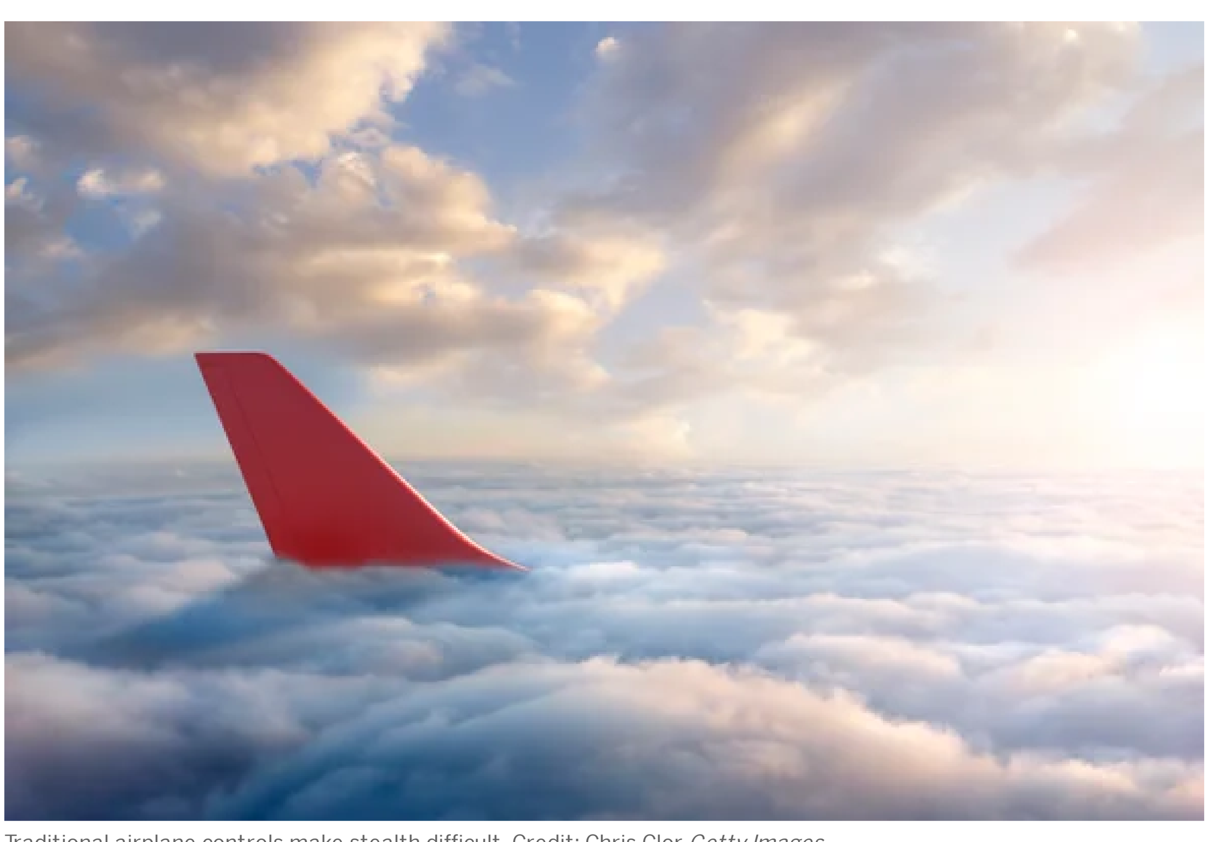
ENGINEERING

The Next DARPA X-Plane Won’t Maneuver like Any Plane Before It

The challenge is to build an airplane without moving control surfaces

By Eric Tegler on January 9, 2020



Traditional airplane controls make stealth difficult. Credit: Chris Clor *Getty Images*

The international aerospace company Airbus recently unveiled a model of a new drone called the Low Observable UAV Testbed (LOUT), which reportedly combines several undisclosed stealth technologies. Hints in the aircraft’s description led some aviation experts to speculate that one of LOUT’s radar-evading powers could come from a lack of conventional moving control surfaces.

