. When the engine developed sufficient power to maintain level flight, the spoilers were retracted. Reducing power was a signal that a descent was desired and the spoilers automatically deployed in proportion to throttle retardation. With the engine idling and the spoilers fully open, the aircraft could descend along an 18° glideslope at normal approach speeds.

As power was reapplied, the spoilers retracted automatically. This arrangement gave the pilot very precise control of the descent profile. However, this arrangement would not help with one of general aviation's modern problems: fast descents *and* the need to maintain engine temperatures.

More recently, NASA equipped a DeHavilland Otter to further evaluate spoilers on lightly wing-loaded STOL transports. Although some questions remain to be answered, Emmett Fry, NASA's project engineer for the program, volunteers: ". . . the results prove that spoilers can be applied beneficially to general aviation airplanes."

Seth Anderson, another of NASA's senior aeronautical engineers, was intimately involved with the Musketeer program and is somewhat more enthusiastic. He states that "spoilers widen the safety margin during approaches and landings without requiring additional piloting skill."

As a result of NASA's research, almost all general aviation airframe manufacturers are regarding future spoiler applications more seriously. And one entrepreneur has even gone so far as to invent an add-on spoiler conversion for the Cessna 172. The system recently was awarded FAA's official blessing, an STC — but more about that later.

The NASA projects demonstrated what airline and sailplane pilots have determined empirically: that spoilers can be useful to anyone who flies fixed wing aircraft.

Consider, for example, the possible need to execute an emergency descent from high altitude. Normally accomplished by chopping power and shoving the nose earthward, this is extremely detrimental to piston engines. Such catastrophic cooling causes internal components to shrivel like prunes; powerplant longevity is adversely affected. And if the aircraft is pressurized, the lack of power also may cause the discomfort (and danger) of decompression.

Steep, diving descents also may result in the airspeed needle creeping toward the red line, a particularly hazardous situation in heavy turbulence. A compromise must then be made between airspeed, rate of descent and the need to lose altitude. The result may not be sufficient to satisfy the urgency of the moment.

Spoilers resolve this dilemma because they destroy considerable chunks of lift while simultaneously creating profile drag. A steep descent can be made at a comfortable airspeed while the engine(s) develops sufficient power to keep the cylinder heads comfortably warm (and the cabin pressurized).

With spoilers deployed, an aircraft descends much more rapidly than might otherwise be possible. Some sailplanes (such as the Schweizer 2-32 and the Czechoslovakian Blanik) have such effective spoiler systems that they can dive vertically (in excess of 12,000 fpm) and indefinitely without exceeding red line speeds. Unlike other protruding devices such as flaps and retractable landing gear, spoilers are not airspeed limited; they can be deployed at any time.

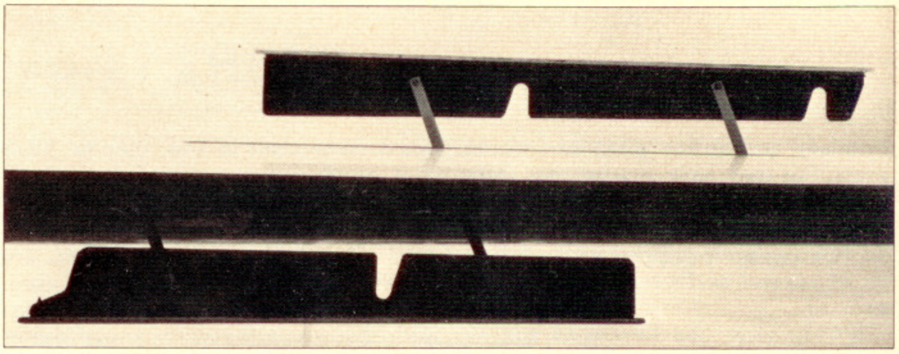
On a more practical note, consider the steep descents often required by ATC, particularly in high-density, IFR environments. Instead of contributing to engine mortality by abruptly reducing power, wouldn't it be nice to have only to "pop the boards?" Descents and airspeed reductions could be made without even touching the throttle(s) or by making gradual power reductions to cool the engine(s) slowly.

Now consider flying beneath a thunderstorm or in a strong mountain wave where the elements conspire to make the aircraft climb when the pilot doesn't want to. Since structural failure has been caused by attempting to dive out of unrelenting updrafts, it is easy to appreciate the value of spoilers.

Paradoxically, properly designed spoilers might even be partially deployed to advantage during cruise flight. In heavy turbulence, they help to prevent inadvertent and possibly dangerous airspeed increases. Spoilers also soften the ride by increasing wing loading (which increases pitch stability).

