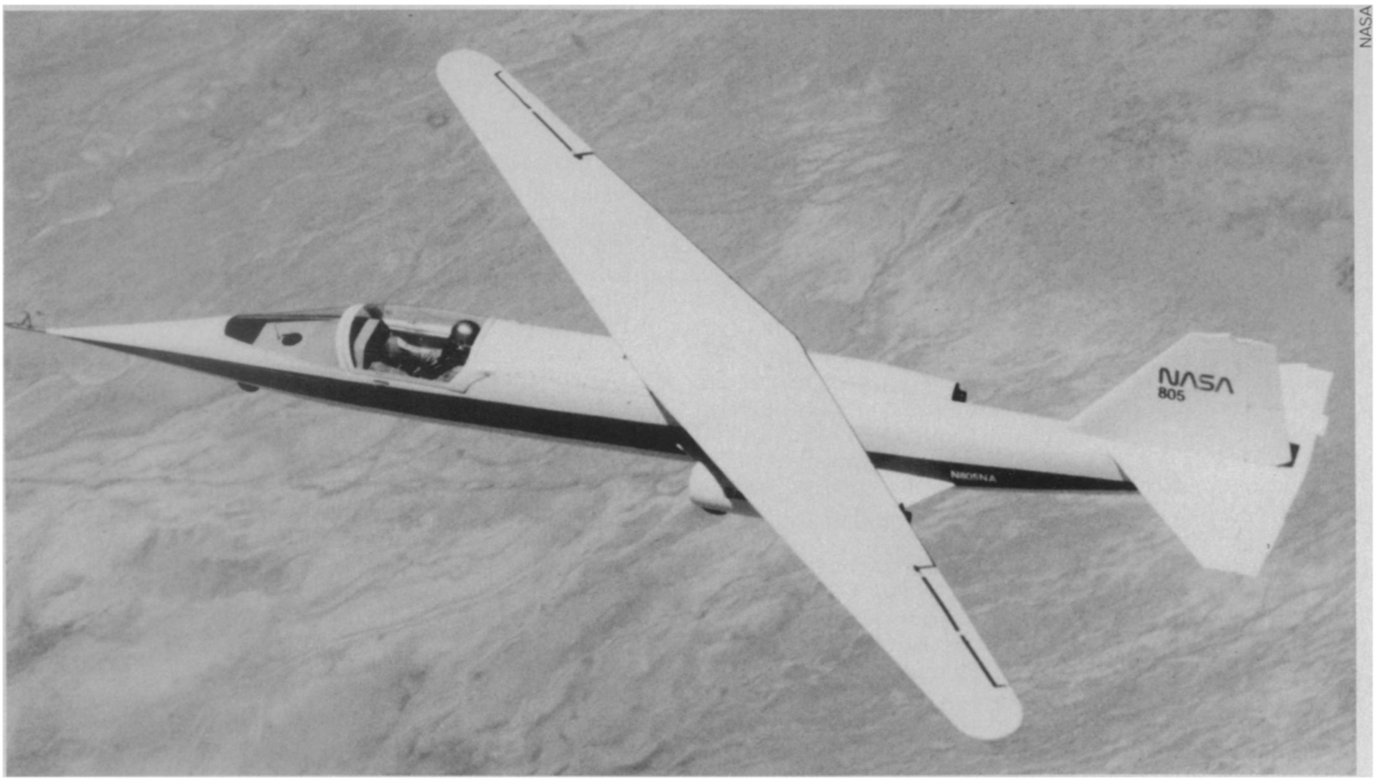
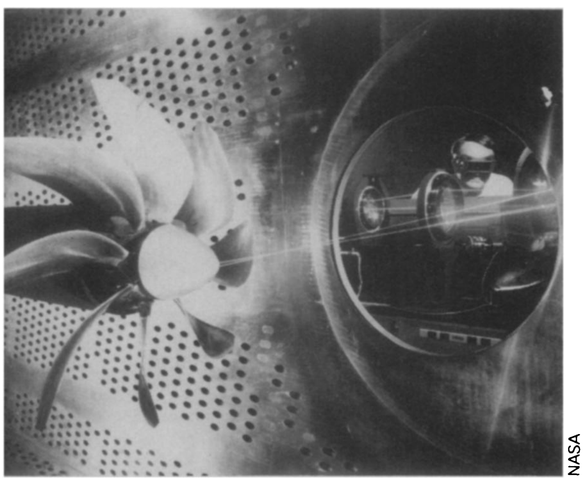



