Maule M-4 Rocket is claimed by its maker as a STOL aircraft, although it sports none of the unique paraphernalia that characterizes other U.S. STOL planes. Manufacturer's performance data indicates the four-place, conventional-geared M-4 will take off in about 380 feet and land in 480 feet. Stall speed is given as 40 m.p.h., with a top speed of 170

Fairchild Turbo Porter, high load capacity plane, represents one of the newer STOL concepts. With full 2,500-pound payload, its 550 h.p. gas turbine engine reportedly will lift it off the ground in about 350 feet

A Closer Look At STOL

Short takeoff and landing planes may cost more, but advocates say increased utility and safety provide economies in the long run

by E. H. PICKERING • AOPA 275656

Wren 460 is credited by its manufacturers with HTOL (heliport takeoff and landing) capability. Built from a Cessna 182 airframe, it incorporates ULS (ultra low speed) controls (the winglike protrusions from the engine cowling). A speed range from 26 to 160 m.p.h. is claimed, and at full gross weight of 2,800 pounds it reportedly will take off in less than 300 feet

Six-place Caballero is one of four STOL models manufactured by Helio Aircraft Corporation. Reportedly stall-proof, it is powered by 250 h.p. engine, takes off after a ground run of less than 150 yards with a 1,500-pound payload and cruises at 150 m.p.h.

Whether it's pronounced as a word, "stol," or as four separate letters, S-T-O-L, it has the same meaning—short takeoff and landing. But what about that first word, short. How short is short?

There's no exact measure. No line of demarcation has been determined—no line drawn at, say, 346 feet as the point not to be exceeded in liftoff. It's a relative thing. Probably the best way to describe a STOL airplane is to say that it requires a strip of ground that other airplanes of a similar size-weight-speed category would find too small to be attempted.

Because small patches of open, level ground are more numerous than larger ones, STOL airplanes can have more utility than ordinary airplanes. Since small patches are easier to clear, level and surface than larger ones, STOL strips are more economical to build and maintain. Generally speaking, a small level area is more likely to be found near a desired destination than is a larger clearing.

In addition to increased utility and in some respects greater economy, there is an increased safety factor in STOL airplanes resulting from slow landing speeds. FAA states that the fatality rate in crashes is far greater when impact is made at speeds over 55 m.p.h.

Why, then, aren't there more airplanes available with STOL characteristics when utility, economy and safety are all plus features? In fact, why aren't all airplanes capable of STOL operations?

The answer is complicated. It contains elements of psychology and economics as well as aeronautical technology.

In the days of *Wacos*, *Eaglerocks*, and other late-'20's-early-'30's-era planes, one feature was always pointed up in aircraft sales efforts—how slowly the plane could land. There was a good reason for this. Fully half the landings were made in open fields that had never borne the name "airport." Airports, as such, were few and far between. Barnstormers used fields along highways or close to towns where crowds could readily be attracted. This economic requirement, coupled with the lack of reliability of early-day aircraft engines, demanded an airplane capable of safe landings in small, rough, unprepared clearings.

To improve airplane safety, especially airline safety, the multi-engine plane was developed. Then came newer engines, featuring increased power and greatly improved reliability. Speed, the airplane's greatest sales feature, was steadily increased.

But as top speeds moved up notch by notch, the features that permitted usable slow-speed flight were sacrificed. The need for slow landing and takeoff speeds became less important as more airports were built with longer runways and smooth surfaces. Engineering concentration was placed on higher and higher speeds, for this had become the most saleable item.

Perhaps the pendulum may be starting its swing toward reemphasis on usable slow-speed flight regimes—so long as little or no sacrifice is made at the high-speed end.

How is STOL performance achieved? Through power and/or through aerodynamic advances.

To take off after only a short ground run requires that the airplane accelerate to flying speed rapidly. Sheer power can achieve this when applied to an airplane capable of ordinary performance with lesser power. An airplane capable of accelerating to flying speed in 13 seconds with a 250 h.p. engine can reach the same speed in seven seconds if the engine is replaced with one of 400 h.p. The plane would still take off at the same flying speed. It would merely reach that speed sooner with more power. This plane would thus achieve the STO part of STOL. It could achieve the short landing roll by use of a reverse pitch propeller, one that was capable of reversing in a matter of two or three seconds or less, for the braking action of the reverse pitch would bring it to a shuddering halt, especially when all of that excess power is used for braking.

