Going With the Flow

Curiosity inspires engineer to build his own wind tunnel

BY MICK BOROUGHS, BOEING WRITER

Sai Mudumba's interest in all-things aviation soared each time he watched airplanes taxi and takeoff from Miami International Airport, near his childhood home. At 10 years old, he tried to grasp how enormous vehicles could become airborne and fly away.

"Living in Florida, I saw rocket launches at Cape Canaveral, like the Mars Curiosity rover. It lifted off in 2011 aboard an Atlas V rocket to travel to another planet millions of miles away," said Mudumba, still with a sense of awe. "It was inspiring for me to see what humans could achieve, and it was a pivotal moment for me to decide to become an aerospace engineer."

AERODYNAMIC ADMIRATION

Sai Mudumba looks inside a reproduction of Wilbur and Orville Wright's 1901 wind tunnel at The Museum of Flight in Seattle. Like the aviation pioneers, Mudumba's curiosity inspires his own wind tunnel experiments.

PHOTO: MARIAN LOCKHART/BOEING

From launches to lift

Mudumba earned his bachelor's and master's degrees at Purdue University School of Aeronautics and Astronautics and a second master's degree in electrical and computer engineering. He joined Boeing in 2022 and is an aircraft design software developer with Boeing's Multidisciplinary Design, Analysis & Optimization engineering team in Everett, Washington.

In 2023, Mudumba reviewed his university notes and thought about airflow around simple shapes and airfoils. The idea of using a wind tunnel as a data source came to mind. At Purdue, he had used the campus's subsonic wind tunnel in his lab courses.

A wind tunnel is an environment to test the aerodynamic effects on objects in a scaled and cost-effective way. Boeing operates several wind tunnels, and Mudumba recently had the opportunity to check out the company's icing wind tunnel in Seattle.

ROLL WITH IT

Mudumba's wind tunnel collects five force components, including lift, drag, pitching, rolling and yawing. The force balance, part of the blue structure in the middle of Mudumba's tunnel, measures the wind forces that act upon an airplane model.

PHOTO: COURTESY OF SAI MUDUMBA

"It was impressive to see the complexity of how they gather data and how it functions overall," he said. "I have so much respect for the wind tunnel designers and operators. Operating one is as complex as building one. It's like a beautiful orchestration of everything working together in sync."

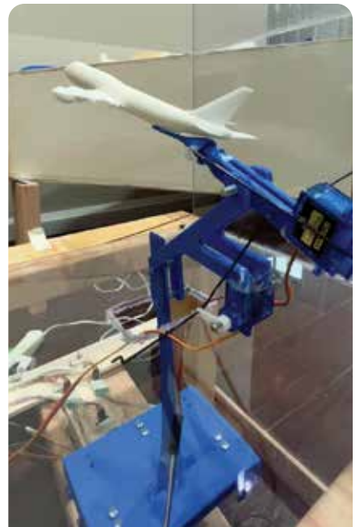
Mudumba decided to design his own wind tunnel using off-the-shelf materials, online tutorials and 3D printing to craft some parts.

"I started looking at YouTube to see if there were any wind tunnels that used more than a simple force balance, but the majority I came across were very simple in nature with just lift and drag sensors and nothing else," he said. "I saw an opportunity to create something that could collect lift, drag and other moments like pitching, rolling and yawing, so it would be a five-component force balance.

LIVE AND LEARN

Mudumba appreciates the complexities of both building and operating a wind tunnel after designing his own.

PHOTO: SAI MUDUMBA



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Winds of Change

BY JAKE SCHULTZ, BOEING HISTORIAN

Wind tunnels have been used for aeronautical study for well over 100 years.

Among the pioneers were Albert Francis Zahm, who built and operated a wind tunnel from 1901-1908 at Catholic University in Washington, D.C. Gustave Eiffel — of Eiffel Tower fame — is among others who conducted early aeronautical research.

In the United States, brothers Orville and Wilbur Wright conducted some of the earliest wind tunnel experiments. While their original 1901 wind tunnel no longer exists, multiple museums exhibit numerous reproductions, including one at The Museum of Flight in Seattle.

