

Researchers investigate airplane seat accommodation

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Smaller seat sizes on airplanes are leading to increased discomfort experienced by airplane passengers. Credit: Pixabay

Whether for business or personal travel, now, more than ever, thousands of Americans spend their days in the air. While most airplane passengers

are hoping for maximum comfort during their flights, airline companies look to maximize their profits—sometimes at the expense of passengers' space.

How to meet the seat needs of airline passengers isn't something that has been quantified, so a team of researchers at Penn State set out to measure seat accommodation.

Through the Open Design Lab, a research lab which focuses on design problems for human variability, Elizabeth Miller, mechanical engineering and Schreyer Scholar alumna, was exposed to the lack of understanding centered around airplane seat design. Miller conducted the research as an undergraduate at Penn State.

"As the world becomes more interconnected, flight is becoming more and more important to help people get to the places that they need. Currently, airplane seats have a pretty negative reputation and don't often provide quality experiences for passengers," she said.

Miller's love of travel provided her with first-hand experience of this. Being able to improve her outside passion through human-centered design research captured her attention and drove her interest in the project.

"You can ask almost anyone who travels on planes, they have probably had trouble fitting in a seat or they know someone who has," she said.

"We saw that a bunch of surveys captured that people associated unhappiness, discomfort and dissatisfaction with seat size. We wanted to understand this from a quantitative perspective."

With direction from lab director Matt Parkinson, professor of engineering design and [mechanical engineering](#), she began investigating how to measure seat accommodation and the different variables which

impact it. These variables include anthropometry, or [body measurements](#); seat dimensions; plane load factor; ratio of men to women; and clothing.

To gather body measurement data, Miller, Parkinson and Samuel Lapp, graduate student in engineering design, used one of the open design lab's most unique tools—its virtual population. This population is created using the National Health and Nutrition Examination Survey, studies completed by the Center for Disease Control to regularly assess various health metrics of United States citizens, and an anthropometric survey of U.S. military personnel. Measurements from these surveys are pulled and processed thousands of times to create an average population that is representative of the entire U.S. population.

Through SeatGuru, a website which features airline seat information, the researchers collected economy seat map and dimension data from major United States airlines. These numbers were compared with the Human Factors and Ergonomics Society's seated environment guidelines. Researchers also manually measured seats while they flew to better understand how armrests relate to seat-width dimension.

Because the sample population is made of a United States average, the team selected the classic economy "three-seat, aisle, three-seat," 24-row, flying environment that Americans see on a Boeing 737 or Airbus A320.

"The majority of the population would fly there [economy] and the impact would be the most significant because the seats are the smallest [in economy]," Miller said.

After collecting population data and seat dimension information, the team applied a random sampling algorithm in MATLAB to select a group of passengers from the virtual population. Seat assignments were made using three different [passenger](#) distribution strategies—random,

behavioral and optimal.

As expected, the random configuration assigns seats randomly. Empty rows and passenger behaviors are ignored. In the behavioral strategy, seats are first assigned using random distribution. Once seats are assigned, passengers redistribute themselves to increase their personal space. Passengers are moved to empty rows nearby or to aisle and window seats to keep middle seats free, when possible. For the optimal strategy, passengers are distributed to the window and aisle seats first, to maximize available space. Passengers are only assigned to middle seats if necessary.

Upon seat assignment, the ratio of accommodated passengers to the total number of passengers on the plane was evaluated based on individual spatial accommodation and contextual accommodation. Accommodation focused solely on hip breadth for the study and highlighted three conditions—strict, margin and compression. Strict accommodation states that a flyer is defined as accommodated if hip breadth is less than the seat width. Margin accommodation includes additional space for clothing and movement. Compression accommodation occurs when a passenger's hip breadth minus a compression margin is smaller than the seat width.

Research results showed that accommodation is at its lowest when all passengers are women, as men have a 20 percent higher accommodation rate than women in a 400-millimeter seat.

"Female passengers tend to be disaccommodated more by seat width because women on average tend to have wider hip breaths," Miller said.

Because gender ratios are not something that can be controlled by airlines, the team was most interested in ways accommodation could be improved.

In relation to seat dimensions, the results showed that more passengers can be accommodated if even the smallest increase in size is made to the smallest seats. But, if the seat is already large, increasing its size won't significantly boost the number of people it can accommodate comfortably.

The team also looked at seat assignment strategy and how it can be used for better accommodation. Results state that if passengers are distributed more optimally by taking advantage of empty seats and leaving middle seats empty as much possible, more people are accommodated.

The work was published in Volume 62, Issue 2 of *Ergonomics*.

Further work on including analysis of shoulder breadth compared to seat width and buttock-to-knee length compared to seat pitch was completed as part of Miller's undergraduate honors thesis. To provide further insight into airplane passenger [accommodation](#), Miller believes additional work relating comfort to emotion must be researched.

"Fit can be something that is as simple as how wide hips are and how wide a seat is, but what matters here is also the human factor of emotion and comfort and how people actually feel," she said. "We have this numeric way of measuring, but we want to directly tie that to people's feelings."

More information: Elizabeth L. Miller et al. The effects of seat width, load factor, and passenger demographics on airline passenger accommodation, *Ergonomics* (2019). [DOI: 10.1080/00140139.2018.1550209](https://doi.org/10.1080/00140139.2018.1550209)

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