# The Shape of Wings to Come

## New materials and manufacturing techniques are making feasible many aircraft designs that hitherto have flown only on paper




*Top: The AD-1 research airplane, whose wing can be pivoted in flight, was successfully flown at various wing angles up to a maximum of 60°.*

*Bottom: A new propeller design is tested in a wind tunnel at the Lewis Research Center in Cleveland. A laser system monitors the speed of various parts of the propeller.*

By IVARS PETERSON

For centuries, tinkerers have dreamed of exotic flying machines. Their sketches showed birdlike contraptions with flapping wings, vast assemblages of propeller-driven balloons and other bizarre forms. Some of these dreams were actually built; a few even flew. Most never got off the ground.

Today, the pursuit of fuel-efficient, high-performance aircraft is putting many innovative designs on drawing boards and into wind tunnels and test facilities. Because of the flexibility of new materials and computer-controlled manufacturing techniques, many of these designs are much more likely to fly than those of the past.

"We're dealing with a number of pacing technologies that will allow us to do things in structures that we couldn't do before or in aerodynamics that we couldn't achieve before," says Roy Lange, advanced concepts department manager of the Lockheed-Georgia Co. "They allow us to have a little more freedom in what our aircraft look like to see if we can't get another step improvement in efficiency."

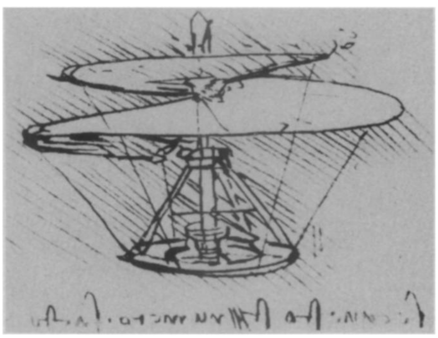
Lockheed engineers, for example, propose Siamese-twin cargo aircraft that consist of two giant airplanes flying side by side and sharing one wing. Another design features a ring-like wing extending from one side of the fuselage to the other. This wing is expected to be half as heavy as conventional straight wings yet may provide the same lifting capacity.

Already flying is the experimental XV-15, a tilt-rotor aircraft built by Bell Helicopter Textron for the National Aeronautics and Space Administration. The XV-15 has helicopter-like rotors for vertical takeoff and landing, but once the aircraft is airborne, the rotors tilt forward to become propellers. Also flying is NASA's AD-1 research airplane although it looks as airworthy as a pair of scissors. This aircraft has a wing that pivots so that during takeoff and landing the wing is perpendicular to the fuselage, but during high-speed flight the wing is obliquely angled to reduce drag.

"The impetus behind all these new design concepts is the high cost of fuel and what that's doing not only to the military but also to the airlines," says Lange.

Cutting fuel consumption is a major goal of aircraft design programs. In 1981, U.S. airlines burned about 10 billion gallons of jet fuel at an average cost of more than one dollar per gallon. If fuel consumption had been 5 percent lower, many airlines could have converted an operating loss into a profit. Similarly, military aircraft could increase their range and