In 1914, Jerome Hunsaker, an aeronautical engineer and engineering educator at Massachusetts Institute of Technology, partnered with his assistant, Donald Douglas, to build MIT's first modern wind tunnel. Douglas later founded the Douglas Aircraft Company, a Boeing heritage company.

The Boeing Company used the early MIT tunnel to test the first Boeing airplane, the B&W, which was also the first airplane to be tested in a wind tunnel prior to its construction and flight. Later, Boeing tested the Model C in the MIT tunnel as well.

Shortly thereafter, William Boeing provided funds for a wind tunnel to be built on the campus of the University of Washington. Boeing was an early advocate of education and collaboration with universities for the advancement of the aerospace industry and for academic research benefiting society.

In 1943, Boeing constructed the Boeing Transonic Wind Tunnel in Seattle. Still in use today, the wind tunnel provides early information to engineers on the effectiveness of aircraft designs and collects data that is crucial for future flight tests.

"Wind tunnel testing is critical to be able to manufacture and fly any airplane," said Andrew Mosedale, a Boeing test engineer who ran wind tunnel testing for the B-52 Commercial Engine Replacement Program in 2022. "It's one of the reasons the wind tunnel here was originally built, to be able to design aircraft. Today, we're just continuing that work."

PHOTO: MARIAN LOCKHART/BOEING

WOOD WIND

Inside the Wright Wind Tunnel replica behind Mudumba, a wing is mounted on a balance that measures its lifting capability, which is expressed in a number called the lift coefficient. The Wrights tested more than 200 wing shapes and collected nearly a thousand data points during their wind tunnel experiments in 1901 and 1902.

PHOTO: BOEING ARCHIVES

DEBUT REVIEW

Victor Ganzer, chairman of the Department of Aeronautics and Astronautics, checks UW's first wind tunnel circa 1953.

PHOTO: MARIAN LOCKHART/BOEING

IN THEIR FOOTSTEPS

Jake Schultz (left) and Mudumba visit the first UW wind tunnel building. William Boeing provided funds for the building's construction in 1918. The university replaced the original tunnel (previous photo) with this one in the 1980s, and students still conduct research in this building today.

PHOTO: BOEING

MODERN MACH

Boeing tests a B-52 with replacement engines in the Boeing Transonic Wind Tunnel, using a 4% model and reaching a maximum speed of Mach 0.92.

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"Half the challenge," Mudumba explained, "was building it with a limited selection of tools. It was a great learning experience to think of what tools I could use to cut the wind tunnel into the shape I wanted. The other challenge was operating it. There's a lot of complexity in learning how to operate a wind tunnel and understanding how it behaves."

Put together with polycarbonate sheets, wood and an attic fan, the 10-foot-long (3-meter-long) wind tunnel came together inside Mudumba's living room.

The tunnel is portable and comes apart in five segments: the converging section, the test section, the diffusor, the fan, and the force balance, along with a small model airplane.

Mudumba laughs, recalling one curious neighbor who asked him, "What's a wind tunnel?"

Like his neighbor, Mudumba's teammates and his manager, Brent Robbins, took an immediate interest in the do-it-yourself project.

"I was blown away at how cool it was," Robbins said. "I always planned on building my own wind tunnel but never figured out how to measure anything but lift and drag forces. I wanted to know moments, and Sai figured that out and implemented it.

"What impressed me most was the mechanisms he developed using sensors for the test stand. Now I know who to talk to regarding my own project."

TUNNEL VISIONARIES

Inspired by Mudumba's ideas, Brent Robbins (right) is considering his own wind tunnel project.

PHOTO: MARIAN LOCKHART/BOEING

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As for Mudumba's next goal, he is pursuing a ground school course at a local community college to help him earn his private pilot's license. He plans to take his first solo flight in 2024. In addition to paying for the coursework, Boeing's Learning Together Program will provide an incentive payment to Mudumba when he obtains his license.

In the meantime, he's gaining more experience in his current role in aircraft configuration and integration so he can help design the next generation of Boeing airplanes.

"Boeing is at the forefront of innovation," Mudumba said proudly. "I'm excited about the future of airplanes, and I'm excited to be a small part of this great company." **IQ**

INSIDE IQ
Look inside Sai Mudumba's wind tunnel.