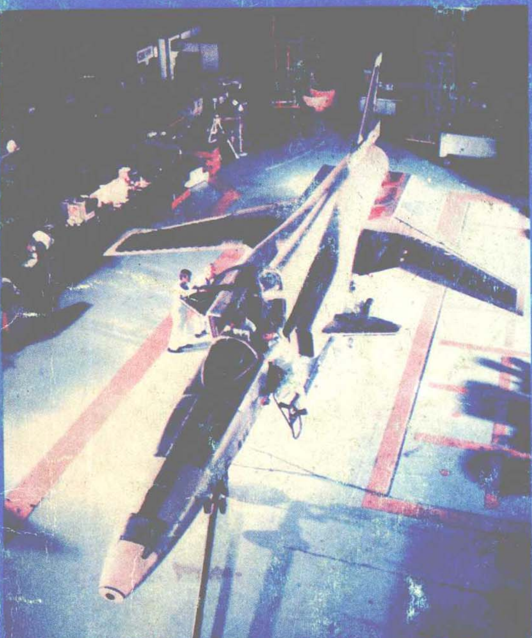
RESEARCH

Testing the Boundaries of Flight



人类征服太空的历程 英汉读本

飞机设计奥妙

Don Berliner 著

马振辉 译

广西科学技术出版社

AIRPLANES

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A Grumman X-29 (see pages 40-41) is carefully checked by aeronautical engineers and technicians.

1

The Research Airplane

Some airplanes are not meant to carry passengers or freight. They are not war planes or personal planes or sport planes. There is no thought of putting them into mass production and building many more like them. They are research airplanes.

Research airplanes are meant to help people learn how to build better airplanes. They are built to explore new areas in the science of flight and to solve problems that are expected to arise 5 or 10 or even 25 years from now. For this reason, researchers must have a clear vision of the future and know enough about trends that are expected to develop so they can visualize airplanes that might be flying when their young children are adults. Some research planes are used to learn how to design airplanes that will fly faster than any other airplane has ever flown. Others are designed for learning how to develop airplanes that can take off from a space as small as a parking lot instead of a long runway.

Designing a Research Airplane

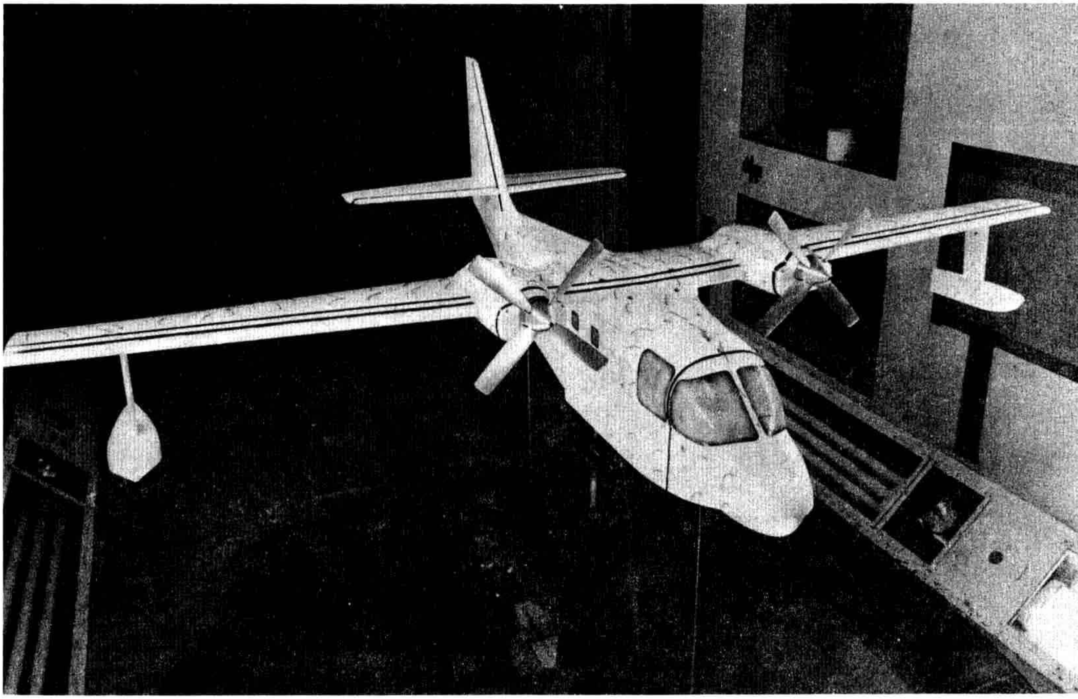
To learn how airplanes might be able to fly faster or more efficiently, scientists and aeronautical engineers research current airplane designs. Once they have pinpointed a problem with an existing design, they must decide how to go about solving it. First, they try to find out if an entirely new type of airplane is needed. Or, perhaps an airplane flying today can be *modified*, or changed. For example, engineers may decide to remove a plane's original wings, engines, or

