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Shape-Shifting Airplane Wings

When designing an airplane, aeronautical engineers need to consider every surface of the plane because they all effect lift (Fig. 1). Most of the heavy lifting is performed by the airplane's wings. Dr. Sridhar Kota, director of the Compliant Systems Design Laboratory at the University of Michigan, created a way to create machines and surfaces that can change their shape even though they have no joints.

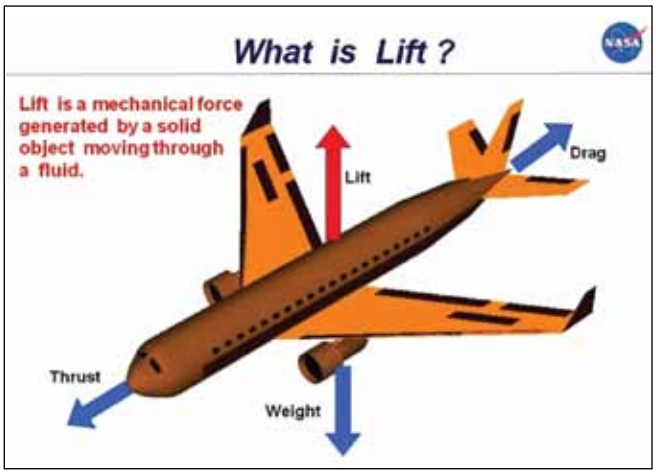

Fig. 1—Lift is a mechanical force created by the interaction of every surface of the airplane with the fluid of air, which is generated by the airplane's engines.

Photos and illustrations courtesy NASA

For an airplane to even get off the ground, it needs the forward motion that is created by its powerful engines. To create lift the rushing turbulent air from the thrust of the engines and the wind from its fast acceleration all streams above and below the airplane's wings.

The air pressure is intensified below the wings by the nose up position of the airplane (angle of attack) and the position of the airplane's wing flaps, which are moveable panels on the trailing edge of the wings. The flaps generate a lot of lift during takeoffs and landings. Without its forward motion and the rushing air, which acts like a high-pressure fluid trying to push the plane's surfaces out of the way, an airplane can't generate lift and fly.

The creation of the shape-shifting airplane wings was a joint project with FlexSys Inc., the company Dr. Kota founded, NASA, and the U.S. Air Force. The test plane (Photo 1) has been outfitted with a set of new wings that have these morphing flaps.

The first iteration of the morphing airplane wing is a redesigned airplane flap that is an integral part of the wings rather than a physical add on. The green area (Fig. 2) shows the location of the ACTE morphing flap (FlexFoil™). You can smoothly run your hand along the wing and you will feel one continuous surface rather than a physical add-on like current wing flaps.

These new flaps can morph their shape to conform to the flight characteristics that the wings need to have during a flight. This breakthrough could eventually eliminate the heavy hydraulic systems and motors that are now used to physically change the surface dynamics of all the mechanical parts of an airplane's wings during the different parts of a flight.

The eventual switch from the current hydraulic systems to new airplane wings with Adaptive Compliant Trailing Edge (ACTE) surfaces in place of flaps, NASA states, "has the potential to save millions of dollars annually in fuel costs, reduce airframe weight, and decrease aircraft noise during takeoffs and landings."

The FlexFoil flap is a seamless section of the wing with a continuous range of motion from 2° to 30° (Photos 2 and 3). So, what was once a mechanical add-on appendage is now a morphing part of the actual wing. Testing of this new technology has been done on the Gulfstream aircraft (Photo 1). Both wings on this plane were replaced and the new ACTE wing

Photo 1—NASA used this Gulfstream airplane to flight test the ACTE morphing wing technology.

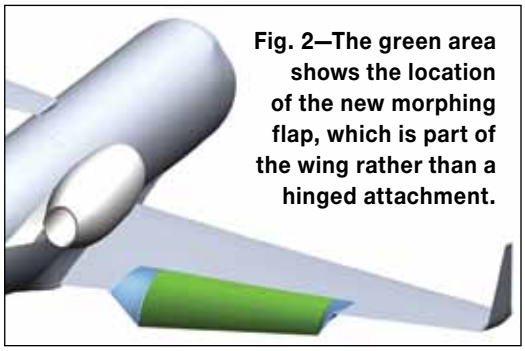

Fig. 2—The green area shows the location of the new morphing flap, which is part of the wing rather than a hinged attachment.

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Photos 2 and 3—The morphing flap lies perfectly flat (left) until it needs to be adjusted. It can morph its shape from 2° up to 30° (right) and hold its shape at any degree angle requested by the pilot.

flaps have surfaces that can be shape-shifted along their entire surfaces. When the ACTE flaps bend to force more turbulent air under the wings, there is no gap between them and their connection point on the wing; this greatly reduces noise. Since the FlexFoil flaps can morph their shape from minimal to major amounts, it can make fine to major adjustments to the curvature of the wings. During a flight they can help deliver the ideal lift-to-drag ratios all the time, not just during takeoff and landing.

The goal is to start testing FlexFoil on commercial planes within the next year or two. After that stage is completed, the next goal will be to use ACTE technology to replace the other rigid moving structures in an airplane wing so the entire wing can morph its shape to provide the best lift-to-drag ratios during the entire flight.

Taking It a Step Further

1. In Sci-Fi movies you often see winged spaceships performing the same moves as fighter jets in a dog-fight. Why is the action in the movie impossible?

2. The plan is to eventually replace the other moving rigid structures on an airplane wing so they can all morph their shape. Research what the other moving parts are and what they do.

3. A mind tease posted on Facebook by the SIG Mfg. Model Airplane Co.: Imagine a 747 is sitting on a conveyor belt as wide and long as a runway. The conveyor belt is designed to exactly match the speed of the wheels, moving in the opposite direction. Can the plane take off? Why?