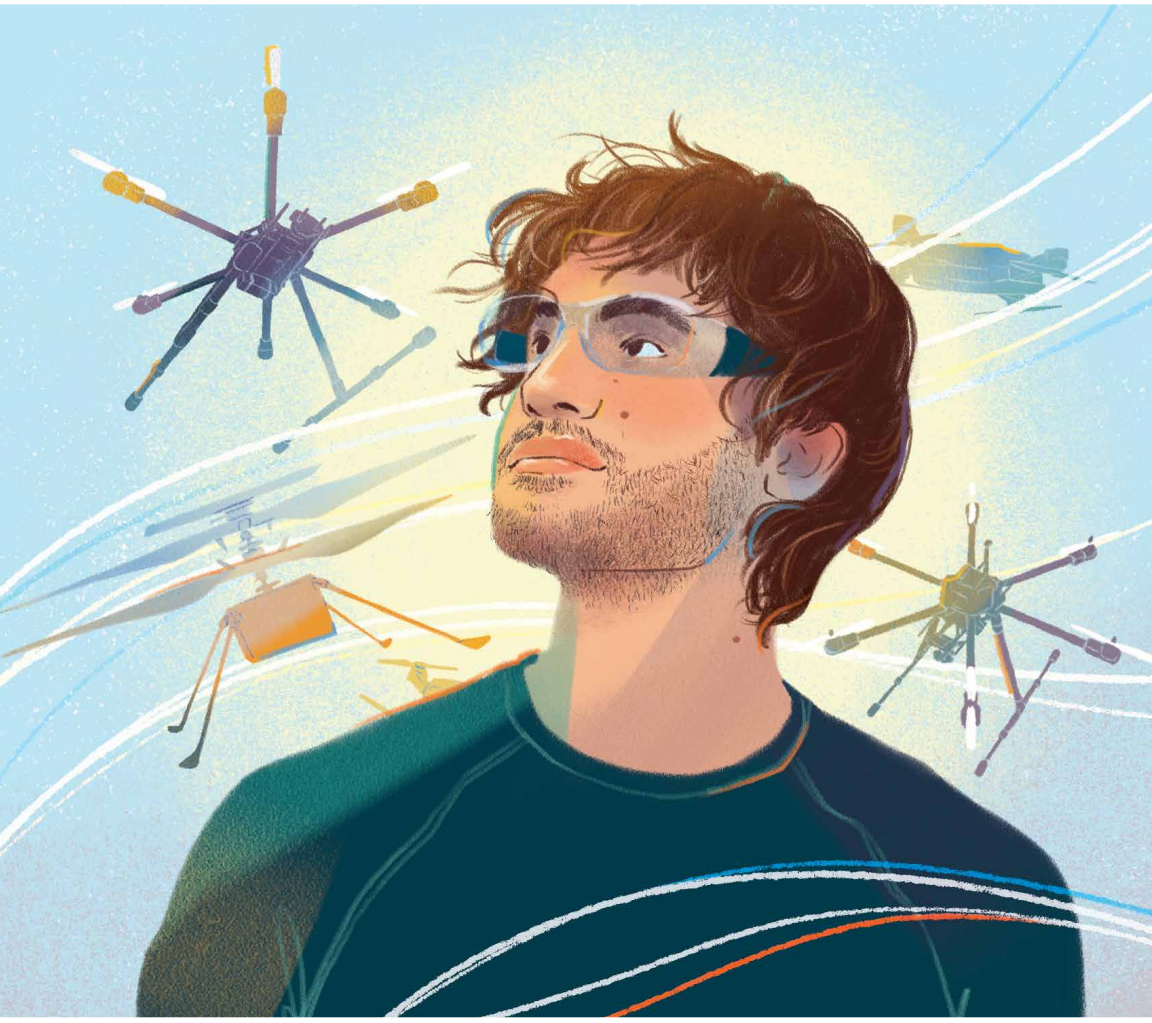
Science Journeys



ALEJANDRO STEFAN-ZAVALA

presents

Flight School for Robots

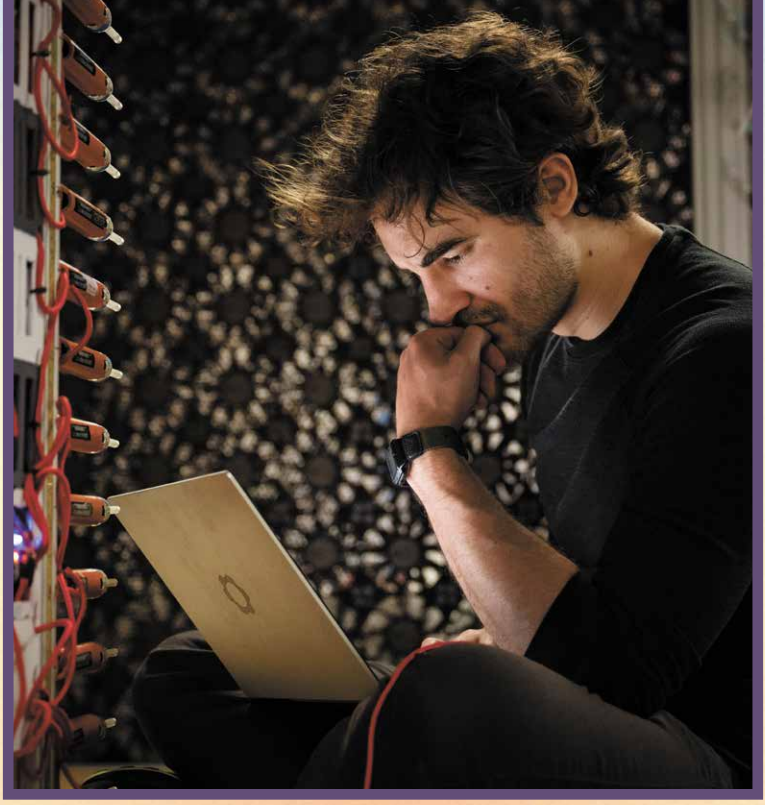
MEET
Alejandro Stefan-Zavala


Alejandro as a child in Venezuela

Alejandro Stefan-Zavala is a PhD candidate in aerospace at Caltech. He works in the lab of Mory Gharib, the Hans W. Liepmann Professor of Aeronautics and Medical Engineering. Alejandro builds wind tunnels and flying robots, also known as drones. He studies the wind that robots use to fly, like the wind near a skyscraper on a windy day. To do this, he makes realistic wind conditions inside labs to investigate how drones fly in these environments and how to make these robots fly safely.

Since he was in preschool, Alejandro has wanted to be a scientist. His favorite part of being a scientist is having an idea, making doodles about it, and then turning the idea into reality. He loves doing this just for fun too: He makes things like titanium notebooks, which keep his notes indestructible, as well as pneumatic braces that he uses to (carefully!) jump from high distances without getting hurt.

Throughout his whole life, science has made Alejandro's dreams come true, and this is what he wants to share with students in Science Journeys in the hope that it might make their dreams come true too.



Explore the Science

Engineering • Aeronautics

How do self-flying, or autonomous, drones learn to fly in unpredictable, windy conditions, such as a storm or the gusty corridors between skyscrapers in a city? Teaching drones to maneuver in the wind is Alejandro Stefan-Zavala's job. As a Caltech graduate student in aerospace, Alejandro uses computers and a wall of small fans to create wild wind patterns in the lab. Then, he builds durable drones to fly in the wind and watches what happens (Spoiler alert: They often crash.)

Go inside the lab with Alejandro in his Science Journeys presentation to learn how he builds crazy things—and how you can too! Hear how Alejandro's love for engineering started in elementary school when he realized he could build little robots in his backyard with a few cheap tools and simple scientific principles. Discover the fascinating field of autonomous flight, including how Alejandro's team helped design a mission to fly a drone on Mars.