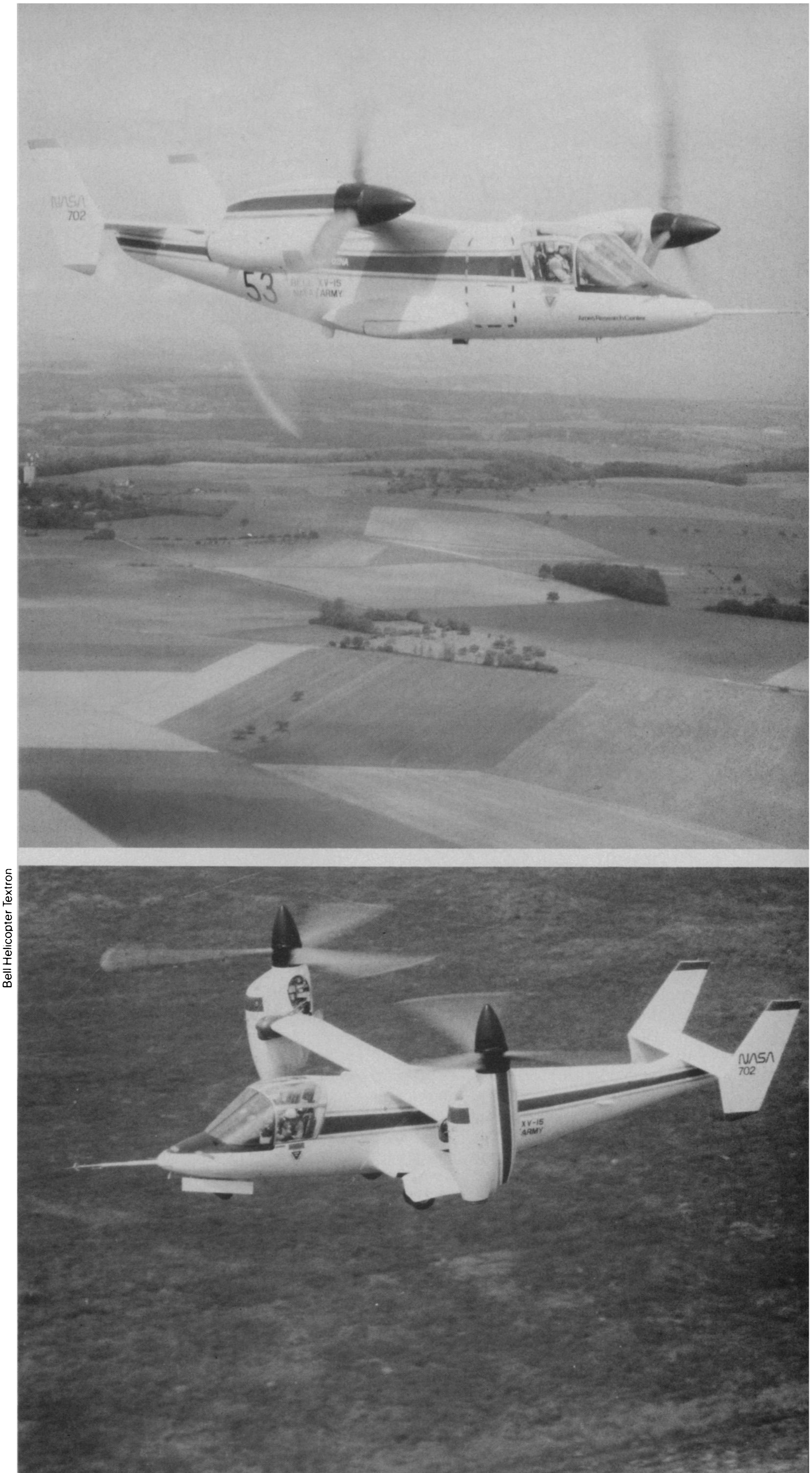
*Leonardo da Vinci's notebooks feature several flying machine designs, including this helical-screw helicopter (1486-90).*



would be less expensive to operate.

