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Air Travel with Dummies

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Air Travel with dummies

How a team of engineers and mannequins is improving comfort and safety for passengers in airplanes

By Greg Tammen

“This is it,” says Byron Jones, professor of mechanical engineering, as he flips several switches. The large, darkened air cabin springs to life with warm electronic hums and the sound of air circulating overhead. Stubby nozzles above passenger seats begin forcefully blowing air downward. Portable lighting rigs illuminate the cabin and its silent, lifeless passengers.

This is a scale-model Boeing 767 passenger cabin. Kansas State University researchers use it as a laboratory to conduct ground-based air cabin research for the Federal Aviation Administration and the commercial air transportation industry.

Byron Jones, professor of mechanical engineering, sits in Kansas State University's scale-model Boeing 767 passenger cabin with some of the 77 silver, inflatable dummies used to conduct research on safety and comfort in air travel.

Jones operates the research passenger cabin with Mo Hosni, the university's Charles and Nona Frankenhoff chair in engineering and professor of mechanical and nuclear engineering. Together with a team of graduate students, research engineer Garrett Mann who ensures equipment is operational, and the 77 silver, inflatable dummies riding in the cabin's passenger seats, they are responsible for the safety and comfort of our air travel.

"We're a one-stop shop when it comes to air cabin research," Jones said. "We develop the experiment, build the components we need to conduct it and then analyze the data from that experiment so we can make recommendations. In the nine years we've been in operation, there really hasn't been anything like this in the U.S."

Ground control

Despite having never left the ground, Kansas State University's lab is considered a crown jewel in aviation research by the FAA and is part of the agency's Air Transportation Center of Excellence for Research in the Intermodal Transport Environment, or RITE. Kansas State University co-leads the center with Auburn University and partners Harvard University, Purdue University, Boise State University and Rutgers Biomedical and Health Sciences, each specializing in a different sector of aeronautical research.

The 10,000 square-foot research lab was previously a showroom for a car dealership and later a children's dance studio. For the past 12 years, though, the space has been used to conduct research ranging from how diseases spread throughout the cabin to what happens to body heat passengers release. All tests are performed with the cabin's crew of dummies — some of which sport magic marker eyes and mustaches.

The space is divided into sections. One section houses large ventilation ducts and cooling units that dry and dehumidify air circulated in the replica passenger cabin. This dehumidified air is the same consistency as air that circulates in passenger cabins 30,000 feet above ground. Another section houses several smaller laboratories and workshops — one of which contains a working jet engine.

In the center of the lab is an elevated, enclosed room containing the replica Boeing 767 passenger cabin, which was built with the seats, air diffusers and outlets from a decommissioned 767. The cabin is monitored with computers and serves as the team's primary testbed.

With hundreds of passengers sitting in close proximity and electronics a staple of air travel, keeping a steady temperature in the cabin can be a challenge as an increase in heat can quickly create discomfort.

Researchers use the dummies to test and account for heat in the cabin. Wires suspended from the cabin's ceiling are taped across every dummy. Each wire set generates about 100 watts of heat, roughly equivalent to how much heat a person puts out when using a laptop or other electronic device, Hosni said.

"It's a bit of an extreme scenario with every passenger using a laptop at once, but it tests everything at its maximum limits, which is important to account for when tens-of-thousands of feet in the air," Hosni said.

As the dummies are warmed, the heat begins to rise and warm the cabin. Cold, dehumidified air is released into the cabin through long metal vents called linear diffusers. The two temperatures mix to create a sustained, comfortable cabin temperature identical to that of an airline in flight.

"The first criteria for how these systems in airliners are designed is to remove the body heat that comes with people in close proximity and using electronics," Jones said. "Even at 30,000 feet up where it's 40 degrees below zero outside, you still have to cool the cabin because all of the body heat in that enclosed space."

Researchers use this method to test for temperature fluctuations in the cabin as well as a variable for other studies.

Air combat

Using the passenger cabin's airflow and ventilation to combat germs, diseases and carbon dioxide is a common focus for the team.

Jignesh Arvind Patel, master's student in mechanical engineering, is studying the effectiveness of the cabin's ventilation systems.

The FAA requires that the heated air and the carbon dioxide passengers produce during breathing need to be ventilated from the cabin as soon as possible for comfort and safety, Patel said.

"If someone has a cold and they sneeze, you don't want those germs to spread among the other passengers," Patel said. "Instead, you want to ventilate those germs as soon as possible so that they are removed from the equation."

To study this, carbon dioxide is injected into the passenger cabin in the lab. The carbon dioxide begins to rise to a steady state. Over time it gradually begins to decline. Patel measures how fast the carbon dioxide takes to decline in the cabin to find out how fast a contaminant in the cabin is ventilated. He then looks at seat arrangement and whether ventilation varies from seat to seat or if it is uniform throughout the cabin.

"So far we've found that it's pretty much uniform," Patel said. "This is ideally what we want because it means that the systems are designed for maximum efficiency."

Another project looked at whether passengers could be getting more than refreshments from the beverage cart.

"We were really curious to see if someone sneezes on the airline attendant or on the beverage cart, how far can those germs be transported," Jones said. "Someone had done a mathematical equation that looked at disease distances on airplanes, but nobody had done experimental measurements on it."

Researchers built a track down one of the cabin's seating aisles. A dummy was attached to a beverage cart and a electronic control system moved the two up and down the aisle to mimic the attendant's route. Carbon dioxide and smoke were released into the cabin so that researchers could visualize the air movement.

