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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.

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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.

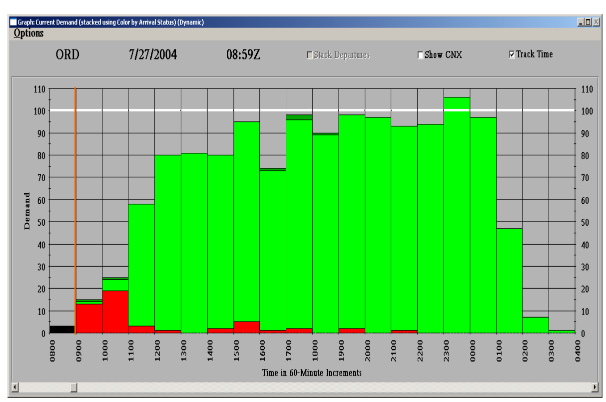

Figure 1: Airport Arrival Demand profile for Chicago O'Hare International Airport for a typical weekday, showing the number (along the left and right sides) of arrivals expected for each hour (along the bottom, in "Zulu Time" or GMT). In this case, an AAR of 92 would cause demand to exceed capacity during 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_ miles, the AAR can fall from more than 50 to 36.

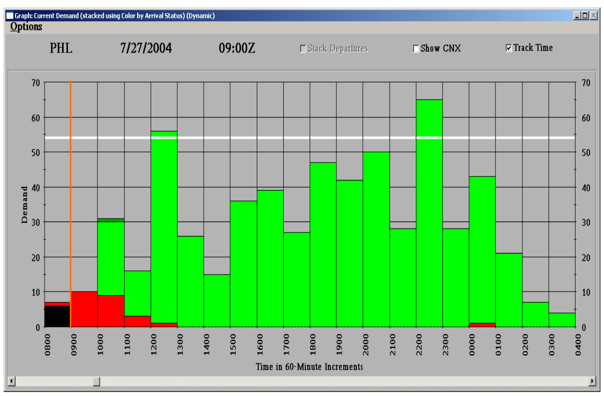

Figure 2: Airport Arrival Demand profile for Philadelphia International Airport for a typical weekday. An AAR of 36 would cause demand to exceed capacity during seven hours.

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.

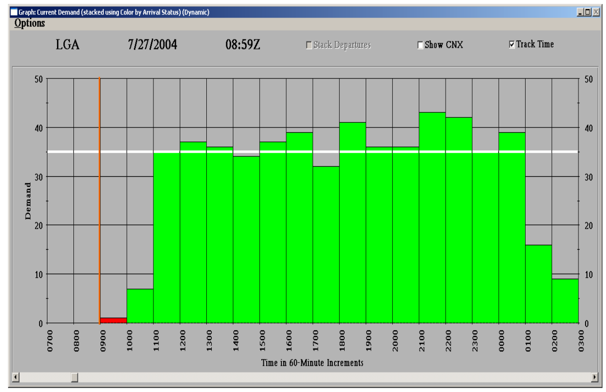

Figure 3: Airport Arrival Demand profile for New York's La Guardia Airport for a typical weekday. An AAR of 29 would cause demand to exceed capacity in each hour over a fourteen hour period.

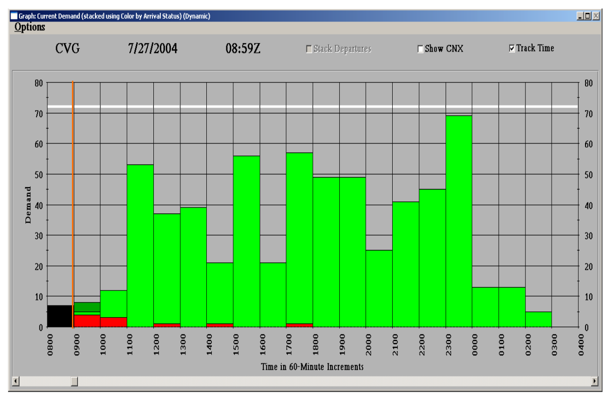

Figure 4: Airport Arrival Demand profile for Cincinnati/Northern Kentucky International Airport for a typical weekday. A decrease in the AAR from 72 to 36 would cause demand to exceed capacity during ten hours.

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.

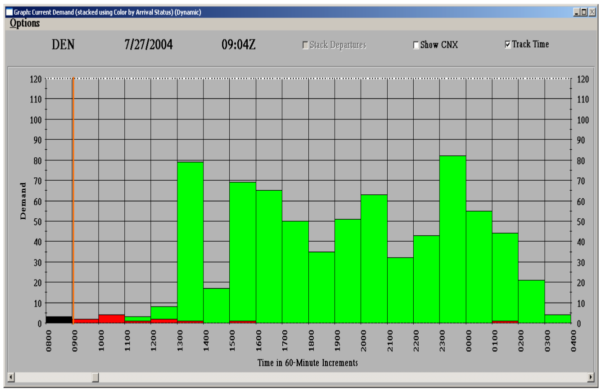

Figure 5: Airport Arrival Demand profile for Denver International Airport for a typical weekday. A decrease in the ceiling as described above would not decrease the AAR which, at 120+, will nearly always exceed demand.

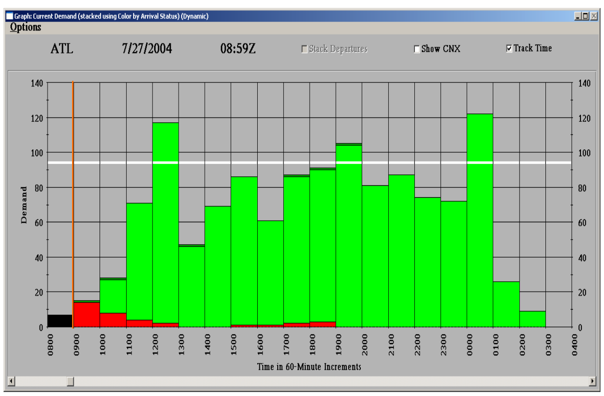

Figure 6: Airport Arrival Demand profile for Atlanta's Hartsfield International Airport for a typical weekday. A 3000 ft ceiling would cause a drop in the AAR from 96 or more to 84 or less, adversely impacting at least eleven hours.

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,* May 13-16, AMS, pp 339-342.

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.