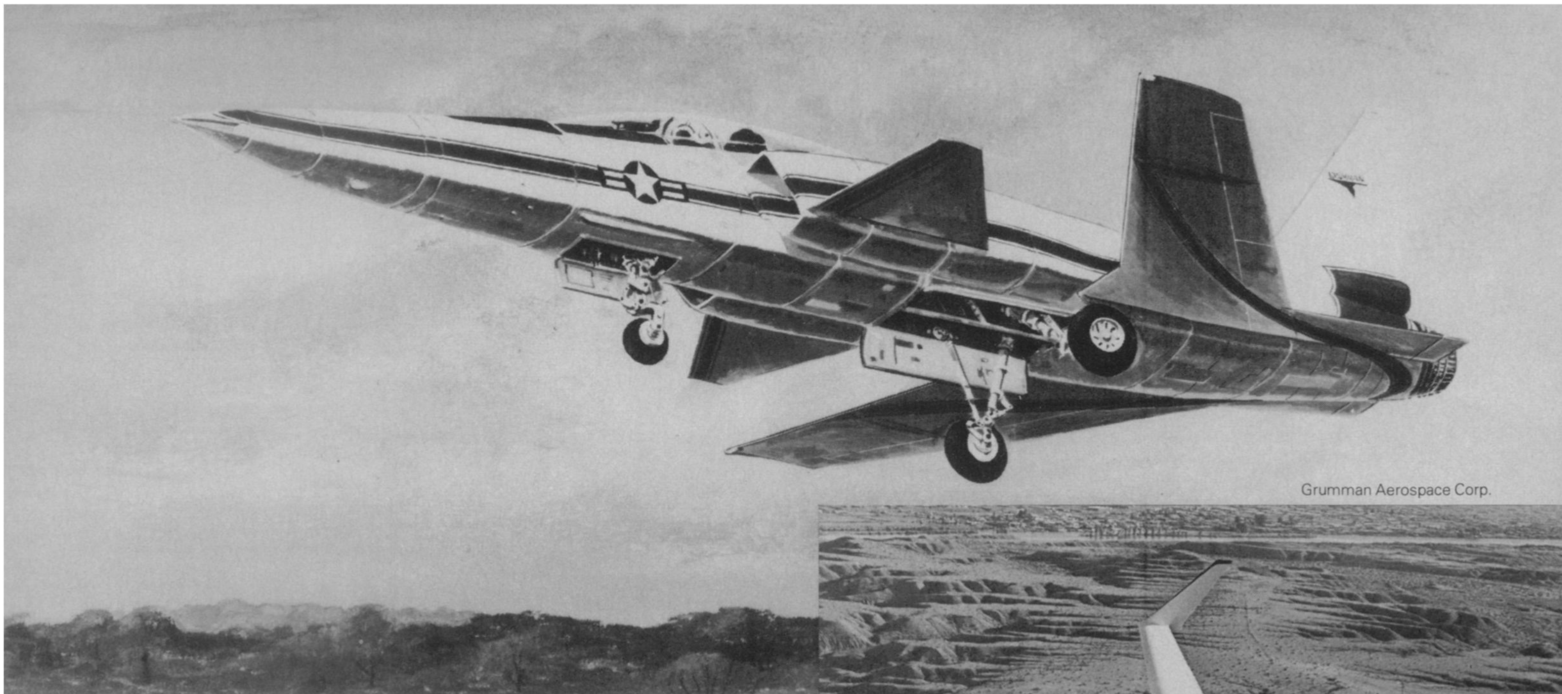
NASA's Aircraft Energy Efficiency program addresses all of the major factors that affect fuel consumption — the type of propulsion system used, the weight of materials, the shape of aircraft, the effective life of engine parts, and the use of computers to smooth an airplane's flight automatically. NASA research has shown, for example, that a turboprop engine with eight or 10 short, thin, curved propeller blades, arranged like a large pinwheel, can drive transport aircraft at jetlike speeds with fuel savings of about 20 percent. A 9-foot-diameter experimental propeller is now being built for flight testing on a demonstrator airplane.

Aerodynamic improvements, which reduce air resistance, also cut fuel consumption. One subtle change is the addition of winglets, near-vertical extensions of the wing that reduce drag and save fuel by smoothing wingtip air turbulence. Many designs now include winglets, and even the familiar McDonnell Douglas DC-10 sprouted winglets in a recent test. The full-scale test showed that winglets worked, and now researchers at the Douglas Aircraft Co., in association with NASA, are doing more wind tunnel tests based on the full-scale findings. "We expect to be able to apply the winglet to the new transport aircraft, the C-17, that we are design-




Bell Helicopter Textron

*The XV-15 tilt-rotor aircraft converts from airplane to helicopter in 12 seconds.*



Grumman Aerospace Corp.

Rutan Aircraft Factory

*Top: This "backwards-looking" tactical jet fighter offers superior aerodynamics and high efficiency.*

*Inset: Burt Rutan has designed numerous innovative, low-cost airplanes, like this "Long-EZ" sport plane, for do-it-yourself plane builders.*

*Far right: The Lear Fan is built almost entirely from graphite/epoxy composites. The airplane's engines are located within the fuselage with only the air intakes exposed. The fan, which looks like a propeller, is at the rear, behind a unique Y-shaped tail.*

ing for the Air Force," says Elayn Bendel. "That aircraft is in a study-development stage right now."