"We saw that there is so much motion in the cabin's air from the ventilation system that even if someone sneezed on an attendant, it did not have a significant effect on how far the germs could travel," Jones said. "There is almost zero chance of germs hitching a long ride."

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>
> **— Byron Jones**

Shortly after 9/11, a big focus was put on national security and air travel. Researchers were asked to study how contaminants such as biological agents moved throughout the cabin and how they could be controlled. Several studies were conducted that used baby powder to visualize the source of the contaminant and its movement. Researchers found that while the contaminants spread to upward of eight rows rather than the predicted three, airflow quickly neutralized the spread to a majority of the cabin.

Researchers also found that personal air outlets or "gaspers" — those round, protruding nozzles above seats that stream air — affect disease transmission.

"We found that when you have these blowing air beside you rather than toward your face, they act as a barrier against disease," Hosni said. "It essentially works as a personal air dam."

Engine safety

Shahin Nayyeri Amiri, instructor of civil engineering, works with a jet turbine engine in one of the smaller labs. He is looking at whether chemicals and tiny, toxic particles in the plane's fuel and oil can be released into the passenger cabin if one of the engines has a leak.

"There are several case studies in which passengers sued an airline because they reported smelling oil during the flight and then after the flight felt sick and had memory loss," Nayyeri Amiri said. "These passengers reported that they could smell oil inside the cabin during the flight. It's something that's hard to prove because you can't see it, so we want to figure out if it's actually happening."

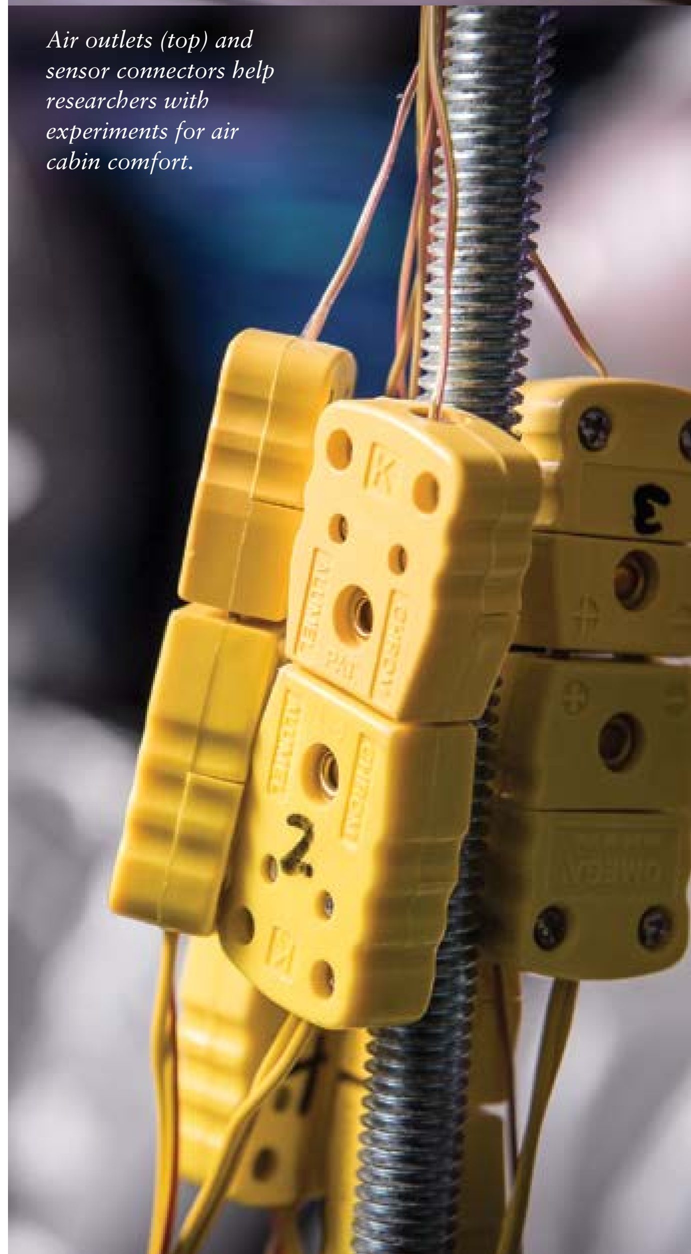
Airplanes do not have an air-conditioning system. The turbine engines that propel the plane also compress fresh air from outside the craft into the passenger cabin to cool it. If oil or jet fuel leak into the engine as it's compressing air, chemicals and particles from those fluids can be released inside the passenger cabin, Nayyeri Amiri said.

To study the particles being released, Nayyeri Amiri relies on a turbine engine and an air simulator to produce particles at different concentrations through temperature and pressure adjustments. Oil and fuel are then injected into the engine and Nayyeri Amiri looks at what comes out during compression.

While he cannot speak to the medical affects, Nayyeri Amiri and colleagues have published multiple studies on their findings about various particles and chemicals that are released.

"If an engine is healthy, this bleed through will not happen," Nayyeri Amiri said. "But if there is something wrong with an engine, even a small amount of oil may leak inside the cabin and cause a problem."

The FAA is working to develop sensor technology that can detect the source of a leak and automatically turn air compression off for the affected engine.



Air outlets (top) and sensor connectors help researchers with experiments for air cabin comfort.