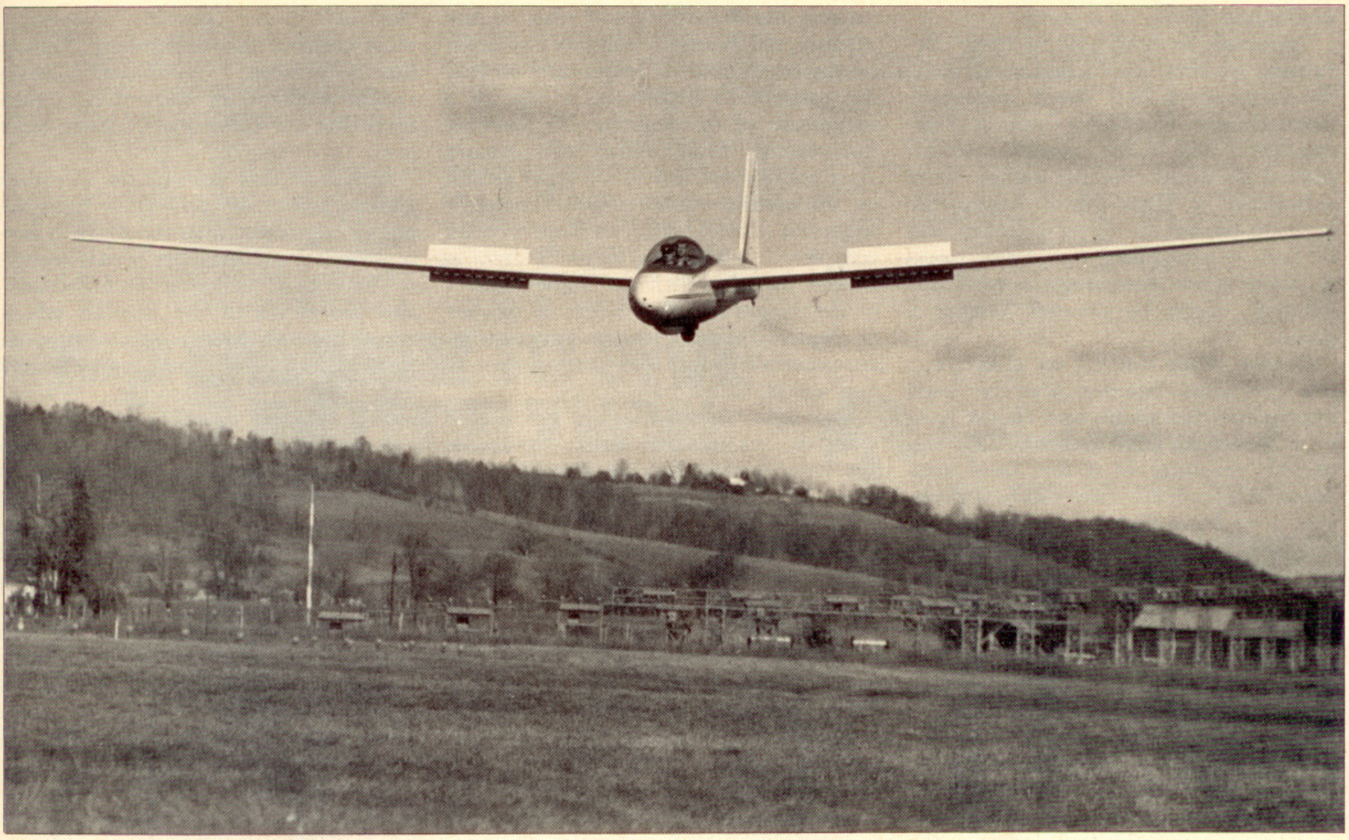
On most jetliners and sailplanes, spoilers are raised by pulling on a handle in proportion to the desired amount of spoiler deployment. NASA's experimental systems do not include this. Instead, spoiler extension is modulated automatically by throttle movement, a scheme designed to eliminate the need for an extra control that might add to cockpit confusion. Future light aircraft employing spoilers are most likely to incorporate this concept. Another design possibility includes a "beep" switch on the control wheel that is much like that used to position an electrically operated elevator trim tab. Pushing forward on the switch gradually extends the spoilers; an aft movement retracts them to restore lift.

Scissor-type spoilers on Ogar sailplane extend above and below wing surface.



Spoilers generally are installed near the wing's center of lift. As a result, extending them creates little or no pitch change. Also, they usually are far enough outboard to prevent interfering with airflow across the horizontal tail surfaces and sufficiently inboard so as not to degrade aileron effectiveness.