But power is costly. It costs more in purchase price. It costs more to operate. It costs more to maintain. And it is generally heavier, thus cutting down on useful load carrying ability and therefore the airplane's efficiency. Similarly, reverse pitch props add additional cost to the purchase price and maintenance expense and subtract pounds from the useful load of the plane.

Excess power and reverse pitch props are the simplest ways to provide an ordinary airplane with STOL capability. They place added burdens on the pilot, however, for it takes more skill to handle an airplane that is overpowered, in the normal sense of the word. Remember, too, that tinkering with an aircraft design to achieve more desirable performance in one respect must be met by a sacrifice in some other respect. It is impossible to get something for nothing.

Mounting more power with more weight in the nose moves the center of gravity forward. This requires a change in elevator and elevator trim design to balance out the c.g. change. More power produces more torque, which in turn may require more rudder and aileron effectiveness for compensation. FAA requires every airplane to maintain a certain balance between the elements of performance on the one hand and the elements of controllability and trim—even under abnormal circumstances—on the other. These FAA requirements are quite inflexible. Seldom do they permit an improvement in one direction, of even the most desirable and safe characteristic, if the sacrifice of even a minor characteristic in another direction finds that minor characteristic moved outside of the required degree of tolerance. Thus, great ingenuity is required of designers when product improvement is sought.

The "short" of STOL can also be

achieved by aerodynamic variations from the ordinary. Wings with increased lifting capability mean that the airplane for a given load and power will achieve sufficient lift to become and remain airborne at lower speeds. So again, the ability to take off after only a short run can be achieved by designing the wing so that the plane will fly at a lower-than-usual speed.

Increased lift can be attained by high-lift wing sections where speed is sacrificed for lifting ability. But speed is the airplane's birthright. It should not be sacrificed to any marked degree. A longer or deeper wing is another method of providing for more lift and thus achieving needed lift at slower speeds. But it requires sacrifice of desirable stability characteristics, especially under turbulent or crosswind conditions.

A better method is to design a wing to meet the high-speed cruising requirements—then to employ devices capable of altering the wing design at will, devices such as flaps, slots, spoilers, drag plates, vortex generators. Such devices require little or no sacrifice in cruising speeds, but mean added costs in design, construction, and sometimes in maintenance.

As a rule of thumb, the cost entailed in subtracting one mile an hour from the slow speed regime is roughly comparable to the cost of adding one mile an hour to the top speed regime. The designer, the manufacturer, the financier—all are constantly faced with the questions: "How much will the purchaser pay for performance? What is the acceptable price tag on speed? On utility? On safety?"

The future of STOL aircraft rides on the answers to these questions.

In 1966 the United States appears to have a potential market for between 300 and 600 STOL airplanes. How far the STOL manufacturers can penetrate this market depends on the sales promotion effort expended and upon the efficiency of their distribution organization in finding these prospects, in arranging effective demonstrations, and in sales negotiating. At the present level of sales efforts, about a 20% penetration seems probable.

What does the buyer get in a STOL airplane that he does not get in an ordinary airplane? First, let's define the STOL airplane a little more specifically. It should conform with advanced aerodynamic principles that provide STOL ability without added demands on pilot competence, and should have direct operating costs comparable to those of an ordinary plane of like size-weight-speed ability. Newer STOL airplanes meet these requirements. Therefore, the main sacrifice is one of dollars involved in initial price. What does the buyer of such a plane gain for his extra money?

Actually, a STOL airplane is primarily a "tool" and, rather incidentally, an airplane. In a few respects it bears a relationship to airplanes and helicopters similar to the relationship between a four-wheel-drive station wagon and sedans and jeeps. The STOL airplane is a passenger or cargo carrier that, like the four-wheel-drive wagon, is capable of comfortable, speedy travel on the aerial highway or, when desired, it can operate over and into rugged and minimally prepared fields. To the contractor or rancher, the STOL airplane is a tool just as is a bulldozer or a squeeze gate.