Terms to Know

- **Actuator:** The part of a robot that moves or otherwise affects the real world, usually in response to information from a sensor. For example, a motor that turns wheels is an actuator. You can think of actuators as a computer's arms and legs.
- **Anemometer:** A sensor that measures wind speed. Anemometers help scientists see what are called "wind fields" by measuring wind in many places at once.
- **Drag:** The force that pushes against a drone or other aircraft as it moves through the air. Drag always pushes in the direction of flow. Most cars, boats, and planes are shaped the way they are to have the least drag possible when they move.
- **Drone:** A flying robot that does not have a person inside controlling it. In some cases, a person may control the drone via remote control. Some drones can fly themselves by just being told where or how to fly. When a drone can fly itself, we say it is "autonomous."
- **Fluid:** A substance that flows when pressure is applied to it and has no defined shape. All liquids, like water, and all gases, like air, are fluids.
- **Flow:** The motion of a fluid. Wind is the natural flow of air on Earth.
- **Lift:** The force that pushes aircraft up when they move through the air. Lift always pushes in the direction perpendicular to flow.
- **Model:** A simplified version of a real thing that scientists and engineers use to study and predict how that thing works. For example, the famous equation "F=ma" is a model for how things move when a force is applied to them.
- **Multicopter:** A flying robot, or drone, with two or more propellers that it uses to lift off, hover, and fly. A quadcopter is a multicopter with four propellers.
- **Propeller:** A device made of spinning wings called "blades" used to move through a fluid. When the propeller spins, its blades push the air in one direction, which pushes the propeller—and whatever is spinning it—in the other direction.
- **Robot:** A computer that moves, interacts, and sometimes makes decisions within the physical world.
- **Sensor:** A device that receives information—like light or sound—from the world around it and translates it into data that a machine can process and respond to. When a sensor receives information on something, we say it "measures" that thing. Sensors often measure things you can feel with your senses. For example, a microphone is a sensor that measures sound.
- **Turbulence:** The chaotic flow of a fluid. When a flow is not turbulent and instead makes a neat pattern without mixing, we call it "laminar."
- **Velocity field:** A map that shows how fast and in what direction a fluid, like air, is moving. A velocity field of air outdoors is called a "wind field."
- **Wake:** The turbulent flow left behind when something moves through a fluid (or when a fluid moves around something), like the trail behind a boat. Obstacles like buildings and mountains have wakes when the wind runs into them, and flying through these wakes can be dangerous.
- **Wind tunnel:** A machine that blows air into a controlled space, called the "test section," to study how machines like robots or planes—or parts of them, such as their wings—interact with the air. We test airplanes and drones in wind tunnels to make sure they work before we fly them outside.
- **Wing:** A surface used to create lift by pushing air down. Wings only create lift if they are moving forward through the air.

Continue the Conversation

Activity: Test paper airplanes

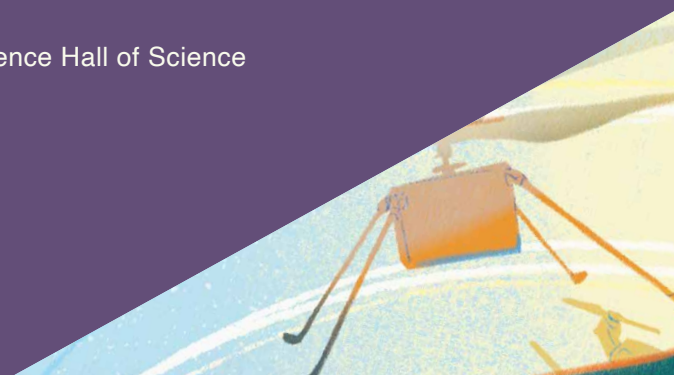
Scientists and engineers like Alejandro Stefan-Zavala use wind tunnels to study how drones perform in various conditions and environments. Build a miniature wind tunnel to observe how paper airplanes respond to air flow.

You'll need:

- 2 empty 2-liter plastic bottles with the ends cut off
- Duct or masking tape
- A box fan or blow dryer
- Yarn or string
- Paper airplanes of different shapes and sizes

Using the tape, join the plastic bottles end to end to form one long tube. Position the fan or blow-dryer at one end of the tube. Then, attach a piece of string, about 10 inches long, to the top of each paper airplane so that you can dangle them in front of the other end of the tube. Turn the fan on and observe what happens to each plane. What difference does the plane's shape make? What about the speed of the air flow?

—Adapted from Lawrence Hall of Science



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Alejandro's talk, plus past events covering topics such as chemistry, underwater robots, and neuroscience.

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