Surprisingly, well-designed spoilers have virtually no effect on stall qualities or handling characteristics and very little effect on one-G stall speeds. During flight tests in NASA's spoiler-equipped Otter, for example, stall speed increased only 3 knots with 40% spoiler deployment. As the spoilers were extended farther, stall speed *decreased* somewhat. This, according to NASA's Emmett Fry, was caused by the airflow reattaching to the wing at a



Schweizer 2-32 uses hinged spoilers to allow "playing" of landing approach angle to make up for lack of a powerplant.

point behind the spoiler.

Many power pilots are mystified by the ability of sailplane pilots to make consistently accurate spot landings. With the availability of power (and usually flaps), airplane pilots also should excel in accuracy landings.

While on the downwind leg, a sailplane pilot deploys the spoilers about halfway. This reduces glide performance and allows the glider to descend about as steeply as an airplane in a conventional glide. During the remainder of the approach, the spoiler handle is used as if it were a throttle. When too low (below the "slot"), the spoilers are retracted (partially or fully) which can double, triple or even quadruple glide efficiency. When excessively high (above the "slot"), additional spoiler is applied, controllability is precise and there are no pitch changes or other adverse side effects. Only the sink rate changes — according to need.

According to a series of NASA flight tests, spoilers can be equally effective on light airplanes. A group of novice pilots were instructed to land on a given point while flying an unmodified Beech Musketeer. The average touchdown point was 275 feet from the touchdown target with extremes varying from 500 feet short to 1,700 feet long. Without any additional instruction, the same pilots were given another chance while flying NASA's spoiler-equipped Musketeer. Not surprisingly, the distribution of touchdown points was cut in half as were the extremes.

Imagine also how spoilers could assist an airplane driver making a dead-stick landing. He could approach a landing area with spoilers extended partially and vary the sink rate the way a sailplane pilot does. This no doubt would ease considerably the strain of a forced landing. An overshoot would be almost impossible. Not much could be done, however, to prevent undershooting.

And, if spoilers are modulated according to throttle position as they are on NASA's experimental aircraft, they could be used during power approaches to obtain a wider selection of descent profiles without the normally accompanying pitch and airspeed variations.

During a landing approach over a towering obstacle, spoilers can be applied to increase the available runway length for landing. Once the obstacle has been passed, a pilot can partially extend the spoilers and literally drop toward the runway. He must be careful, of course, to retract the spoilers and restore lift before ground contact is made at such a high sink rate. Such a technique admittedly requires considerable skill and proficiency but is nothing new to experienced glider pilots.

Spoilers also are handy during the landing flare. Instead of floating down the runway to dissipate excessive airspeed, spoilers can be raised *slightly* to both add drag and place the aircraft on the ground at any chosen point.

Once the tires kiss the concrete, applying maximum spoiler deflection forces the aircraft to remain on the ground — firmly. With so much lift destroyed, there's very little chance of a bounce or having a wing raised by a persistent, gusty crosswind. That is one reason why several jet aircraft (the L-1011, DC-9, et al.) have systems that automatically deploy all spoilers fully when the mains touch.

And since spoilers are so effective at "dumping" lift, most aircraft weight is forced immediately onto the tires, which increases brake effectiveness — a significant factor when operating on short or slick runways.

Spoilers also can be deployed while taxiing to prevent a strong gust from an unplanned lifting of a wing.

Seemingly without end to their usefulness, spoilers should be raised when the airplane is tied down, especially when blustery winds are forecast. During World War II, for example, aircraft parked in South Pacific islands were vulnerable to high winds during the typhoon season. A clever solution was to lash two-by-fours (or palm trees) spanwise across the wings to spoil any lift that might be created during a storm.

On the other side of the coin are a few problems. Spoilers can be used improperly. Sailplanes and bizjets have been launched with spoilers fully deployed, resulting in a few fatal accidents. Mechanical failure can be a problem, too. Manufacturers need to demonstrate that an aircraft has sufficient roll control in case of asymmetric deployment, a situation where spoilers rise on one wing but fail to operate on the other.

In the meantime, San Diego pilot and inventor Prentiss Cleaves has taken matters into his own hands. The 71-year-old former test pilot has equipped his own 1964 Cessna 172E (N3994S) with a pair of leading-edge spoilers.

These are electro-mechanically activated and operate through a momentary toggle switch adjacent to the throttle. As the right hand rests on the throttle, the thumb is used to tap down on the toggle and incrementally extend the spoilers 10 degrees at a time to a maximum of 50 degrees. To prevent inadvertent deployment, the system does not operate unless a trigger switch on the control wheel is simultaneously squeezed closed. The spoilers retract completely when the toggle switch is flicked up (also with the right thumb) or the trigger switch is released. In case of electrical failure the spoilers retract automatically because of return springs and aerodynamic blow-down.

