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THE NEED FOR PRECISE WEATHER FORECASTS
IN AIR TRAFFIC MANAGEMENT

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1. INTRODUCTION

A certain number of air travel delays in a system where
demand often exceeds capacity are unavoidable. Even
when all goes as planned there are occasions when
more aircraft are scheduled to land at an airport in a
fixed period of time than are permitted to, given the
FAA's aircraft separation minima. The excess will have
to be delayed, either on the ground before departing or
in the air. Some other delays are the result of required
maintenance on airplanes, airports, aids to navigation,
radio frequencies or any of a number of necessary air
travel components. The vast majority of air travel
delays, however, are the result of weather that slows
down the flow of air traffic. In the enroute environment,
adverse weather conditions can cause portions of
airways and large sections of airspace to be unusable.
At an airport, reductions in the ceiling or visibility,
increases in the wind speed or changes in the wind
direction can significantly reduce the Airport Arrival Rate
(AAR), the maximum number of aircraft that can land at
an airport in one hour. Minimizing weather related air
traffic delays require not only the work of air traffic
management specialists and others within the FAA and
airlines but also precise and frequently updated aviation
weather forecasts.

Traditional studies of forecast verification focus on the
meteorological accuracy (e.g., Manning, et al., 2002), or
on accuracy and accompanying metadata (e.g., Ling,
2002). However, there are few studies that relate the
precision of the forecast to the sensitive parameters of
the actual application.

2. THUNDERSTORMS

The weather feature that is more frequently disruptive to
air travel than any other is the thunderstorm. On a day
when a significant thunderstorm event occurs, the
number of flights delayed nationwide can total in the
thousands and the impact can be felt in every corner of
the National Airspace System, even in locations far from
any convective activity. Meteorologists who are
forecasting thunderstorm activity for the aviation
industry are asked to provide forecasts that include an
accuracy level and specific information that is often
beyond the limitations of the science.

Traffic management specialists in the FAA and at the
airlines who are planning the flow of air traffic need to
know the thunderstorm initiation and dissipation times
within a half hour. They need to know the location of
the storms within 30km to 40km (this can mean the
difference in a major airway being useable or not). They
need to know the degree of aerial coverage within ten to
twenty percentage points to determine if flights will be
able to fly between thunderstorm cells. They need to
know the expected height of the storms within a few
thousand feet (many flights can "top" a 32,000 foot
storm but not a 35,000 foot storm), and they also need
to have this information as much as six hours in
advance, which is the lead time required to plan and fuel
a transcontinental flight.

3. CLOUD COVER

Every major airport has a unique set of threshold cloud
ceiling values that are significant in determining the
AAR. If the ceiling decreases to below a certain
designated height, pilots and controllers must transition
from Visual Flight Rules (VFR), which are comparatively
relaxed, to Instrument Flight Rules (IFR), which are
more restrictive. IFR weather will, in effect, increase the
aircraft separation minima and thereby, in most cases,
reduce the AAR. A subtle change in the ceiling can
have a large impact on the airport. For example, if the
ceiling decreases from 1,000 feet to 900 feet at Chicago
O'Hare International Airport the AAR can decrease from
100 an hour to 92. If it decreases further to 600 feet the
AAR can fall to 80, a significant difference when you
consider that O'Hare can have a demand that exceeds
105. For the forecaster, being off by only 100 feet can
mean the difference between a reduced AAR that is
expected and can be planned for and an AAR that
catches planners by surprise and leads to lengthy
delays.

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Figure 1: Airport Arrival Demand profile for Chicago O’Hare International Airport for a typical weekday, showing the number (along the left and right sides) of arrivals expected for each hour (along the bottom, in “Zulu Time” or GMT). In this case, an AAR of 92 would cause demand to exceed capacity during five hours of airport operations. An AAR of 80 would cause demand to exceed capacity during nine hours.

