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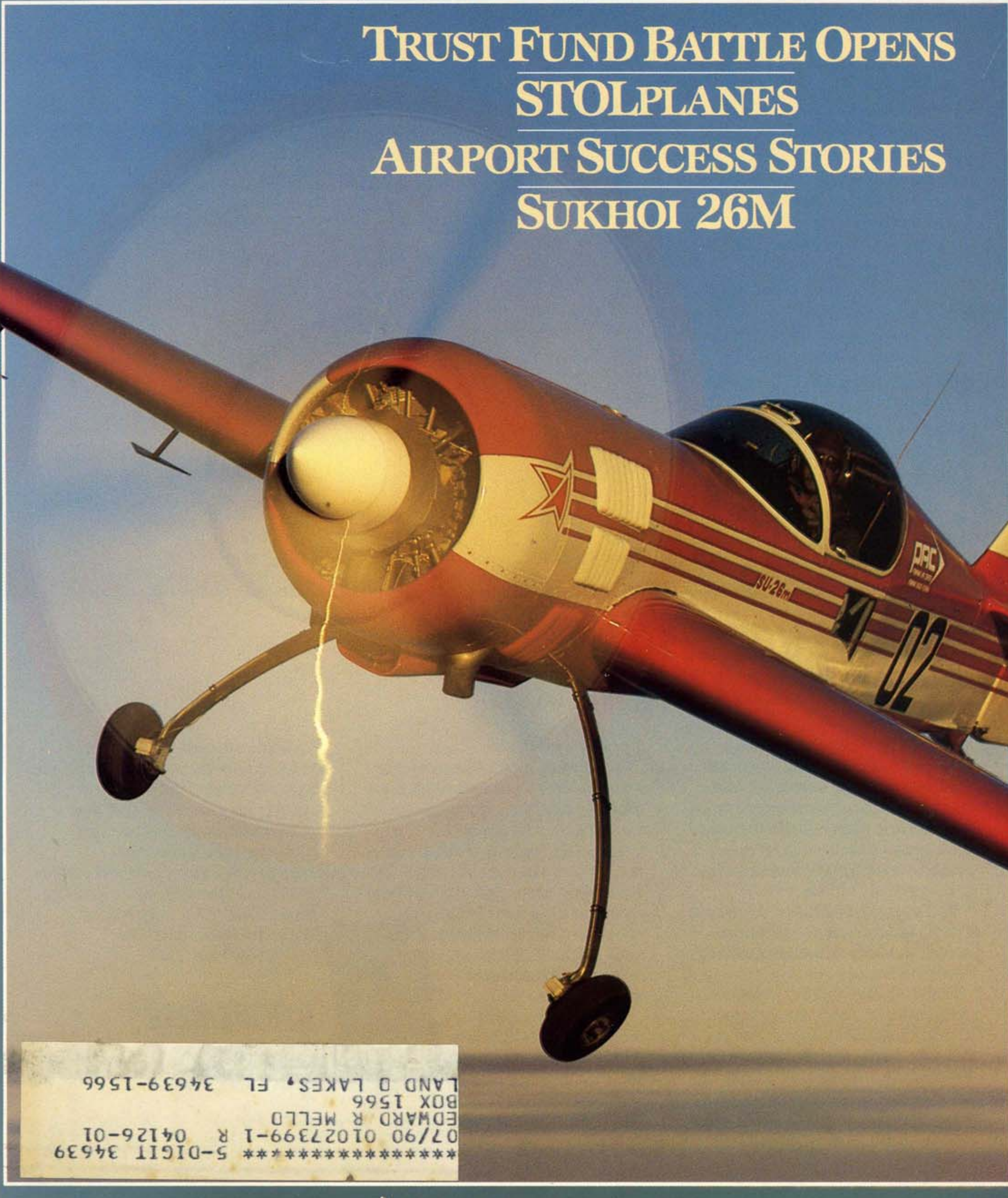
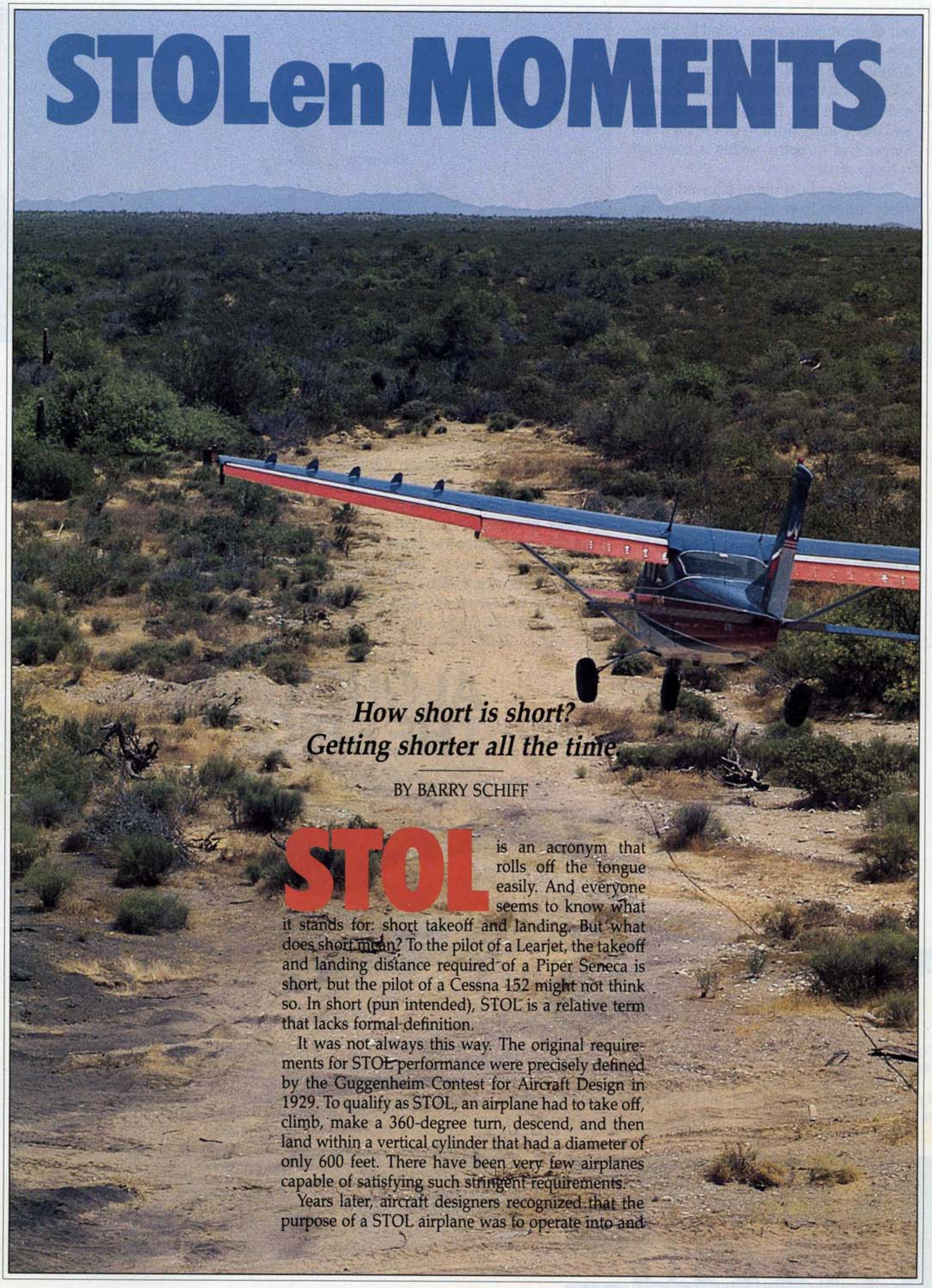


