



Computer-generated image of the Terrafugia Transition in flight. The company unveiled a production prototype in 2010.

# Fast Lane to Sky High

Fluid flow simulation software co-pilots design of production prototype roadable aircraft.

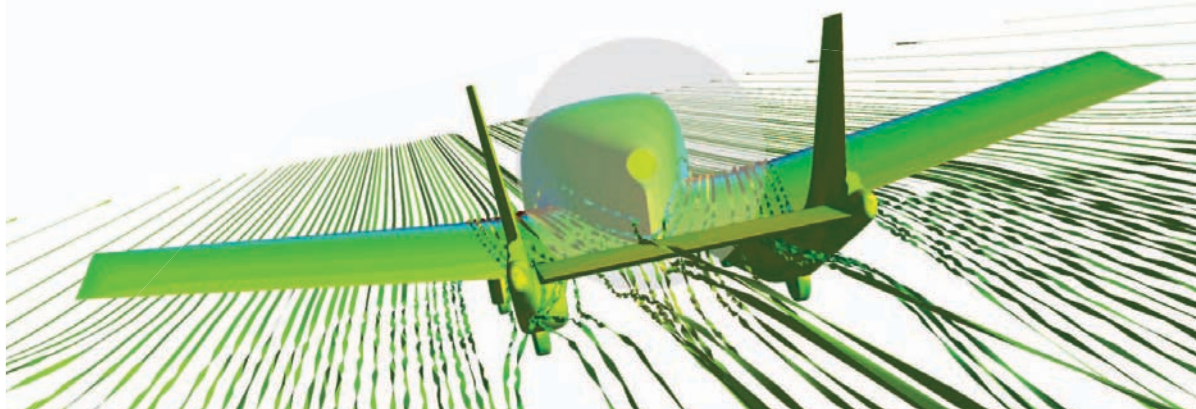
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Since the earliest days of the aviation industry, inventors and entrepreneurs — from motorcycle racers to homebuilt-aircraft enthusiasts to the largest automakers — have sought to develop the iconic mashup of future transportation technology known as the “flying car.” Some of their attempts did manage to test successfully and even reside in the Smithsonian. Sporting names such as Autoplane, Aerobile and Airphibian, these machines were impressive for their time, but they never lived up to their mythological pedigrees as conjured by science fiction authors and filmmakers. The concept is a proven one. But due to the engineering challenges involved in combining a lightweight, aerodynamic aircraft with the stability needed for long-distance driving, to date none of these vehicles, which are more accurately called “road-ready” airplanes, have been successfully brought to market.

Recently, however, the Boston-area startup Terrafugia revealed its production prototype for the first commercially

available street-legal aircraft with hopes of beginning manufacturing in 2011. Terrafugia — Latin for “escape from land” — used simulation tools from ANSYS to arrive at a production prototype of its innovative Transition® Roadable Aircraft. After earning global attention following successful test flights in early 2009, the new prototype was revealed to the industry in 2010 at the annual Experimental Aircraft Association (EAA) AirVenture Oshkosh national airshow. It was a critical step in commercializing this one-of-a-kind vehicle.

With a flight range of up to 490 miles and cruising speed of 105 mph, the Transition can also drive up to 65 mph on the road. It is capable of transforming from plane to car in less than 30 seconds. The sophisticated design features foldable wings that span over 26 feet, a rear-wheel-drive system for the road, and a rear pusher propeller for flight. While the Transition is not designed to replace anyone’s car, it is intended to drive at normal



Rear view showing pathlines passing by Terrafugia's beta prototype design flying at 105 mph



The Transition's foldable wings allow the aircraft to be driven on the highway as well as parked in a typical residential garage.

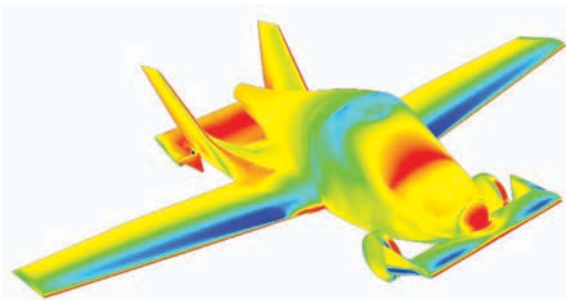
highway speeds, so that owners can easily access their local airports. This required Terrafugia's engineering team to simultaneously consider the aerodynamics of flying and driving — activities that exert very different forces on the vehicle. While physical tests in a wind tunnel helped to validate the initial concept design, they were both time- and cost-intensive. For this reason, Terrafugia engineers turned to ANSYS FLUENT software to make and verify design modifications for the new production prototype, working in a virtual simulation environment that saved time and money while also enabling engineers to assess a complex range of design considerations.

