AIRCRAFT

An affordable aircraft based on the technology of the '90s rather than the '30s could revive a dying industry

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Time to reinvent the general aviation aircraft

For all practical purposes, the production of small general aviation airplanes in the U.S. has come to an end. Fewer than a thousand small four-seaters were produced in 1986, and manufacturers that formerly could be considered the big three have almost abandoned the business. Production of all general aviation airplanes is about 1,500 a year, less than 10% of what it was a decade ago. Although there are many reasons for the erosion of this industry, outmoded technology is the most important. Although some high-end general aviation aircraft such as the Beach Starship and Piaggio Avanti incorporate advanced technologies, most small aircraft were designed in the late '40s using technologies established a decade earlier. Indeed, the average age of U.S. small airplanes is 20 years. Prices have risen, not only because of decreasing volume, but because liability costs here skyrocketed and production techniques are outmoded. Revival demands reinvention of the small general aviation aircraft to shape it into what might be called the Modern Equipment General Aviation (MEGA) airplane. Such radical rethinking could cut prices to where ordinary persons could afford them, boost production to 50,000 a year by the year 2000, and establish general aviation as an important adjunct to commercial air transport.

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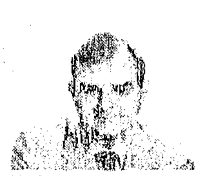
Since general aviation has minimal impact on the domestic economy, its slide has been allowed to proceed unchecked. Although general aviation is said to be a $15-billion business, only $150 million of that can be attributed to the sale of small airplanes. Ultimately, however, its decline affects commercial air travel. As the income of fixed-base operators shrinks, small airports near major urban areas are being driven out of business, increasing the already heavy congestion at most major airports. General aviation has long been a spawning ground for airplane pilots, but it has not been producing enough well-qualified pilots to meet the demand. Consequently, the right seats of many commercial aircraft cockpits are occupied by relatively low-time pilots.

Most of the reasons for the decline in production of small airplanes boil down to cost and are self-feeding. Certification costs have risen, as have production costs, and both increase for each aircraft as sales decline. Manufacturers' liability insurance or "self-insurance" has become a significant percentage of the total cost of



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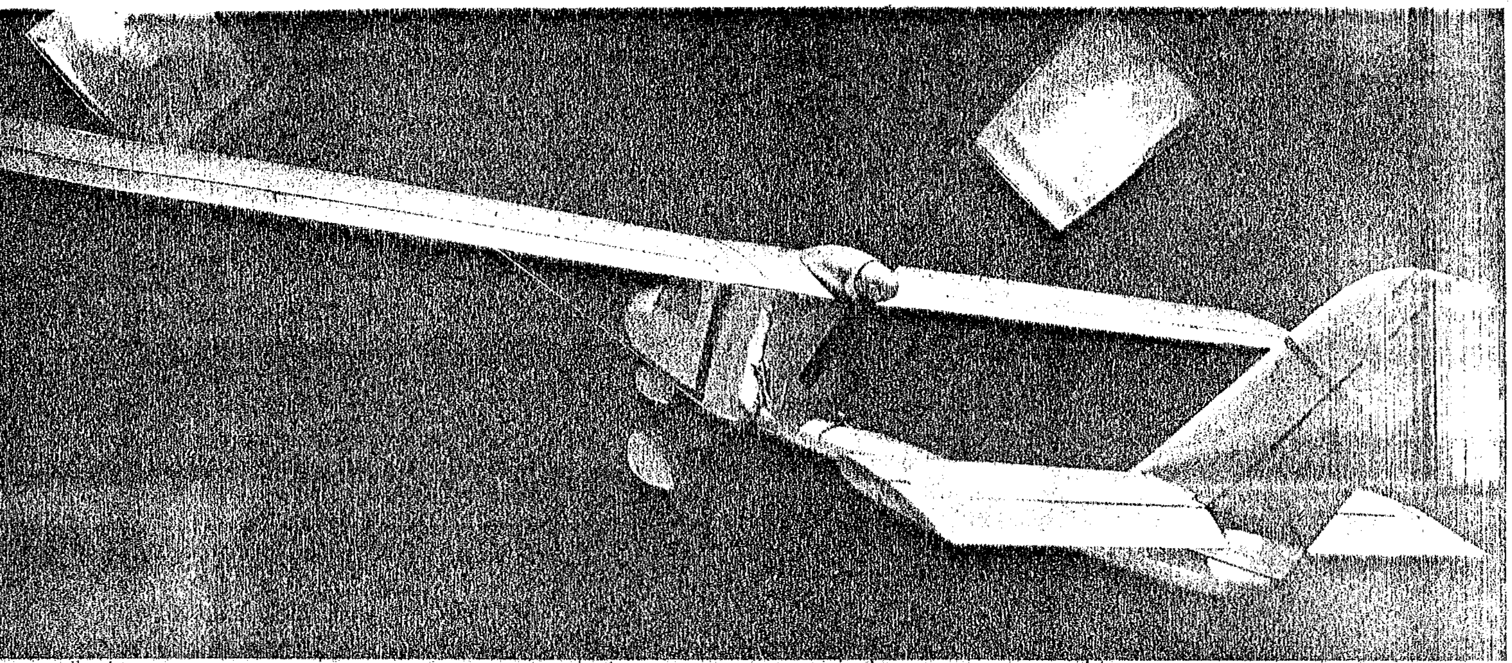