Computers such as the ones shown here are used to design research airplanes.

control surfaces and replace them with new, untried ones.

Engineers design new planes using computers as electronic drafting tables. A design for a new airplane is programmed into the computer, and then changes are made on the screen with a special hand-held device. Computers allow engineers to find out how a new or modified airplane will fly even before it is built, which saves both time and money.

When the engineers have developed a good design, a large scale radio-controlled model of the real airplane may be built. A model can be redesigned easily and quickly, and no

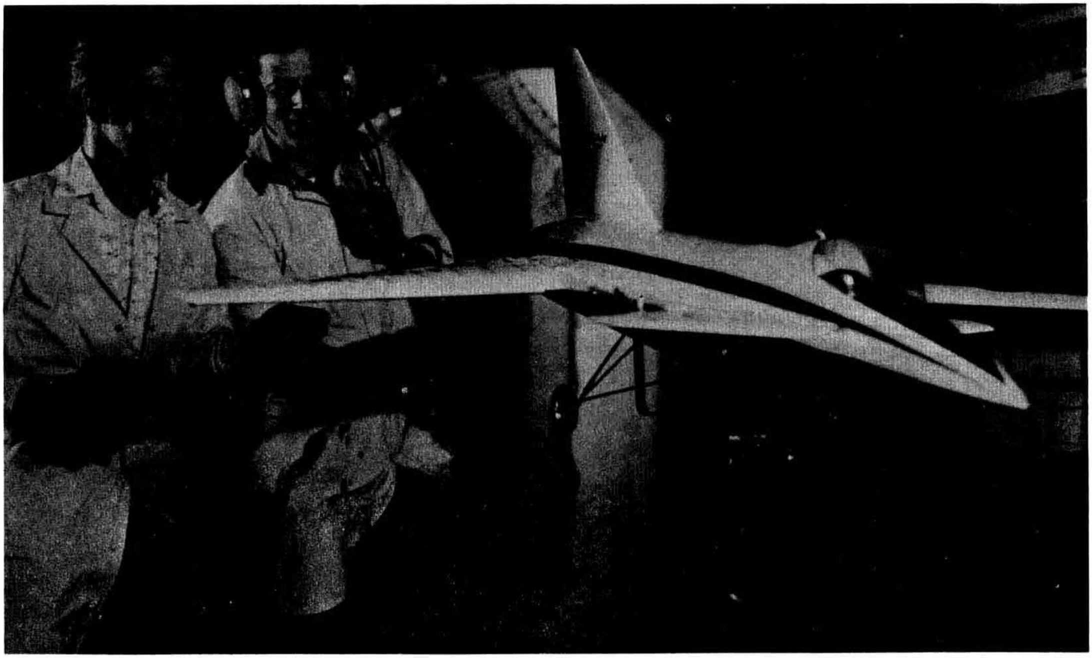


In a wind tunnel, pieces of string are glued to a model to show the direction of the air flowing over an airplane. If the strings fall straight back, the air is flowing correctly.