STOLen MOMENTS



How short is short? Getting shorter all the time.

BY BARRY SCHIFF

STOL is an acronym that rolls off the tongue easily. And everyone seems to know what it stands for: short takeoff and landing. But what does short mean? To the pilot of a Learjet, the takeoff and landing distance required of a Piper Seneca is short, but the pilot of a Cessna 152 might not think so. In short (pun intended), STOL is a relative term that lacks formal definition.

It was not always this way. The original requirements for STOL performance were precisely defined by the Guggenheim Contest for Aircraft Design in 1929. To qualify as STOL, an airplane had to take off, climb, make a 360-degree turn, descend, and then land within a vertical cylinder that had a diameter of only 600 feet. There have been very few airplanes capable of satisfying such stringent requirements.

Years later, aircraft designers recognized that the purpose of a STOL airplane was to operate into and

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out of short fields surrounded by obstacles. This led to a revised, but unofficial, definition of STOL: an airplane that can take off and land over a 50-foot obstacle in 600 feet or less. The climbing, turning, and descending portion of the flight no longer had to occur within a confined column of air.

This relaxed definition allowed previously unqualified airplanes to be regarded as STOL aircraft. Today, the term is applied loosely to airplanes that have better takeoff and landing performance than similar aircraft.

A Wren-modified Cessna 182 claws for altitude; it blooms with STOL-enhancing hardware, including stall fences, canard, and drooped ailerons.

There is more to STOL operations, however, than taking off and landing within confined quarters. There also is the matter of controllability. Aircraft operating from short fields obviously must operate at relatively low speed. They must be tolerant of gust encounters and have forgiving stall characteristics. An aircraft that does not afford this kind of low-speed protection probably should not be regarded as STOL irrespective of its short-field performance.

Twenty-five years ago, Dr. Otto C. Koppen, noted aircraft designer, STOL guru, and professor emeritus at the Massachusetts Institute of Technology, proposed certification standards for STOL aircraft. According to Koppen, "The STOL machine should be certified on the basis of controllability."

Adopting such standards, however, would have represented a revolutionary change in the Federal Aviation Administration's attitude toward certification criteria because aircraft are approved on the basis of structure and performance. If aircraft components are found capable of withstanding design loads, operational limitations are then developed to protect the pilot from any adverse control problems that might exist. For example, Koppen pointed out that "when it was discovered that twin-engine airplanes [other than those with centerline thrust] could not be controlled at low airspeed [with one engine inoperative and the other developing maximum power], the solution was simply to advise pilots not to attempt flight at less than the minimum single-engine control speed."

This solved the problem but resulted in longer takeoff distances and, according to Koppen, is a classic example of the certification process: "Flight limitations are substituted for safety. An alternate approach would be to require designers to make the aircraft controllable at all speeds capable of sustaining flight.

"By installing a larger vertical fin and rudder and placing them farther aft, single-engine control problems could be eliminated from most twin-engine airplanes.

"This, of course, ups manufacturing costs and really isn't necessary. As long as sufficient runway exists to accommodate the twin and its control limitation, the pilot should be capable of operating it safely."

Koppen called this the "trade space (more runway) for safety" approach, and he claimed that it is a traditional part of the certification process. This explains why he wanted STOL aircraft to be certified on the basis of controllability. "Trading space for safety," he claimed, "is not feasible because [extra] space usually is not available during STOL operations. The airplane should be designed to operate in and out of 'minimum-space airports' with certification based on controllability under these low-speed conditions."

According to Koppen's suggestions to the FAA, "STOL aircraft should have an angle-of-attack margin of at least 50 percent over the angle of attack in landing attitude." In other words, a STOL aircraft should be capable of accomplishing its mission without ever exceeding two thirds of its stalling angle of attack.

Such criteria, however, would disqualify several so-called STOL aircraft from being referred to as STOL, even though they can take off and land in relatively short distances. The Fokker D–7 of World War I fame could launch in only 70 feet, but it would not qualify as a STOL aircraft because of its intolerable low-speed handling qualities and wicked stall characteristics. "An additional requirement," according to Koppen, "would be sufficient aileron power to produce a minimum wing-tip velocity of 10 feet per second at landing speed." Typically, this is the equivalent of a 16-degree-per-second roll rate, which is greater than that of most general aviation aircraft. Koppen insisted that both the angle-of-attack margin and rapid roll rate are required to provide adequate safety margins during STOL operations.

Koppen stated further that the requirement for a spunky roll rate at low speed probably eliminates the conventional flap-type aileron from STOL aircraft. They are inefficient at low speed and often induce adverse yaw effect. Instead of ailerons, Koppen advocated some type of airflow separation device, or spoiler, to raise or lower a wing positively and without hesitation at low speed. Examples of such roll controllers are the Wren's "teeth" (on the Wren-modified Cessna 182) and the interceptors (spoilers) found on the Helio Courier, which was designed, incidentally, by Koppen along with Lynn Bollinger, who was professor of aviation research at Harvard University.