For the past century, airplane control mechanisms have relied on hinged surfaces such as ailerons and rudders. Shifting their positions alters the shape of the wings or tail, changing the surrounding airflow—and thus air pressure. This adjustment pushes the aircraft to maneuver in predictable ways. But traditional control surfaces require external seams that radar can detect with relative ease. A seamless airplane would have greater stealth capabilities and performance. It could also have lower weight, size, complexity and cost, compared with planes that use traditional steering methods.

Airbus declined to comment on whether LOUT contains such a control system, but the quest to develop a craft without these moving control surfaces is definitely accelerating. This past August the U.S. government’s Defense Research Projects Agency’s (DARPA’s) recently established Control of Revolutionary Aircraft with Novel Effecters (CRANE) program asked innovators to design and build an airplane that can be maneuvered without movable surfaces—and to produce this functional, full-scale craft by 2024.

ACTIVE FLOW CONTROL

Such a plane would most likely have to be guided with a method called active flow control (AFC), which DARPA called for in its announcement. Instead of changing the airflow around a craft by moving hinged surfaces, AFC alters it in other ways. One technique, for example, puffs air extracted from a jet engine through one- to four-millimeter-wide holes in the relevant parts of the plane’s skin. Another uses arrays of electrodes to discharge electrical pulses that rapidly heat the air nearby, causing it to expand and thus thermally altering the airflow. These precisely placed disruptions change the lift and drag at a specific location to initiate a pitch (nose up or down), roll (wing up or down) or yaw (nose left or right) movement.

Theoretical work on active flow control stretches back to the early 1900s, but interest increased after World War II. Some of the most significant early work came out of Lockheed Martin’s Skunk Works engineering division, according to Daniel Miller, senior fellow for air vehicle systems and sciences at that division. (Skunk Works has filed more than 50 AFC patents, and Lockheed Martin incorporated limited AFC features in its SR-71 Blackbird and F-104 Starfighter.)

Despite this history, AFC never really took off because manipulating the flow of air around a plane required too much energy. “You simply could not integrate an AFC system onto most aircraft when you [were] using 10 percent [of available aircraft energy],” Miller says.

Since the 1950s, however, researchers have learned to better manipulate airflow by pinpointing where a puff of air or electrical pulse will have the most impact—one might liken this process to aiming a bullet at a target instead of blasting the general area with a bomb. Because modern AFC techniques are more precise, they require much less of a plane’s energy. “As we’re now looking at one percent [of aircraft energy],” Miller says, “things are starting to snap into place quite nicely.”

DARPA’S LAUNCH PLAN

Commercial and academic researchers have already conducted several independent wind-tunnel and flying demonstrations of AFC technology. For the past five years, DARPA has been studying these tests, according to Alexander Walan, a program manager at the agency. In 2015, for instance, NASA and Boeing performed joint tests on a limited system in the tail of a 757 airliner. In 2018 a small, tailless drone known as Innovative Control Effectors, or ICE—developed by a collaboration among Lockheed Martin, the U.S. Air Force and the Illinois Institute of Technology—performed a flight demonstration as part of a NATO research project. The same NATO program was responsible for the 2019 flight of a similar autonomous flyer called MAGMA, developed by BAE Systems and the University of Manchester in England.

These small-scale successes convinced DARPA that the time for an experimental plane, or X-plane, using AFC had arrived. “Between modeling and simulation, component demonstrations and flying demonstrations, we felt that the technology had matured enough to where a full-scale aircraft program was feasible,” Walan says.

CRANE will unfold over four phases. The first, which is now underway, is a call for proposals. Designs have already been submitted by a variety of industrial and academic teams (including Lockheed Martin’s Skunk Works). These plans are closely guarded, which makes it tough to guess what the new X-plane will look like. “I didn’t want people to lock into a concept, a picture, too early,” Walan explains. He adds that the X-plane might be piloted or pilotless, as well as tailless or more conventional-looking. It could even use AFC in conjunction with traditional moving control surfaces. “If someone wants to do more of an [uncrewed combat aircraft] approach at a higher Mach number, they may have conventional surfaces for takeoff and landing—and AFC could enhance maneuverability up and away,” Walan says.

The biggest challenge, he notes, will be integrating a novel AFC system under the skin of a full-size airplane. But CRANE applicants, including the Skunk Works team, are optimistic. “Our conclusion is: it looks feasible,” Miller says. “I think we’re within striking range of putting all of these component technologies together and trying to do a flight demonstration.”

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