The STOL operator gains the ability to consistently land on and take off from any reasonably level patch 800 feet long and with reasonably clear approaches. He can use such a patch with no more ability required on his part than he needs to use a 2,000-foot strip with an ordinary airplane. In an emergency, such as in deteriorating weather, oncoming darkness, or incipient engine trouble, he can put his STOL airplane into a 400-foot patch and most likely do no damage. With a little skill and luck he can get into a 200-foot patch, possibly risking some bent metal, but he can walk away from it. The knowledge that he can do this is a great "peace of mind generator." It's an insurance policy on which the pilot and his passengers collect instead of their heirs.

As STOL aircraft become more common, they may be permitted to operate away from the runways at major air terminals, thus speeding their own arrivals and departures and not delaying the movements of more mundane planes. The elimination of a 20-minute wait on a planned flight of an hour is

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THE AUTHOR

E. H. Pickering, president of Wren Aircraft Corporation of Fort Worth, Tex., has a broad and varied background in virtually every facet of aviation. His interest and activity in the field goes back to 1931 when, while still in high school, he began taking flying instructions in a Ford Tri-Motor. At the same time, he served as a publicity representative for Curtiss Flying Service of Pittsburgh, Pa., wrote an aviation news column for the Pittsburgh Press and prepared and broadcast thrice-weekly aviation news programs on radio station KQV. Since then he has served as photographer, publicist, writer and editor for aircraft manufacturing and air carrier companies, aircraft tool designer and planner, director of technical and editorial research for an aircraft engine company and public relations director for two general aviation companies. Somewhere, he also found time to create a lightweight single headphone for airline pilots, the first such device to receive CAA Type Certification, and to operate a Texas cattle ranch. With Wren Aircraft Corporation since 1962, he has served successively as vice president for marketing, secretary and treasurer, and now president.

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like advancing the cruising speed of a 150 m.p.h. airplane to 200 m.p.h.—no small consideration in justifying the purchase of a STOL airplane.

Similarly, the ability to land directly adjacent to a construction site, eliminating a 20-minute journey by car from the closest airport, is comparable to greatly accelerated speeds. If the same time saving can be achieved at both ends of the journey, a STOL plane can be as efficient as an executive jet on short hauls—on longer hauls, too, if ground travel time is increasingly greater than 20 minutes.

Now, how about slow flight capability in the 40 to 60 m.p.h. range for a duration of several hours, if required—without placing an added burden on the pilot over what would be encountered in the 100–150 m.p.h. range?

The 40–60 m.p.h. range is a "patrolling" speed. Notice, on a drive through the country, how travel at this speed lets a person enjoy the landscape. Apply the same speed to a patrol "drive" along miles of power transmission lines, pipelines, above busy highways; searching for lost cattle, for fugitives or for overdue aircraft; inspecting pasture conditions, proposed highway sites, endless acres of forest; counting game; trailing a magnetometer; or just sightseeing at low levels over this magnificent land of ours. All of this is enhanced by use of a modern STOL airplane.

Low-level aerial sightseeing deserves special comment. The layer of air from 500 feet above the surface down to two feet off the ground offers the greatest view, but, in the opinion of many, it is the most dangerous airspace because of the speeds at which hazards are encountered. Not so in STOL aircraft, at least down to a degree that is no more hazardous than traveling busy highways in an auto. The helicopter offers similar viewing ability, but at greatly added cost and with limited range. Some of today's STOL airplanes can fly at slow speeds from dawn to dusk, should the aerial viewer so desire, and at costs no greater than those of an ordinary airplane.

Speaking of costs, all of the items of expense are not limited to aircraft purchase price, fuel, oil, insurance, maintenance, and hangaring. The ground from which it takes off and lands is costly, too. The larger the airport, the greater the cost. Where special strips are required for special operations—at construction jobs, well sites, near jungle missions, by moun-

De Havilland Canada Fills STOL Gap

With a growing number of short takeoff and landing aircraft invading the commercial market, de Havilland Canada recently unveiled its newest model which, it claims, will fill a significant gap in the STOL line. It is the DHC *Twin Otter*, a short field performer powered by two Pratt & Whitney 550 h.p. turboprop engines, capable of carrying 17 passengers or 4,000 pounds of cargo and cruising at speeds up to 180 m.p.h.

The *Twin Otter*, publicly demonstrated for the first time in mid-July, is the sixth plane in the current de Havilland Canada line. All are fixed-wing, STOL-performance craft, as DHC defines that term—capable of taking off and landing on a field 1,000 feet or less in length.

