Data Visualization of Invisible Airflow Hazards During Helicopter Takeoff and Landing Operations

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Abstract

Many aircraft accidents each year are caused by encounters with unseen airflow hazards near the ground such as vortices, downdrafts, wind shear, microbursts, or other turbulence. While such hazards frequently pose problems to fixed-wing airplanes, they are especially dangerous to helicopters, which often have to operate in confined spaces and under operationally stressful conditions.

We are developing flight-deck visualizations of airflow hazards during helicopter takeoff and landing operations, and are evaluating their effectiveness with usability studies. Our hope is that this work will lead to the production of an airflow hazard detection system for pilots that will save lives.

Introduction

Turbulence and other wind-related conditions were implicated in 2,098 out of 21,380 aircraft accidents in the NTSB accident database from 1989-99 [1]. Addressing the controllability problems created by airflow disturbances has thus been a major issue in aviation safety. Disturbances in airflow, including weather-related hazards (e.g. thunderstorms, low level wind shear or microbursts), and locally-generated airwake hazards (such as downdrafts, hot exhaust plumes, wake vortices from other aircraft, turbulence and vortices from surrounding vegetation or structures near the landing site), have all been documented to be hazardous to aircraft of all categories and classes. These hazards can be dangerous even to airliners; there have been hundreds of fatalities in the United States in the last two decades attributable to airliner encounters with microbursts and low level wind shear alone. However, helicopters are especially vulnerable to airflow hazards due to the type of operations they conduct, such as emergency search and rescue, and military or shipboard operations.

Providing helicopter pilots with a flight-deck visualization of local airflow hazards may be of significant benefit. However, the form such a visualization might take, and whether it does indeed provide a benefit, had not been studied before our experiment.

We recruited experienced military and civilian helicopter pilots for a preliminary usability study to evaluate a prototype flight-deck hazard visualization system. The study had two goals: first, to assess the efficacy of presenting airflow data in flight; and second, to obtain expert feedback on sample presentations of hazard indicators to refine our design choices.

The study addressed the optimal way to provide critical safety information to the pilot, what level of detail to provide, whether to display specific aerodynamic causes or potential effects only, and how to safely and effectively shift the locus of attention during a high-workload task. Three-dimensional visual cues, with varying shape, color, transparency, texture, depth cueing, and use of motion, depicting regions of hazardous airflow, were developed and presented to the pilots.

Conclusions

The study results indicated that such a visualization system could be of significant value in improving safety during critical takeoff and landing operations, and also gave clear indications of the best design choices in producing the hazard visual cues.

Acknowledgments

The author would like to thank her advisor, Professor Marti Hearst, for her guidance and support.

References

[1] FAA National Aviation Safety Analysis Center, https://www.nasdac.faa.gov/.