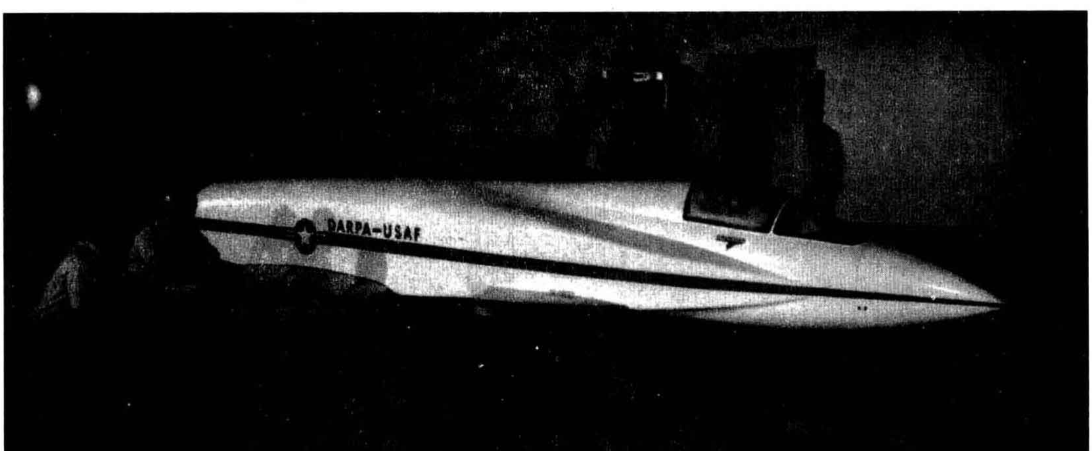
one will be injured if it crashes. Models of several different designs are often tested at the same time in order to find out which one works best.

If a design is substantially new or different, it may be necessary to build a *flying test bed* before trying to fly the actual research airplane. A flying test bed is a construction of the main parts of the new airplane that will be tested to see if the new design ideas will work. Attached to strong cables to keep it from going too high, a test bed may fly just a few feet above the ground.

If all the preliminary steps have proven the basic idea to be sound, a research airplane is built. It will be carefully constructed by hand by the most experienced technicians available, and many changes will be made during its construction as the engineers continue to adapt and improve its design. At the beginning, no one knows exactly what the finished plane will be like.



Above: Technicians prepare a small model of a research airplane for tests in a wind tunnel. Held by the technician on the left, the radio control box will change the model's *attitude*, or angle with the ground, during the test. Below: Designers work with a larger model with forward-swept wings.



Preparing for the First Flight

Flying a research airplane is a job for a highly trained test pilot—a pilot who will be able to feel every little movement of the plane and sense immediately if something is about to go wrong. Because the purpose of the airplane is to try out new design ideas, the pilot will be exploring an unknown aircraft a little bit at a time. In order to learn as much as possible about the airplane, it will carry in-flight recorders and telemetering equipment to radio data to technicians on the ground who will monitor everything that happens in the air.

Everyone involved in the first flight of a research airplane is under great tension. Years of hard work and millions of dollars are at stake. The airplane is checked from nose to tail and checked again. A single loose wire, a missing connector, or a tiny flaw in the computer software could bring a quick end to the first flight—and the entire project.

The Test Flights

If the first flight goes exactly as planned, it will be surprisingly dull! There will be no spectacular climb to amazing altitudes, no blazing passes just a few feet above the runway, and no sensational aerobatic display. Far too much has gone into the project to risk losing a plane during a few seconds of reckless flying.

The pilot will begin the flight by carefully accelerating to takeoff speed and then gradually climbing to a safe altitude for some cautious maneuvers to see how the new plane handles. The modern test pilot is more of an engineer than a cowboy and will be

Colonel Albert Boyd buckles on his parachute before flying 624 mph (998 km/h) in a Lockheed P-80R to set a new world air speed record in 1949.

concerned with checking the many dials on the instrument panel and reading their numbers every minute or two. Even if the purpose of the airplane is to fly faster than any other plane has flown, it will not be flown at its top speed during the first few flights. Only after the airplane has been flown slowly for takeoff and landing will it be safe to fly faster.