Wings are changing in other ways. One modification involves perforating a wing's skin with thousands of tiny holes. Pumps would draw air through the holes creating, scientists hope, a smoother cushion of air flowing over the wing. A wing equipped with such a "laminar flow control" system is being readied for flight testing next year.

Boeing, together with NASA and the Air Force, is developing a "mission-adaptive" wing, which acts somewhat like a bird's wing in flight. A hydraulic system changes the shape of the leading and trailing edges of the wing to its optimum shape for various flight conditions. Future systems may contain computerized sensors that allow the wing to adjust automatically to changes in the plane's direction, speed and load.

A lighter airplane would also increase fuel efficiency. One way to save weight is by substituting new composite materials for conventional aircraft metal alloys. Composites consist of networks of graphite, glass or man-made fibers embedded in plastic. Often these materials can be not only lighter but also stronger than the metals they replace. The first composites with the right combination of weight, strength and rigidity appeared in the early 1970s. The two materials now used most often in aircraft manufacture are Kevlar, invented by DuPont, and carbon fibers. These fibers are encased in plastics such as epoxies. Carbon-fiber-reinforced plastics are used in areas requiring stiffness or high strength. Kevlar-reinforced plastics are lighter but less resistant to bending or compression. As an extra bonus, both are immune to corrosion and cracks caused by fatigue in the material. Often a composite structure can be made from fewer parts than an equivalent metal structure. More complicated shapes, like the networks of ducts needed for a wing with laminar flow control, are also easier to build.

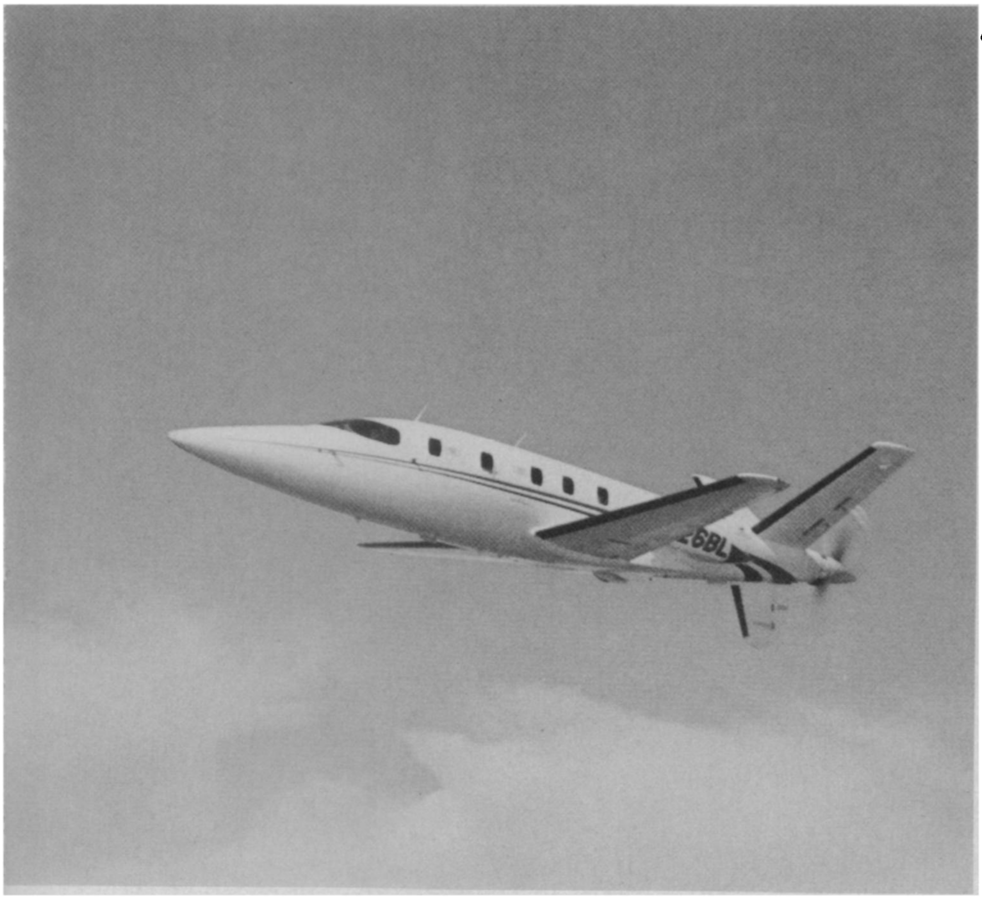
One important disadvantage is that composite materials are expensive. Researchers are also concerned that composites provide significantly less protection than metal against lightning strikes (SN:11/27/82, p. 346). However, military aircraft began using composites in the early 1970s, and now fighters and bombers with as much as 40 percent plastic content are on the drawing board.