When DHC entered the STOL field 18 years ago with its four-place *Beaver* (designed for and initially aimed at the Canadian bush flying market) it enjoyed almost a monopoly in that type of aircraft production. As the concept caught on, competition increased and demands grew for higher performance and greater load capabilities in STOL craft. DHC responded with development of the six-place, single-engine *Otter* in 1951; the 28-passenger, twin-engine *Caribou* in 1958; the turboprop, 10-passenger *Turbo Beaver* in 1963; and in 1964 the six-ton capacity *Buffalo*, which has been delivered to the U.S. Army for evaluation as a twin-turbine tactical troop transport aircraft.

Introduction of the "in between" size *Twin Otter* fills the need for a light twin STOL, according to DHC chairman and managing director P. C. Garratt. A wide market for both commercial and military applications is seen for the *Twin Otter*, he said. Structured along the same lines as the single-engine, piston-powered *Otter*, DHC's newest model is designed to be easily fitted with wheel, float or ski landing gear.

From the standpoint of units in operation, de Havilland Canada has to be ranked as the world's leading STOL manufacturer. More than 2,300 of its aircraft are in use today in some 65 countries. Company officials foresee an increasingly larger market for their products in the years ahead and are

DHC Twin Otter Performance Specifications

Takeoff distance (10,500 lb. gross weight)	600 ft.
Landing distance (9,500 lb. gross weight)	370 ft.
Fuel capacity	391 gals.
Payload	4,000 lbs.
Service ceiling	29,250 ft.
Cruising range	800 miles
Stall speed	63 m.p.h.
Maximum cruise	184 m.p.h.
Normal cruise (80% power)	170 m.p.h.
Rate of climb (two engines, full gross)	1,650 f.p.m.

tain mines, for example—the cost saving in preparing a 600-foot strip over that needed for an 1,800-foot runway may more than cover the added cost of a STOL airplane over that of an ordinary plane.

The number of active pilots and airplane owners represents a small part of the total population. We have no idea of the number of potential pilots and eventually of airplane owners who shy away from flying merely because they lack confidence in their ability to zip in to a smooth, safe landing. Every pilot has allowed someone to handle the controls of his plane who enjoyed doing so while the plane was in flight, but who wanted no part of doing so close to the ground, as in a landing approach.

A plane with a slow-speed ability, which eases its way toward a landing at speeds with which the novice is familiar from driving his car, stands to attract many newcomers to flying who today are simply scared away. A properly engineered STOL trainer of the Cessna 150 or *Cherokee 140* class seems to have real potential in this field. Someday someone will bring out such a plane. It could have a beneficial effect on the entire industry.

STOL aircraft, at least those that are stable and maneuverable, also have capabilities in instrument approaches under ILS or radar guided conditions that make them the world's easiest planes to handle for this purpose. As an instrument trainer they can be used to familiarize the neophyte with the experience of instrument approaches before graduating him into the whizbang letdowns of the ordinary airplane. Most instrument-rated lightplane pilots seldom practice instrument approaches. They reserve this luxury for the occasion when they may get trapped into having to do so. In a STOL airplane capable of true slow-speed flight, no instrument-rated pilot should hesitate to encounter instrument approach conditions, because this becomes a simple matter at low speeds. Thus the STOL in still another manner extends the utility of an airplane.

STOL aircraft maintain most of the advantages of conventional airplanes, and in addition offer utility, safety, peace of mind, and fun that is over and above an ordinary plane's ability, STOL enthusiasts believe. There are more STOL airplanes flying today than ever before and there are more companies manufacturing them. It remains to be seen how many prospective aircraft buyers are willing to pay extra for STOL ability. ●

at work to strengthen an already respectable parts and supply network throughout the world, Garratt said.

As with other de Havilland Canada aircraft, key factors of the *Twin Otter* are reported to be its low drag, low speed stability and control, and good ground-braking characteristics. Its basic price in the United States will be slightly under $300,000. ●

Newest addition to de Havilland Canada line of STOL aircraft is its turbine-powered Twin Otter, above. Below are shown (from left) DHC's Caribou, Otter and Turbo Beaver. Tail of medium-heavy Buffalo, an enlarged version of the Caribou, can be seen in the background with U.S. Army markings