DeVore Sunbird incorporates advanced technology in a new general aviation aircraft, as the author advocates. Here a model undergoes testing in NASA-Langley 12-foot wind tunnel.

each new airplane. The high costs are not entirely unjustified, since the accident rate for general aviation aircraft still is substantially higher than for other forms of transportation. If accident rates could be reduced to that for automobiles, by such means as simpler flying qualities and tighter but less onerous air traffic control, liability costs per airplane would shrink drastically, and the sale of new airplanes would be encouraged.

As a result of escalating costs, in most cases flying a general aviation airplane is more expensive than traveling by other means. Aside from cost, general aviation has special advantages for rapid point-to-point travel for small groups of people. It cuts straight across and complements the hub-to-hub and hub-spoke services of the airlines. Given area navigation and sufficient satellite airports, general aviation airplanes could be routed through underused airspace, avoiding areas of congestion both in the air and on the ground. By diverting significant numbers of travelers from the public carriers, general aviation could reduce congestion in the terminal area.

For new American-made airplanes to attract buyers, they must offer greater benefits than used or foreign-made airplanes. A truly advanced aircraft could enlarge the domestic market, recapture sales lost to foreign manufacturers, and win back our former large share of the export market. Manufacturing small airplanes could be a multi-billion-dollar business. But if the industry is not rebuilt, it will probably fall to overseas competition.

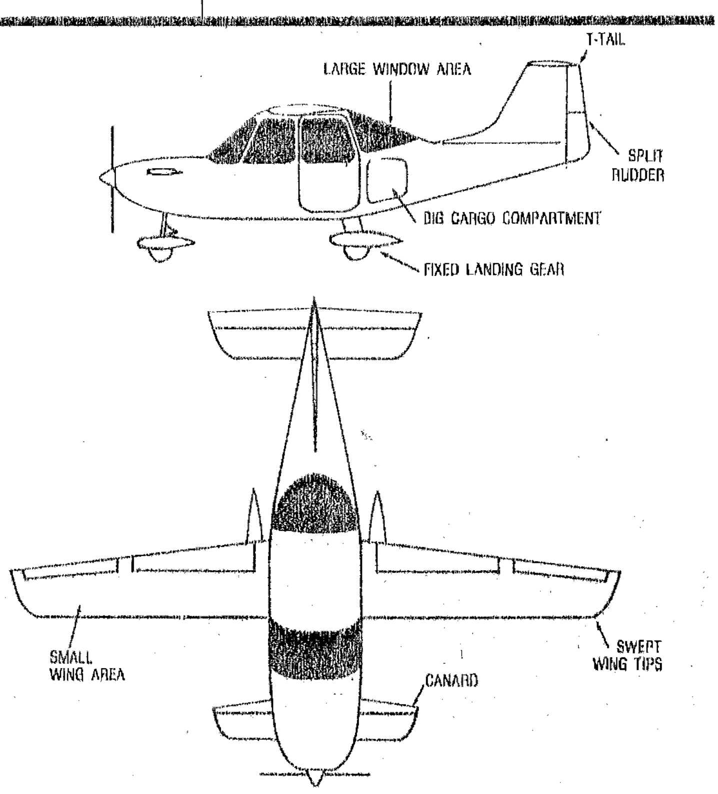
At this low point in the industry's fortunes, the aeronautical engineering profession has an opportunity, if not an imperative, to reinvent the general aviation airplane to satisfy the needs of potential users while accounting for the realities of the National Airspace System and encouraging manufacturers to build such airplanes.