To suppress the stall and supply an extra angle-of-attack margin, Koppen suggested using some sort of boundary-layer control on the wing. This could be in the form of slats, slots, leading-edge flaps, or a drooped leading edge. The full-span, leading-edge slats of the Helio Courier are so effective that, during flight at very large angles of attack, the primary purpose of the wing seems only to keep the slats attached to the airplane. This is because at such low airspeed, the slats alone produce 60 percent of the total lift.

What might be described as the most radical form of boundary-layer control was once applied to the prototype of the Boeing 707, the Boeing 367-80. Bleed air from the turbine engines was literally blown over massive, 85-degree flaps. This created so much additional lift that the aircraft had a touchdown speed of only 70 knots.

Other STOL devices include: (1) wing fences that help to prevent a stall from propagating laterally toward the wing tip; (2) flaperons, which are flaps that—in response to control wheel movement—deflect in opposite directions from the ailerons; and (3) drooped ailerons that extend in conjunction with normal flaps to provide the effect of full-span flaps.

The Helio Courier, which was certified in 1954, may well be the only U.S. general aviation airplane designed from scratch to be a STOL aircraft. The Courier incorporates all of the controllability and runway performance criteria discussed above.

The popularity and demand for STOL aircraft took a giant step forward in 1967. This is when a young designer named Jim Robertson modified a Cessna 182 with a drooped leading-edge cuff, stall fences, ailerons that drooped 20 degrees, aileron gap seals, and a flap-dump switch on the control wheel. (Raising the flaps immediately after touchdown reduces wing lift, which increases braking effectiveness and shortens landing roll.) The result was a STOL aircraft, popular because it was safer and in demand because it was offered at a reasonable price. The original Robertson modification sold for $3,500. Robertson's genius for STOL aerodynamics and design ultimately was applied to a host of general aviation aircraft.

Even heart patients owe him a debt of gratitude. When a medical firm was having trouble designing an efficient inlet to an artificial heart valve, Robertson commented that "the only difference between blood and air is color and viscosity." Applying the same knowledge of fluid dynamics that made his STOL conversions so successful, he designed a heart valve inlet that still is in widespread use. It is, by the way, a miniature dead ringer of the much larger inlet of a JT3D turbine engine. If it was a fluid and it moved—whether through your heart or over your wing—Robertson knew how to make it sit up and do tricks. (His father also had a company called Robertson Aircraft Corporation, but it was located in St. Louis instead of Bellevue, Washington. The elder Robertson operated a flight school and had the air mail contract for the St. Louis to Chicago route. His chief pilot was a modest young man who later became the first aviator to fly solo across the Atlantic.)

There have been a host of other aircraft modifiers that have applied STOL technology to existing aircraft. The most extensive such modification, the Wren 460/B, also was based on the Cessna 182. The Wren actually uses many of the features found on Robertson's experimental Sky Shark, a research aircraft with a prodigious 420-horsepower engine that could be flown under full control at only 23 knots TIAS (no, that is not a typographical error). These features include a full-span, leading-edge cuff and full-span, double-slotted flaperons.

Most unusual, however, are the Wren's "teeth," which are miniature, roll-control spoilers placed on the upper, outer panel of each wing. These allow crisp roll control no matter how slow the airspeed. They are so effective that they are capable of rolling the aircraft out of a spin with the pilot's feet flat on the floor (or as much of a spin as one can achieve with a high-lift wing).

One of the most visible features of a Wren-modified 182 is a miniature horizontal stabilizer and elevator assembly mounted on each side of the cowling. These canard surfaces take advantage of the high-energy airstream immediately behind the propeller to provide additional pitch control. The nose of the airplane can be raised while motionless on the ground by pulling back on the control wheel during a full-power runup with the brakes locked. During the takeoff roll, the canard allows the nosewheel to be lifted off the ground in less than one length of the aircraft.

The most dramatic feature of the Wren is the optional fully reversible propeller. By reversing the blades and applying power, the Wren can descend almost as steeply as a helicopter and without any airspeed increase. Applying reverse pitch and power during the landing flare almost stops the aircraft in midair and reduces landing distance to 150 feet.

STOL technology is available today at a fraction of the price of VTOL (vertical takeoff and landing) aircraft. With continuing evolution of airfoils and powerplants, plus application of high-technology techniques such as vectored thrust, we can only guess how short the takeoffs and landings of tomorrow will be. It will be fun to watch. □