ABSTRACT

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Title: Convective Weather Avoidance with Uncertain Weather Forecasts

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Abstract Text (610 words):

Convective weather events have a disruptive impact on air traffic both in terminal area and in en-route airspaces. In order to make sure that the national air transportation system is safe and efficient, it is essential to respond to convective weather events effectively. Traffic flow control initiatives in response to convective weather include ground delay, airborne delay, miles-in-trail restrictions as well as tactical and strategic rerouting. The rerouting initiatives can potentially increase traffic density and complexity in regions neighboring the convective weather activity. There is a need to perform rerouting in an intelligent and efficient way such that the disruptive effects of rerouting are minimized. An important area of research is to study the interaction of in-flight rerouting with traffic congestion or complexity and developing methods that quantitatively measure this interaction. Furthermore, it is necessary to find rerouting solutions that account for uncertainties in weather forecasts. These are important steps toward managing complexity during rerouting operations, and the paper is motivated by these research questions.

An automated system is developed for rerouting air traffic in order to avoid convective weather regions during the 20-minute – 2-hour time horizon. Such a system is envisioned to work in concert with separation assurance (0 – 20-minute time horizon), and longer term air traffic management (2-hours and beyond) to provide a more comprehensive solution to complexity and safety management. In this study, weather is dynamic and uncertain; it is represented as regions of airspace that pilots are likely to avoid. Algorithms are implemented in an air traffic simulation environment to support the research study. The algorithms used are deterministic but periodically revise reroutes to account for weather forecast updates.

In contrast to previous studies, in this study convective weather is represented as regions of airspace that pilots are likely to avoid. The automated system periodically updates forecasts and reassesses rerouting decisions in order to account for changing weather predictions. The main objectives are to reroute flights to avoid convective weather regions and determine the resulting complexity due to rerouting. The eventual goal is to control and reduce complexity while rerouting flights during the 20 minute – 2 hour planning period.

A three-hour simulation is conducted using 4800 flights in the national airspace. The study compares several metrics against a baseline scenario using the same traffic and weather but with rerouting disabled. The results show that rerouting can have a negative impact on congestion in some sectors, as expected. The rerouting system provides accurate measurements of the resulting complexity in the congested sectors. Furthermore, although rerouting is performed only in the 20-minute – 2-hour range, it results in a 30% reduction in encounters with nowcast weather polygons (100% being the ideal for perfectly predictable and accurate weather).

In the simulations, rerouting was performed for the 20-minute – 2-hour flight time horizon, and for the en-route segment of air traffic. The implementation uses CWAM, a set of polygons that represent probabilities of pilot deviation around weather. The algorithms were implemented in a software-based air traffic simulation system. Initial results of the system's performance and effectiveness were encouraging. Simulation results showed that when flights were rerouted in the 20-minute – 2-hour flight time horizon of air traffic, there were fewer weather encounters in the first 20 minutes than for flights that were not rerouted. Some preliminary results were also obtained that showed that rerouting will also increase complexity. More simulations will be conducted in order to report conclusive results on the effects of rerouting on complexity. Thus, the use of the 20-minute – 2-hour flight time horizon weather avoidance techniques performed in the simulation is expected to provide benefits for short-term weather avoidance.

Comment [p1]: HYPHEN AND EM-DASH USAGE ERROR.
Usage notes:
Hyphen vs. dash. There are three hyphen-like characters: the hyphen itself, the en dash (–) and the em dash
(—). Here are the uses for each:
Hyphen
Use the hyphen is when a multi-syllable word breaks at the end of a line, to link compound modifiers and other
hyphenated words (e.g., *20-minute to 2-hour time horizon*), and for telephone numbers (e.g. *800-555-1212*). Do not put a space before or after a hyphen
En Dash
An en dash, roughly the width of the letter "*n*," is a little longer than a hyphen. Use it to designate periods of time when you might otherwise use the word "*to*" or "*through*." For example:
• *20-minute – 2-hour time horizon*
• *The years 2001–2003*
An en dash is also used in place of a hyphen when combining open compounds. For example:
• *North Carolina–Virginia border*
Em Dash
An em dash is the width of the letter "*m*." m. Use an em dash sparingly in formal writing. In informal writing, em dashes may replace commas, semicolons, colons, and parentheses to indicate added emphasis, an interruption, or an abrupt change of thought. For example:
• *You are the friend—the only friend—who offered to help me.*
OPTIONAL: A space before and after the – (en dash) and — (em dash) is optional. Just be consistent.