5.12 THE IMPACT OF THUNDERSTORMS ON LANDING TRAFFIC AT FRANKFURT AIRPORT (GERMANY) – A CASE STUDY

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1. INTRODUCTION

Adverse weather significantly influences safety and operating efficiency of air traffic, particularly in the terminal area, resulting, generally, in a reduced operating efficiency and in particular in delays, diversions, and cancellations of flights. In Germany, thunderstorms are among the major weather phenomena affecting airport operations. Other important phenomena are e.g. reduced visibility, snow, fog and sudden wind shifts. Weather impact studies have been made predominantly in the US, e.g. by Evans and coworkers (Evans, 1995, 1997), while similar studies for Germany are still missing. The present study to the author's knowledge is the first quantitative study on the impact of a specific weather phenomena on aviation in Germany. Here we focus on Frankfurt airport, which belongs together with Munich and Düsseldorf to the busiest airports in Germany. Frankfurt was chosen, because the airport operates at more than 100% of its nominal capacity with about 460000 flight movements in 2000 and a peak value of 78 per hour. As the total delay observed at an airport during a period of adverse weather depends strongly and in a non-linear way on the number of affected aircraft and the throughput of the airport, a clear signal could be expected. The study was confined to thunderstorms affecting landing operations in the years 1997 and 1998. The purpose of the study was to provide quantitative information about one of many adverse weather phenomena within Germany for a specific airport. The study also contributes to the evolving discussion about the role of weather for aviation in Germany (see Hauf et al, this conference).

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2. DATA AND METHODOLOGY

To identify the impact of thunderstorms on the landing traffic, a comparison was made between days without thunderstorms at Frankfurt airport, referred to as reference days, and days where thunderstorms passed over the airport. Five thunderstorm days in each of the summer months of 1997 and 1998 were selected and five reference days in the same period of each year. No distinction was made between weekends and normal working days, though substantial differences in flight operations may occur. For all days the hourly flight data were investigated using the *STANLY* (Statistics and Analysis System) information system of the *Deutsche Flugsicherung* (DFS), the German air traffic control authority. The time series of delay data for the five reference days of every year were averaged to yield the delay characteristics of a mean thunderstorm-free reference day. Then the difference in the delay times between a thunderstorm day and the mean reference day was determined on an hourly basis. This difference, respectively the additional delay, during the time of the thunderstorm passage and the subsequent hours is considered in the following as the weather related delay.

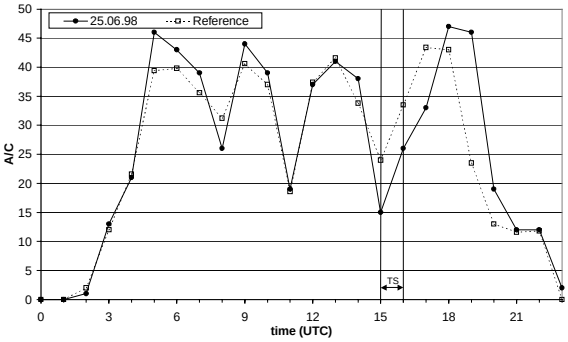

Fig. 1 Arrival rate at Frankfurt Airport in number of a/c per hour on June 25, 1998 (full line) and during the average reference day 1998 (dotted line). TS denotes the thunderstorm passage time at the airport.

Weather data was provided by the German Weather Service and consists of weather radar data, METAR, DWD warnings, and lightning location data. This data was used to identify thunderstorm days where thunderstorms passed directly over the Frankfurt airport region such that an impact signal can be expected. In the following, results from one day, June 25, 1998 will be shown.

3. RESULTS

Fig. 1 shows the time series of the arrival rate (number of a/c per hour) at Frankfurt Airport on June 25, 1998 (full line) and during the mean reference day of 1998 (dotted line). The time of thunderstorm passage as documented by METAR was between 15 UTC and 16 UTC, while radar data indicate that the whole approach area was affected by the storm from 14 to 17 UTC. The arrival rate drops down during the thunderstorm event, increases later again and returns back to normal at about 21 UTC. The crossover time, i.e. the time when the actual arrival rate equals the reference arrival rate again, was shortly before 18 UTC, and approximately two hours after the passage of the storm.

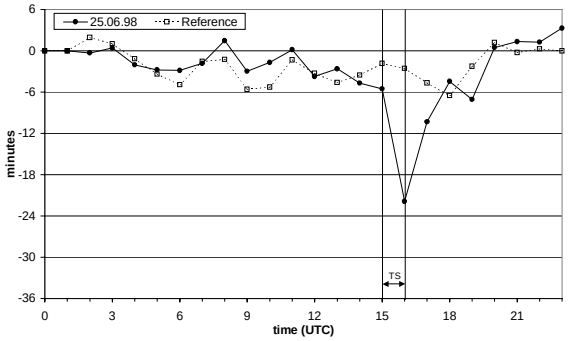

Fig. 2 Arrival quality, respectively delay minutes, for June 25, 1998 (full line) and for the average reference day 1998 (dotted line).

In Fig. 2 the time series of the so-called total arrival quality is shown for both the reference day and June, 25. The total arrival quality is one of many products of the STANLY data base and denotes the average deviation in flight minutes from an idealized flight path including the en route, holding and approach flight phases. The delays increase during the thunderstorm period from about three minutes (reference value) to 21 minutes. Total arrival quality and number of landing aircraft shows a quite different behaviour after the immediate passage of the storm. While the former continuously decreases in magnitude till at ~ 18 UTC, the crossover time, the reference values are reached, the latter, following in parallel the reference values, still increases till its maximum is reached at 18 UTC. Moreover, although the airport operates again with normal efficiency at about 18 UTC, landing aircraft are still behind schedule for about three hours after the crossover time and five hours after the storm has passed the airport. The net effect of this thunderstorm day was a delay of about 14 hours for a sum of 79 arriving aircraft between 14 UTC and 17 UTC. Compared with the reference, this is an additional amount of about nine hours.

4. SUMMARY

Taking into account all days, it can be summarized that a thunderstorm passing over the Frankfurt airport area impacts approximately 100 arriving aircraft within four hours of impact time with ~1000 total delay minutes, approximately 800 more than the normal delay for this period. Here the net impact time takes into account the thunderstorm impact in the whole approach area. Since only the delay of arriving aircraft has been investigated, more studies are required to estimate the total amount of delay and the related costs. This includes the en-route flight section separately, the departing traffic and other airports in Germany as well. Also, the impact of other weather hazards has to be investigated. This first analysis of weather impact on aviation shows that thunderstorms have a significant impact at Frankfurt Airport and that it is necessary to continue this line of research in order to improve air traffic efficiency in Germany .

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