4. VISIBILITY

As is the case with cloud ceiling height, every major airport has a unique set of threshold horizontal surface visibilities that go into determining the AAR. And again, the needs of air traffic management specialists are specific and exact. If, for example, the horizontal surface visibility at Philadelphia International Airport decreases from 2 miles to 1 mile, the AAR can fall from more than 50 to 36.

Figure 2: Airport Arrival Demand profile for Philadelphia International Airport for a typical weekday. An AAR of 36 would cause demand to exceed capacity during seven hours.

5. SURFACE WIND

Each airplane, with the exception of those classified as experimental, has a maximum crosswind component, set by the manufacturer, which it can safely operate under. The aircraft’s operator might put into affect additional standards. Aircraft's demonstrated operating windows with respect to wind combined with the anticipated surface wind dictate the runway(s) that the airport’s air traffic controllers will put into use. A difference in 10 degrees in direction or 5 knots in speed can necessitate a change in the airport’s runway configuration that can, and usually does, affect the AAR. New York’s LaGuardia Airport has two runways that intersect at 90-degree angles. If the wind is strong enough to force the use of only one runway for the purpose of avoiding a significant crosswind component on the other runway, the AAR can decrease to 29 which would cause demand to exceed capacity for a period of several hours. If the wind at Cincinnati/Northern Kentucky International Airport is strong enough from either the east or the west to force controllers to utilize the one east-west runway instead of the two north-south runways, their AAR can be cut in half.

Figure 3: Airport Arrival Demand profile for New York’s La Guardia Airport for a typical weekday. An AAR of 29 would cause demand to exceed capacity in each hour over a fourteen hour period.

Figure 4: Airport Arrival Demand profile for Cincinnati/Northern Kentucky International Airport for a typical weekday. A decrease in the AAR from 72 to 36 would cause demand to exceed capacity during ten hours.

6. INSUFFICIENCIES IN CURRENT FORECAST FORMATS

The effect that changes in ceilings, visibilities and wind have on an AAR vary significantly from one airport to another. However some of the forecasts that planners have to use in trying to foresee fluctuations in the capacity of portions of the National Airspace System are not site sensitive enough to always be useful. The amendment criteria that the National Weather Service applies to their Terminal Forecasts (TAFs) is an example of how uniform standards applied to widely varying needs makes a tool such as the TAF less useful than it needs to be. If a forecaster had expected ceilings to be at 4000 feet and later believed that they would be at 3000 feet instead, an amendment to the TAF would likely not occur because this change would
not meet the NWS’s TAF amendment criteria. Such a
decrease in the ceiling at Denver International Airport
would have no impact on either the AAR or on
operations. The same decrease at Atlanta’s Hartsfield
International Airport would cause a significant decrease
in the AAR, and if it were to occur during a weekday
afternoon it would probably necessitate a traffic
management initiative to adjust the Atlanta arrivals.

7. CONCLUSIONS
Aviation forecasts of all kinds need to be created and
written with Traffic Flow Management’s precise needs in
mind. Aviation weather forecasters need to continue to
develop methods of forecasting that can deliver greater
detail and exactness. The forecast formats and
amendment criteria need to reflect those precise needs
and be site specific.

REFERENCES
Ling, Alister, 2002: TAF Quality Improvement (TQI)
Efforts in Canada, 10th Conference on ARAM,

Manning, D. R., S. A. Amburn, and J. M. Frederick,
2002: Uses of Real-Time Verification to Improve
Terminal Aerodrome Forecasts, 10th Conference
on ARAM, May 13-16, AMS, pp 343-346.

Figure 5: Airport Arrival Demand profile for Denver
International Airport for a typical weekday. A decrease
in the ceiling as described above would not decrease
the AAR which, at 120+, will nearly always exceed
demand.

Figure 6: Airport Arrival Demand profile for Atlanta’s
Hartsfield International Airport for a typical weekday. A
3000 ft ceiling would cause a drop in the AAR from 96
or more to 84 or less, adversely impacting at least
eleven hours.