An exciting array of new technologies for the most part has not been applied to small airplanes. The microprocessor has revolutionized products as mundane as the steam iron, but has done little for general aviation aircraft. Most of today's general aviation airplanes are essentially custom-made by labor-intensive methods untouched by modern manufacturing techniques. The new methods are applicable to moderate volume because they emphasize flexibility—using computers, communication networks, and robotic devices, including numerically controlled machines—to perform a wide variety of functions from preliminary design to laying on the paint.

New materials promise weight savings and drag reduction. Dramatic breakthroughs in subsonic aerodynamics made in recent years may soon be followed by others. Great strides made in automobile engines, such as electronic ignition and stratified charge, could be applied to reciprocating engines for small airplanes, and contemporary research on propellers and rotary and turbocharged diesel engines promise more efficient propulsion.

The principal objective in reinventing the general aviation airplane should be to fashion alternate transportation attractive to a large number of air travelers in the same way automobiles are a desirable alternative to the train and bus. To satisfy this objective, the MEGA-Plane must be designed for production, for safety, and for cost.

A typical four-place MEGA-Plane might have as its most obvious new feature a controllable canard surface in addition to a conventional horizontal tail. More subtle visual characteristics would include a split rudder, a T tail, small wing area, swept wing tips, large window area, fixed gear, and a sizable storage compartment. Internally, however, the MEGA-Plane would be very different from today's general aviation airplane.



The author's concept for a typical four-place MEGA-Plane features design improvements that might revive a flagging general aviation industry.

MEGA-Plane should be as simple as possible, containing few clever-but-failure-prone gadgets. For example, it may be preferable to forego the extra aerodynamic efficiency of an intricate flap deployment mechanism in favor of a simply hinged flap. The latter device is easy to build and certify, unlikely to fail but easy to fix, and can back up the ailerons for roll control. Electronic systems should consist of as few easily changed line-replaceable units as possible. Redundancy should be added where single-string reliability is inadequate, particularly in the electronics and systems having to do with control of the aircraft. Failures should be forgiving, allowing time for human decision making. Flying qualities and displays must be good enough to allow a relatively inexperienced or out-of-practice pilot to maintain safe control in a wide range of weather and traffic.

The principal control features of the MEGA-Plane would be its three-surface longitudinal control, control redundancy, and simple flaps. Three-surface control would allow the center of gravity to travel farther, permit trimming in pitch for minimum cruise drag, give two means of pitch control, and, because the canard rotates the aircraft at takeoff by positive lift, reduce wing area. From its position immediately behind the propeller, the canard would deflect the slipstream, producing strong forces and moments that could reduce takeoff distance, smooth the rough ride caused by gusts, and prevent or help recover from stalls and spins.

Each control surface would be simply hinged and independent. Hence, 10 surfaces could be used in numerous combinations to produce three forces and three moments for control. Ailerons could act like flaps, and flaps like ailerons, in the event of failure. Cockpit controls could be similar to current devices or could be side-arm controllers. In either case, the pilot's inputs would be processed by central computers that would take into account flight conditions, desired flying qualities, drag minimization, and failed actuators, if any, before sending commands to the control surfaces.

Reconfigurable control surfaces would require uninterrupted electrical power. To ensure an electrical supply, the aircraft would carry an auxiliary power unit and large-capacity batteries. The auxiliary power unit would also feed anti-icing heaters for the primary aerodynamic surfaces.

In fact, after one or two random failures, changes in flying qualities would be barely discernible. Electric actuation would be possible because hinge moments for this small an airplane need not be large. Cost and reliability benefits would accrue from using identical actuators on all control surfaces.