Although the spoilers are not visible from the cockpit, mechanical pointers are provided to indicate spoiler position.

Cleaves' infatuation with lift control began in 1934 when he convinced Cessna to equip a model AW monoplane with spoilers. He felt that such devices would be helpful to Navy carrier pilots who needed the added touchdown precision that spoilers could offer. The test aircraft performed relatively well, but lack of funding allowed the project to die aborning. (As a test pilot, Clea Cleaves also flew a Cessna Airmaster with a *one*-bladed propeller as well as Lockheed's "Big" and "Little Dippers.")

After a demonstration of Cleaves' "Liftrol" spoiler system, however, I must confess disappointment. Perhaps this is because I compared Cleaves' system with other spoiler configurations that are considerably more effective.

Although this attempt to introduce glidepath-control spoilers to light airplanes appears to miss the mark, it does represent a certification breakthrough.

The major airframe manufacturers also are aware of the obvious advantages offered by properly designed spoilers and the abundance of available technology. Considerable research money is being spent investigating the potential for future spoiler development and application. The only negatives in the equation are the costs of manufacture and certification. But, according to reliable industry sources, the future for spoilers is bright—it is only a matter of time.

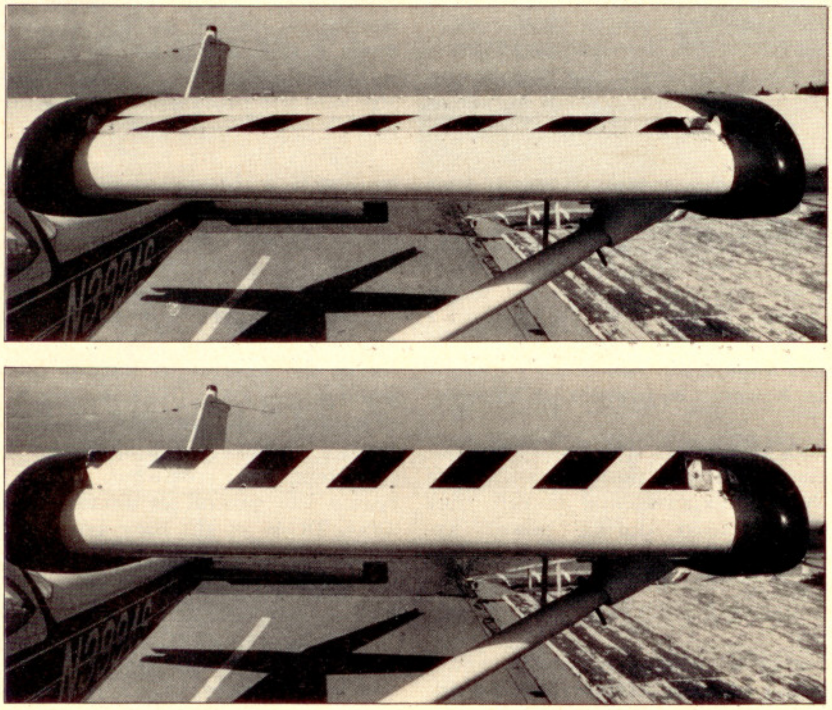
A few years ago Robertson Aircraft Corp., the people responsible for popularizing STOL conversions, equipped a Cessna 150 with a pair of spoilers. Perhaps the lessons learned here will evolve into a spoiler conversion.

Experimenting with various airspeeds and configurations, Cleaves' spoilers never produced more than a modest increase in sink rate or drag. But one must be careful not to be excessively critical of such inventiveness. Prentiss Cleaves is on the right track and his efforts should be encouraged.

Although Cleaves designed the system to attach easily to the wing's leading edge (and therefore not require tearing into the wing structure), this may be the system's aerodynamic weakness. Most experts contend that spoilers should be farther aft (between 25% to 50% of the chord) to perform effectively. But perhaps Cleaves may be able to improve performance by enlarging spoiler area. Presently, each of the two spoilers measures three feet by two inches.

Other system characteristics include no altitude change during spoiler deployment, very little buffet and a design that appears fail-safe. With spoilers extended, stall speed (flaps down) increases only 2 mph; with flaps up, however, stall speed increases more than 20 mph.

The Liftrol system is approved for all Cessna 172's up to and including the 172L. Subsequent models have leading-edge cuffs over which the present system does not fit. The conversion weighs 24 pounds and installs in about 16 man hours. Cleaves estimates that the kit will be priced at $1,000. □



Prentiss Gleaves' "add-on" leading edge spoilers on his Cessna 172 are not as effective as larger, built-in units, but they work, and further the argument for using such devices on general aviation aircraft.