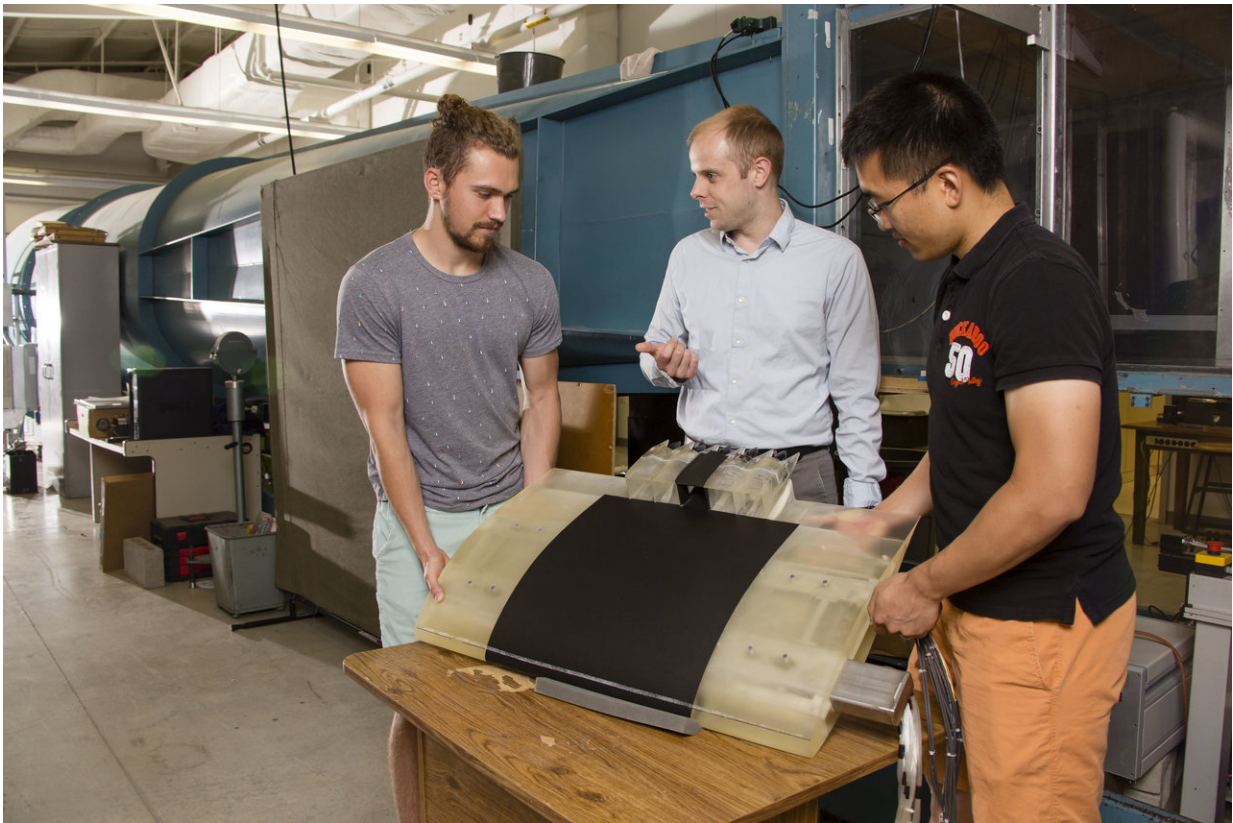


# Opening communication lines between propulsion and airflow poses new questions

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Doctoral student Aaron Perry, Assistant Professor Philip Ansell, and former master's student Je Won Hong discuss the construction of the airfoil model with overwing ducted fans. Credit: University of Illinois Department of Aerospace Engineering

On the runway to more fuel-efficient aircraft, one alternative propulsion

scheme being explored is an array of electrically powered ducted fans. The fans are distributed across the wing span or integrated into the wing. Researchers at the University of Illinois gained new understanding in how the fans and especially their precise placement on the aircraft can affect the cross-conversation between propulsion and the airflow around the wing.

In most commercial aircraft, the engines are isolated from the rest of the [wing](#) system. Instead of being embedded in the wing or mounted more closely to that surface, they hang out from underneath the wings. This is done, in part, to try to reduce the influence in cross coupling—the cross-communication between the engine's RPM and the airflow characteristics about the [airplane wing](#).

"If we allow those two systems to talk to each other, there is a lot of increased complexity in the flow field over the wing and into the propulsor—which also substantially alters the performance," said Phillip Ansell, assistant professor in the Department of Aerospace Engineering in the College of Engineering at the University of Illinois. "We've taken two subsystems—propulsion and aerodynamics—and we've said that these are not isolated subsystems. These are now one thing."

Ansell, along with his graduate student Aaron Perry at U of I and Michael Kerho from the Rolling Hills Research Corporation conducted the study to understand on a basic level what those interactions are and how that coupling between ducted fan systems and wing sections will modify the aerodynamic behavior and the overall lift, drag, and pitching moment characteristics.

"If we integrate the propulsors, which in this case are fans, into the wing, we can improve the aircraft's propulsive efficiency by ingesting the low-speed air across wing surface into the propulsor. But it's challenging to figure out how to do it in a smart way."

This research project was conducted experimentally using a 3-D printed model of an airfoil, which is a cross-section of a wing, mounted inside a subsonic wind tunnel. "We had a model with ducted fans mounted over the trailing edge of the airfoil. The flow goes across the upper surface and then into the fan," Ansell said.

He said that the manipulation of the throttle of the ducted fan mounted on top of the wing provided large changes in the aerodynamic behavior of the airfoil.

"We can adjust the throttle to make the fan spin faster or slower, so that I now have a high-speed jet that's coming out the back end and acts to substantially lift the aircraft through a phenomenon known as supercirculation. It also changes the flow across the surface," he said. "I have little regions of the flow on the surface called boundary layers. Whenever I ramp up the throttle and start pulling air into that propulsor, it thins out the boundary layer. It modifies the distribution of the pressure across the airfoil itself. There are some complex things happening. That fan RPM talking to the aerodynamics of the larger airfoil is substantial."

Ansell said the study provides a new way to understand the dialogue between a full aircraft system and a propulsion system. It's not just about increasing the throttle to create a larger thrust and produce a force that goes through the axis of the orientation of the fan.

"It's not that simple because it also changes the air flow over the wing," Ansell said. "The different orientations of the end of the fan changes the performance of the wing section as well as the pressure distribution because it changes the local flow quality characteristics. We have now quantified that and can understand some aspects of what that looks like.

"We were able to take measurements to better understand what those

variations in coupling characteristics are. Previously we knew that if we ramp up the throttle on this fan, the result is a thrust vector pointed in a certain direction. Now we know that it will also modify my local wing aerodynamics."

The paper, "Aero-Propulsive and Propulsor Cross-Coupling Effects on a Distributed Propulsion System," was written by Aaron Perry and Phillip Ansell. It appears in the *Journal of Aircraft*.

**More information:** Aaron T. Perry et al, Aero-Propulsive and Propulsor Cross-Coupling Effects on a Distributed Propulsion System, *2018 AIAA Aerospace Sciences Meeting* (2018). [DOI: 10.2514/6.2018-2051](https://doi.org/10.2514/6.2018-2051)

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