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Green Air Space Design: Reducing Fuel Burn

Could making small adjustments at the beginning and end of aircrafts' flight paths add up to big benefits to the environment? That's what MITRE's Center for Advanced Aviation System Development (CAASD) is trying to find out through a new internally funded research effort called Green Airspace Design. The project studies how flight paths can—and cannot—be adjusted in terminal areas to minimize fuel consumption.

An idea to reduce fuel burn is to make more use of crossing runways at an airport.

In airspace design parlance, the "terminal area" refers not so much to the airport as to the airspace above and around it. Reducing fuel burn in the terminal area will cut down the emissions of carbon dioxide (a greenhouse gas), nitrogen oxides (a precursor for smog and acid rain), and sulfur oxides (a precursor for acid rain). The project does not focus directly on explicit environmental metrics like greenhouse gas equivalents or acid rain formation. Rather, it focuses on fuel use, which not only is a surrogate for several environmental metrics but also is directly related to the airlines' operating costs.

"Over the last several years we have seen increasing interest by the FAA and airlines in reducing the environmental impact of aviation," says associate director Debra Pool, of CAASD's System Operations, Safety, and Performance Division. "Results of our research into green design will be used to establish design guidelines to apply to future airspace design projects."

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>
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Reducing Level-Offs

For several years CAASD has looked into the benefits of reducing level-offs as airplanes arrive and leave terminal airspace. Also known as "optimal profile" flight paths, reducing level-offs on one routing near a southwestern airport has saved each flight up to 23 gallons of jet fuel. As part of the Green Airspace Design program, MITRE researchers Gene Lin, Camille Shiotsuki, Joe Hoffman, and Ralf Mayer have been exploring how to harvest these savings by changing the layout of routes (re-designing terminal airspace). Can the crossings and level-offs be adjusted system-wide so that the airplanes burn less fuel?

One area of this study looks at where the flight paths of departing and arriving airplanes require level-offs to cross each other. "At a crossing in one terminal area, for example, arrivals from the north hold their altitude at 11,000 feet for 20 nautical miles," says Lin. "Departures hold their altitude below 10,000 feet until they pass under the arriving airplanes. If arrivals were at a higher altitude, departures might be able to climb faster, eliminating the need for level flight at that crossing and saving them some fuel, and probably noise and emissions too. Meanwhile, the arrivals being higher could avoid their own level-offs, again saving fuel."

Using Cross Runways

Another idea is to make more use of crossing runways at an airport. An important concern for many terminal areas is maximizing capacity—the total number of arrivals and departures. One technique is to use parallel runways only whenever possible. However, funneling all traffic to parallel runways can make some aircraft fly farther. "At one airport we've examined, arrivals from the north sometimes must fly south past the airport, then double back," says Lin. "If they could use a cross-runway, they could save 20 miles or more."

But allowing the use of a crossing runway doesn't always save as much fuel as it may first appear. "It depends on many issues," notes Lin. "For example, where is the flight going to or coming from? Are there other obstacles in the terminal area that complicate the routing? Is the crossing runway long enough to be used by all aircraft?"

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Also, using crossing runways can complicate the job of pilots and air traffic controllers, as they work harder to maintain safe distances between aircraft. For this reason, using crossing runways usually reduces capacity compared to using only the parallel runways. In busy periods, the reduced capacity can lead to more delayed flights—which, among other things, burn more fuel.

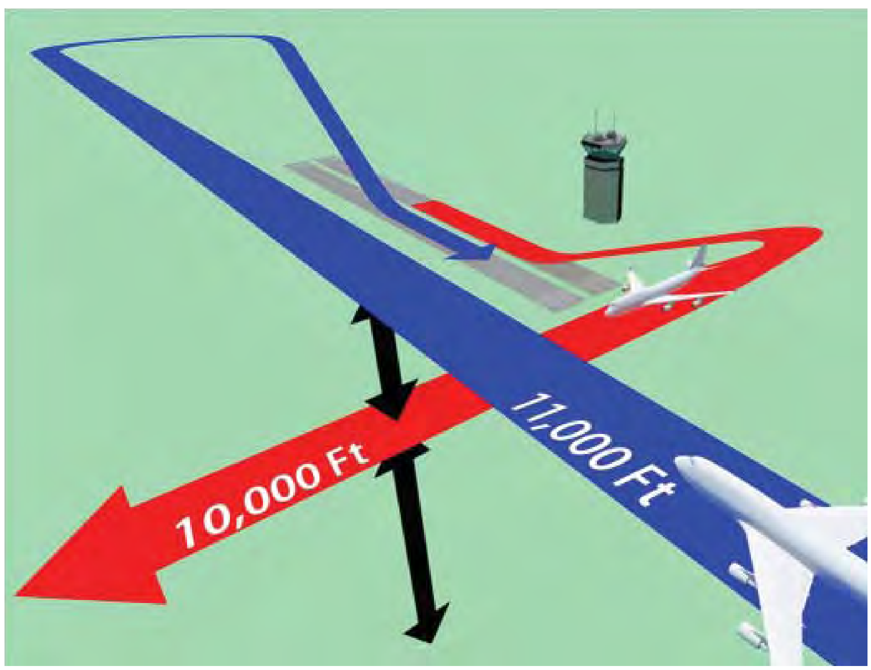
Complex Tradeoffs

Airspace redesign can have multiple, conflicting effects. "If you can adjust the crossings so pilots don't have to interrupt their climbs and descents, then you can save some fuel. But if to do that you make them fly farther, you can lose the benefit. You could also introduce new situations with other flows of aircraft that impact safety or overall efficiency. Sometimes we can eliminate these issues by doing something clever. If we can't, at least we can show what tradeoffs are being made.

"So it's hard to say how widely applicable Green Airspace Design research will be," notes Lin. "Benefits in any particular airspace will vary with the mix of large and small aircraft, the profiles of the routes, and the location of immoveable airspace restrictions such as those from national parks or other airports. Each terminal area will have different tradeoffs. When you design airspace to minimize fuel burn, do you lose capacity? Are there other costs like increased complexity of airspace that make it more difficult for pilots and air traffic controllers to do their jobs? We're developing our methodology to take into account the many variables associated with flights in terminal areas.

> "We're developing our methodology to take into account the many variables associated with flights in terminal areas."
> -Gene Lin

"We'll build upon this initial research and identify additional ways to limit the environmental impact of aviation. As best practices are developed, we'll help the FAA adapt them for the Next Generation Air Transportation System."



MITRE is studying potential ways of reducing aircraft fuel burn in airport terminal areas. Possibilities for this particular layout include changing the altitude of the departure and arrival paths and moving the crossing point closer or farther away from the airport.

—by David A.Van Cleave

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