Grumman Aerospace Corp.'s new tactical jet fighter features wings that sweep forward from the rear of the plane, giving the impression that the fighter is flying backward. Although designers have recognized the aerodynamic advantages of forward-swept wings for many years, these wings undergo considerable stress at high speeds and tend to break off. Sufficiently stiff metal wings prove to be too heavy, canceling out any aerodynamic gains. This wing design did not become practical until suitable advanced composite materials were available. The fighter may be flying early in 1984.

The Boeing 767, which entered airline service last year, is the first commercial jetliner to use composites extensively as substitutes for heavier aluminum and fiberglass parts. The airplane is 3 percent plastic, which cuts about 1,500 pounds from the craft's typical 130,000 pound weight. The fuel savings could amount to 22,500 gallons in a year's worth of flying for each plane, according to Boeing estimates.

The first non-military aircraft to use reinforced plastics in its basic, load-bearing structure is the Lear Fan 2100, designed for the executive aircraft market. While most manufacturers use composites to cut the weight of components that do not carry the aircraft's weight in flight, the Lear Fan is 95 percent plastic. However, the airplane is still waiting for certification from the Federal Aviation Authority.

Some of the most innovative designs and uses of materials are seen in the homebuilt aircraft market. These are fly-



Learavia Corp.



ing machines produced, with the aid of plans or kits, from parts or raw materials. Walter J. Boyne of the Smithsonian's National Air and Space Museum in Washington, D.C., says, "The homebuilder has long surpassed the standard wood-and-metal techniques of 'Spam Cans,' a derogatory term used by homebuilders for airplanes turned off the assembly line. They are using sophisticated new materials, such as fiberglass and composites, and they are using them in new ways. In a similar way, they have left behind the configurations of conventional small aircraft and gone into advanced designs which can produce very high performance with engines of very low horsepower."

One of the most successful and innovative of all homebuilders is Burt Rutan. His designs have included the VariEze, which does away with the tail and uses canards (small lifting wings located in front of the main wing), the Grizzly, designed for backwoods camping, and others. Rutan is now designing a special aircraft for "Project Voyager," a 10-day, round-the-world, non-stop, non-refueled flight. Rutan says such a flight is now possible because of the combination of low-drag, high-lift airframes and low fuel-consumption engines. "Project Voyager" is both a technical challenge and an interesting adventure, he says.

While homebuilders can afford to be adventurous in testing exotic aircraft and modifying their designs by trial and error, manufacturers of large aircraft must be more cautious. Safety concerns and the costs involved are much greater. Thus, changes in the visible forms of commercial airliners or even military aircraft are subtle. Wings are shaped a little differently; winglets are added; composites are used; computers invade the cockpit. Most of these changes come about after extensive research, often supported by NASA.

Even now, with new materials and manufacturing techniques, many designs remain on paper. For example, recent theoretical work on Lockheed's ring-wing design shows that it doesn't look as good as the engineers thought earlier. In the same way, the ungainly twin-body concept looks inefficient now, but in the future, for payloads of two or three times the size of those carried by a Boeing 747 or a C-5, this cargo aircraft may be useful.

Lange says, "Sometimes our futuristic ideas look unrealistic to the average person, but a designer has to think 'far out' in order to lower the direct operating and life cycle costs of tomorrow's aircraft." On top of that, aircraft designers still can't predict exactly how a new plane will fly until they build and fly first a model and finally a full-scale prototype. □