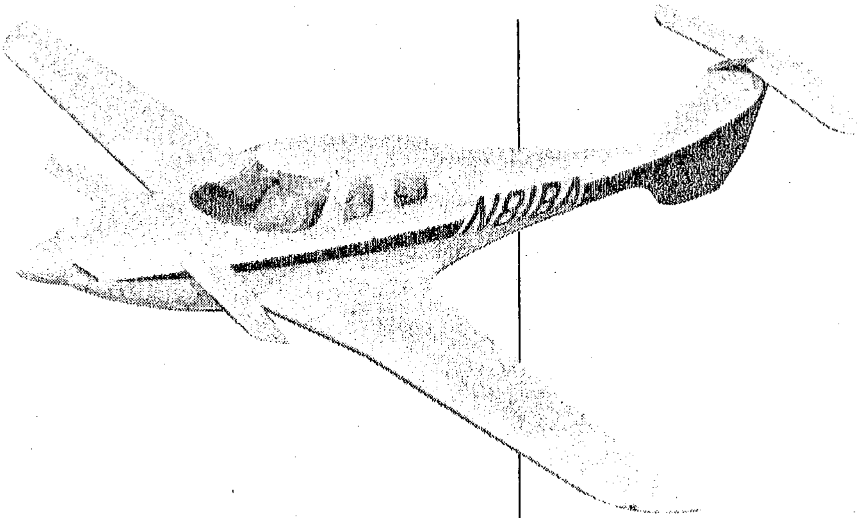
Though a pilot should have great difficulty in putting such an aircraft into a spin, if he manages to do so, he would discover that it responds readily to traditional methods of recovery owing, in part, to the unshadowed vertical tail and the full-length rudder.

Recent flight research has shown that encouraging natural laminar flow over the airplane can significantly reduce drag. Similarly, long-held notions of planform effects are being questioned. Swept tips and even more dramatic treatments, such as sheared tips, crescent planforms, and serrated trailing edges, may further reduce subsonic drag.

MEGA-Plane must be specifically designed for easy certification and to fit into the air traffic control system, or none of the suggested improvements can be realized. If a production rate of 50,000 small planes a year were reached by the year 2000, by 2015, MEGA-Planes would attain an equilibrium population of a million. Though there is a lot of unused airspace that could be occupied without infringing on airline operations, a million small aircraft could not take to the air without positive assurances that they would not interfere with each other. Our biggest problems and most tragic accidents have resulted from mixing controlled and uncontrolled traffic. One solution is to put all under control. Thus, in areas such as the Northeast, no one would be allowed to fly uncontrolled.

But control need not be burdensome. As soon as the pilot turned the ignition key, the plane would automatically report in, give its destination, and receive directions. The area navigation system would automatically incorporate instructions into its planning and would inform the pilot of what he needed to know when he needed to know it. An area navigation system would be as important as wings and engine to this airplane. As the plane flew along, it would continue reporting in automatically. Wearing this electronic bit and reins, MEGA-Plane could be given preferential departure, routing, and arrival assignments without degrading safety or disrupting airline schedules.

Fail-safe area navigation would be integrated with the flight control system. Both systems would use solid-state motion sensors and external navigation aids like Loran. The integrated navigation, guidance, and control system would have artificial intelligence as well as collision avoidance and wind shear and wake-vortex warning and avoidance features. Electronic cockpit instruments would be backed up by a few air driven essentials.



This Beech Model 81 single-engine, all-composite aircraft is designed to increase aircraft performance and efficiency.

MEGA-Plane's structure should be designed for inexpensive, automated fabrication and assembly. Off-the-shelf components that can be ordered out of a catalog should be used where possible, and major elements should be designed to minimize labor-intensive fabrication. Basic construction would still be an aluminum frame partly covered by aluminum skin. At least those portions of the skin designed to attain laminar flow would have to be smooth composite. Many components would be common to most models of most manufacturers and be made by one or a few suppliers to hold down cost. Propulsion might come from a turbocharged rotary or diesel engine that could use widely available fuels, such as auto gasoline or Jet A.

All of this sounds rather expensive, and if pursued using current methods and costing, it would be. However, designing for new technologies, new manufacturing techniques, and large production runs should keep costs low. Reinventing the small general aviation airplane is a systems problem, involving airplane design, human factors, and air traffic control. We have dealt with the first. The other two will need attention also, and soon even coping with hardware design may become difficult. Although important research continues in applicable technology areas such as stall and spin dynamics and aerodynamic flow control, neither the FAA nor NASA supports substantial research and development specifically directed at general aviation. If general aviation declines into a pursuit for hobbyists and the well-to-do, remedying that situation will become increasingly difficult. But if government, academic, and industrial researchers start now, they can reshape air transportation and stimulate the economy.