Prandtl-D Aircraft

The Prandtl-D No. 3 research aircraft had its first flight on Oct. 28, 2015. (NASA / Lauren Hughes)

NASA's Armstrong Flight Research Center engineers in Edwards, California, are working on an increasingly complex aircraft called the Preliminary Research Aerodynamic Design to Lower Drag, or Prandtl-D.

The aircraft features a new method for determining the shape of the wing with a twist that could lead to an 11-percent reduction in drag. The concept may also lead to significantly enhanced controllability that could eliminate the need for a vertical tail and potentially to new aircraft designs.

Flight data from the first two Prandtl-D vehicles validated the use of twist to tailor the lift distribution across the aircraft's wing – bell shaped rather than the traditional elliptical shape – leads to more efficient flight. In fact, engineers estimate future aircraft could see more than a 30 percent increase in fuel economy by using the new methods of wing design and eliminating the weight of the modern aircraft tail and its flight control surfaces. In that regard, Prandtl-D research also borrows from how birds fly. Birds turn and bank without vertical tails that are required for such maneuvers on traditional aircraft, but not on the Prandtl aircraft.

The first two subscale Prandtl-D aircraft had a 12.5-foot wingspan and were constructed of a machined foam core wrapped in a skin of carbon fiber. Initially, each aircraft was radio operated with a hobby-grade controller and launched with a bungee cord system. The second aircraft also featured an Arduino flight data system.

The Prandtl-D No. 3 first flew Oct. 28, 2015, with double the wingspan of the earlier versions. The third aircraft also has the same Arduino flight control system as the second Prandtl-D subscale model and is constructed of carbon fiber, fiberglass and foam. Follow on flight tests will switch from a bungee launch method to a towed launch like a glider. Another key difference in the third Prandtl-D is an addition of a University of Minnesota-developed off-the-shelf data collection system. Flight data also reinforces a number of wing design solutions used on the Prandtl-D aircraft that were an outgrowth of ideas by aeronautical engineer Ludwig Prandtl in the early 20th century. Prandtl was a German whose research is considered a foundation of modern aerodynamics. The Prandtl-D's designs are also based on glider concepts of German brothers Reimar and Walter Horten and incorporate the conclusions of NASA aerodynamics pioneers R.T. Jones and Richard T. Whitcomb.

Albion Bowers, NASA Armstrong chief scientist and Prandtl-D project manager, put all the pieces together from the classic aeronautical theorists and has led the NASA effort with help from student interns.

In March 2016, Bowers published a technical paper entitled, "On Wings of the Minimum Induced Drag: Spanload Implications for Aircraft and Birds," NASA/TP – 2016-219072. Detailing the aerodynamic properties and mathematics associated with the project, Bowers discusses in depth the science behind altering the spanload distribution on aircraft wings and the data gathered from experiments that demonstrated validation of its critical principles. Bowers' publication can be requested either electronically or in paper form, via NASA's Scientific and Technical Information Office, at 717-864-9658, or by email at help@sti.nasa.gov.

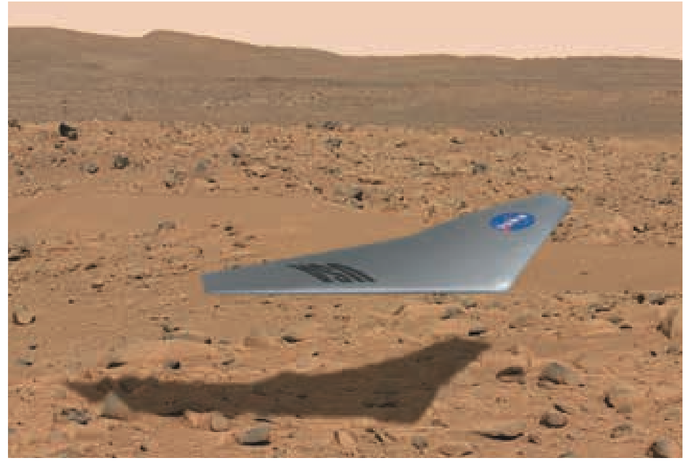
Prandtl-D No.3 Specifications

- Wingspan: 25 feet
- Weight: 28 pounds
- Airspeed: 18 knots (approximately 21 mph)
- Testing Altitude (maximum): 220 feet
- Primary Materials: Carbon fiber for structure, with fiberglass for the skin

Prandtl-M

Work on the Prandtl-D led to a concept for a Mars airplane. If the Preliminary Research Aerodynamic Design to Land on Mars, or Prandtl-M aircraft, is successful, it could collect and transmit valuable information back to Earth.

Envisioned with a wingspan of two feet and weighing less than three pounds, the aircraft would be able to deploy, fly in the Martian atmosphere, glide down and land. The Prandtl-M during its flight over Mars could collect very detailed high-resolution topographic images that could tell scientists about the suitability of potential landing sites.



This illustration shows what a Prandtl-M might look like flying above the surface of Mars. (NASA / Dennis Calaba)

Prandtl-M would have a flight time of about 10 minutes and would glide for the last 2,000 feet to the Mars surface. Its range would be about 20 miles.

Student Involvement

If a NASA Armstrong concept for a Mars airplane takes flight, it will be in part thanks to support from college and university student interns.

The students started with a boomerang-shaped aircraft constructed of carbon fiber and conducted research by flying it down Armstrong hallways, in a conference room and then in an aircraft hangar. Those flights allowed a peek at the aircraft's aerodynamics before moving on to more complex tests and higher altitudes, resulting in a more delta-shaped aircraft.

Students in NASA education programs have had opportunities to perform hands-on job experiences across disciplines to learn what it takes to pave the way for the technologies of tomorrow such as the Prandtl-D and Prandtl-M.

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