Unlike a typical car or plane, the Transition has a host of extra components to consider when analyzing air flows around the vehicle, as wheels, propellers, foldable wings and other shapes affect dynamic flows whether it is driving or flying. Using the modeling capabilities of the software, Terrafugia engineers conducted whole-vehicle

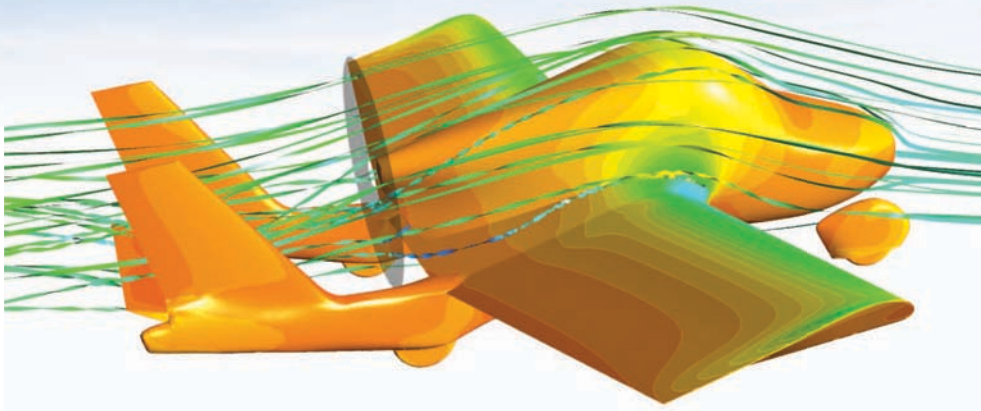
airflow tests to study the effects of the slightest design change on overall performance. The team addressed issues such as maximizing wing lift in the air while simultaneously minimizing the effects of crosswinds along the road. Without an ability to work in a virtual environment, Terrafugia's team would have had to construct complicated physical models, modify or rebuild them, and conduct hours of real-world testing. Simulations powered by fluid dynamics software from ANSYS enabled rapid testing and verification of some modifications to the Transition design, based on the physical performance of the initial proof-of-concept vehicle.

Wind tunnel tests revealed an adverse interaction between the vehicle's front suspension and its canard, which serves as a wing while flying and a front bumper while driving. Rather than relying on additional physical testing, Terrafugia used ANSYS technology to further explore this interaction as well as potential solutions. As the work of the engineering team progressed, it became clear that, while the canard configuration had initially been integral to the design, it was undesirable from a number of standpoints. With the Transition receiving classification as a multipurpose passenger vehicle, the full-width bumper requirement for passenger cars — the original reason for the canard — was no longer applicable. Engineering simulation software verified that lighter weight, better flight characteristics and improved looks were all potential benefits of a canard-free design.

Another challenging aerodynamic design aspect of the Transition was attaining a wing stall speed — the speed at which an aircraft stops flying — of under 52 mph, which is a requirement for the light sport category of aircraft. Since slower in-air speeds generally create safer flying conditions, it was important for the Terrafugia engineers



Proof-of-concept design of the Transition showing pressure contours on the vehicle surfaces. Since the Transition was classified as a multi-purpose passenger vehicle, a bumper was not legally required, so engineers conducted simulations to see if they could eliminate this feature. ANSYS models confirmed that the canard was not needed, and this feature has been eliminated in the production prototype design.



Production prototype design showing airflow pathlines over the vehicle body. The VBM plug-in to ANSYS FLUENT enabled Terrafugia engineers to model the vehicle's propeller under near-stall conditions, which helped to ensure the safety of the aircraft while in flight.

to design the vehicle to operate at a low speed for safety and stability without stalling. Stall prediction can pose a difficult problem, even for sophisticated CFD tools. However, with close support from ANSYS experts, Terrafugia developed a detailed engineering approach necessary to obtain accurate predictions, including the use of a virtual blade modeler (VBM) that plugged in to the fluid dynamics software and created additional capabilities to model the Transition's propeller. After deploying the specialty VBM tool, the team reshaped the wing and

the remainder of the body as needed to match the weight and center-of-gravity requirements of the vehicle.

The new design improves both the in-air and on-road performance of the Transition as well as ensures that the vehicle lends itself to full-scale manufacturing. Terrafugia's team found that simulation software from ANSYS was critical in advancing them to the production prototype stage with a high degree of confidence in their design. The company credits ANSYS tools for helping to bring their product to market so quickly.

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