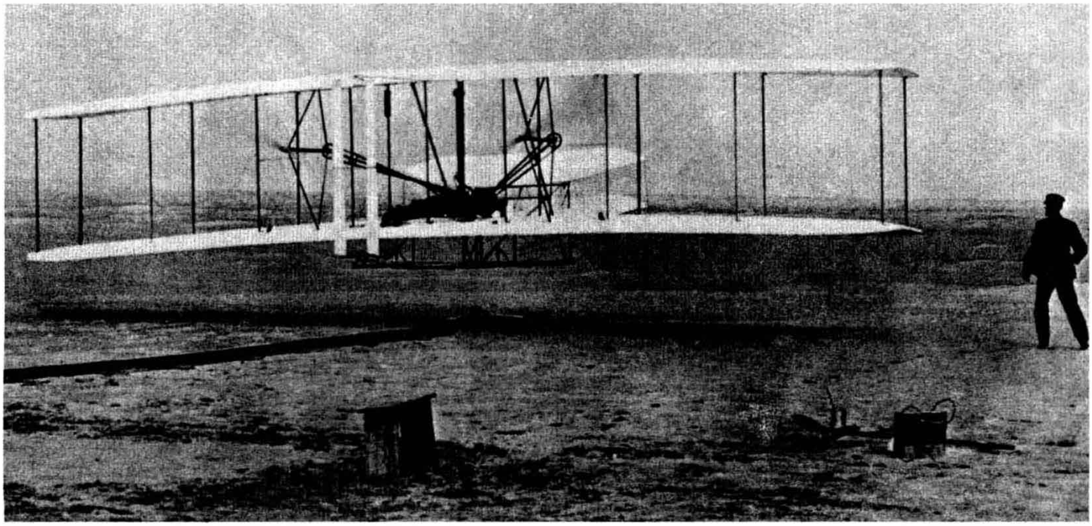
After the first test flight, the mechanics and engineers will check the entire outside of the plane and then open the access doors to get to the inside. Anything that was broken during the flight will be fixed or replaced, and any part that did not work properly will be redesigned. For this reason, a second test flight may not take place for several days or weeks.

Once the plane's low-speed handling characteristics have been proven safe, the test pilot will start to push the throttle forward, a fraction of an inch at a time, as much as the test program permits. In the 1930s, it was not uncommon for a test pilot to take up a new design, point its nose straight down, and, with its engine wide open, fly as fast as possible. Numerous airplanes shed their wings in such wild tests, and many good pilots died.

While the experimental airplane is undergoing tests in the air, an identical airplane will undergo different tests on the ground. In a large laboratory room, the *static test vehicle* will be mounted on special equipment that will bend and twist every part thousands of times to simulate the stress of takeoff, climbing, descending, and landing. To see how they stand up to the forces of actual flight, the test vehicle's wings will be covered with hundreds of bags of shot or sand several times heavier than the total weight of the airplane. In order to discover its breaking point, this nonflying airplane may be tested until it is destroyed. These tests will reveal what parts of the test plane might fail if it were maneuvered too tightly.

By the time the airplane is ready to fly again, so much will be known about it that there should be very few surprises. But since the research flights may take the plane to unknown speeds, altitudes, or maneuvers, there is always the chance that something totally unexpected will happen. In such instances, the people on the ground will be glad that an expert test pilot is in control.

The lifetime of most research airplanes is fairly short. They either work well and complete their tests, or they fail and are grounded while another plane is prepared for testing. When an airplane has finished its work, it may be modified for another project or broken up so engineers can use its parts in other airplanes. If the plane is successful and helps to advance our knowledge of flight, it may be presented to an aviation museum so people can see it up close and better understand what it did and how.



Orville Wright lies in the *Flyer* and Wilbur Wright runs alongside to steady the wing in the only photograph of the first successful motor-powered flight.

The First Research Airplane

The first piloted airplane that flew—the Wright brothers' 1903 *Flyer*—was also the first research airplane. Orville and Wilbur Wright were inventors more than they were pilots. They had built and flown gliders for several years, and they probably knew more about flying machines than anyone else in the world at that time.

When the Wright brothers built their 1903 *Flyer*, they equipped it with instruments to record how fast the plane flew and how well its engine worked. If it flew, they wanted to know why it flew. After their successful flight on December 17 at Kitty Hawk, North Carolina, the Wright brothers knew even more about what made an airplane fly properly. They had learned about airplane engines and about propellors. They had discovered how to make an airplane fly where they wanted it to go and how to keep it from crashing into the ground.

The Wright brothers were the first airplane builders who tested an airplane like real scientists, and the planes they built and flew were true research airplanes. When they had learned all they could from their first plane, they retired it and built a better one.

This photograph of the Grumman X-29 research airplane was taken just after its completion and before its successful first flight on December 14, 1984.

2

High-Speed Research Airplanes

Ever since the first airplanes lifted off the ground nearly 90 years ago, men and women have worked hard to make them fly faster. At first, designers increased speeds by making planes more streamlined so the air could flow around them more easily. Then they had to use bigger engines.

The first airplanes, however, were anything but streamlined, and they had all of their parts—engine, wheels, even the pilot—sticking out. Soon it became obvious that putting the plane's components inside the plane where they would not disturb the flow of the wind would make the plane go faster. The original bundles of sticks and wires that connected the wings to the tail were covered to make a *fuselage*, or body. The early pilots were convinced they needed to feel the wind in their faces in order to fly well, so they sat in cockpits with their heads poking out in the wind. In the 1920s, airplanes with clear canopies over the pilot's head finally became popular.

In order to operate without overheating, an engine must have air flowing over it. Airflow causes wind resistance, however, so metal *cowlings* were built around the engines to make them more streamlined. *Baffles* directed cooling air around the engine parts, and the center of the propellor was covered by a piece of metal called a *spinner*.

The next important development to be tested on research airplanes was retractable landing gear. Although an airplane's wheels are needed for takeoff and landing, they can be pulled up into the wings or fuselage during flight so as not to create any wind resistance. Today, all but the slowest of airplanes have retractable landing gear.

As airplanes traveled faster, their rough, uneven covering was made smoother and more uniform. This, too, cut down on wind resistance. Sheet aluminum replaced fabric, which distorted easily, and the rivets that held the aluminum in place were made *flush*, or even, with the covering so they would not interfere with the airflow.

Faster airplanes also needed bigger engines. The 1903 Wright *Flyer* had only a 12-horsepower (9-kilowatt) engine, but, by the late 1930s, some airplanes had 1,000-hp (745-kw) engines. And engines of 2,000 hp (1,500 kw) were becoming common by the mid-1940s. The introduction of the jet engine brought about even greater advances in power levels. A jet engine's power is measured in pounds of thrust instead of horsepower, and the first jet engine used on airliners produced over 50,000 pounds of thrust (222 kiloNewtons), which at top speed equalled about 100,000 hp (75,000 kw).

It was the mysterious *sound barrier*, an imaginary wall airplanes were thought to encounter when they flew at the speed of sound—750 miles per hour (1,200 kilometers per hour) at sea level and 650 mph (1,040 km/h) at high altitudes—that forced designers and engineers to build pure research airplanes. They wanted to know exactly what would happen when an airplane flew that fast.

Some experts thought it might be impossible to control an airplane when it reached *Mach 1*, which is how scientists refer to the speed of sound. Others thought the air would pile up in front of the airplane to prevent it from going any faster. But everyone agreed that only a carefully designed and powerful airplane would stand a chance of breaking through that unknown barrier.

Subsonic Airplanes

At first, all airplanes flew at *subsonic* speeds, or slower than the speed of sound. When airplanes neared Mach 1, they started to fly strangely. Some would go into a dive from which it was very hard to recover, and others acted like their controls were working in reverse. Engineers wanted to design and build airplanes that could fly at the speed of sound, and their efforts resulted in the first high-speed research airplanes.

deHavilland deH.108 Swallow

British engineers who wanted to build a faster jet airliner decided to build a plane with swept-back wings and a vertical tail—but no horizontal tail. To test their idea, they built three small single-engined jet Swallows.

The deH.108 used the fuselage and engine of a deHavilland Vampire jet fighter with special wings and tail. This small, streamlined airplane, the most modern-looking plane at that time, first flew in the spring of 1946.

Then trouble struck the second Swallow. On a flight to attempt the world air speed record, the plane crashed and was destroyed. Pilot Geoffrey deHavilland, Jr., the son of the company's founder, died in the crash.

Engineers wanted to find out why the Swallow crashed so they could make sure the plane's problems were corrected. Tests in a huge wind tunnel showed that an airplane of this shape wanted to tuck its nose under while flying close to the speed of sound. If the plane had been flying at high altitudes, there might have been a chance to slow it down and get it back under control. But Geoffrey deHavilland had been skimming over water when he ran into trouble, so he had no chance to recover from the dive.

By 1950, the two other Swallows had also crashed on test flights. But thanks to some very brave test pilots, engineers now understood what the problems were. When jet airliners with swept-back wings began carrying passengers, they were safe. But because of what engineers had learned from testing the Swallow, these passenger jets all had horizontal tails.

This early research airplane—the deHavilland Swallow—later crashed on a high-speed flight, killing pilot Geoffrey deHavilland, Jr.