ANALYSIS OF THE IMPACT OF BASIC METEOROLOGICAL ELEMENTS AND PHENOMENA ON REULARITY AND SAFETY IN AVIATION

Tomáš Gajdoš – Ľubomír Fábry

The topic of this diploma is analysis of the impact of basic meteorological elements and phenomena on reularity and safety in aviation. The thesis is devided into theoretical and empirical part. The theoretical introduction describes meteorological factors and the way how they can affect regularity and safety in aviation. Focus of work is a practical part, focused on the most dangerous meteorological factors in aviation. From the available information about the number of accidents and incidents caused by or affected by adverse weather is designed the ranking for the most risky factors. The work use data from the National Transportation Safety Board NTSB in the U.S. for the years 2003 and 2007, and by analyzes are created graphic representations of dangerous meteorological factors.

K e y w o r d s: Safety, Regularity, Weather, Aviation

1 INTRODUCTION

Aviation, probably more than any other mode of transportation, is greatly affected by weather. From thunderstorms and snow storms, to wind and fog as well as temperature and pressure extremes, every phase of flight has the potential to be impacted by weather. Commercial aviation must deal with these adverse types of weather regularly. According to FAA statistics, weather is the cause of approximately 70 percent of the delays in the National Airspace System (NAS) in the United States of America. In addition, weather continues to play a significant role in a number of aviation accidents and incidents. While National Transportation Safety Board (NTSB) reports most commonly find human error to be the direct accident cause, weather is a primary contributing factor in 23 percent of all aviation accidents.

2 EFFECTS OF WEATHER ON AVIATION

On the ground, aircraft may have to be deiced prior to departure, sometimes having to be coated with a fluid the night before to prevent snow or ice build-up. Runways have to be plowed or treated. Lightning in the area prevents ground handlers and fuelers from carrying out their work. And rules require that when temperatures/wind chills are too low, workers are allowed outside only for short periods of time. During the enroute phase of flight, jetstream winds and temperatures have a significant impact on fuel burn and on-time performance. In passenger-carrying aircraft, turbulence is a major concern, while thunderstorms can close air routes for hundreds of miles.

The most common phenomena and their effects on Aviation:

Wind is the horizontal movement of air currents across the Earth's surface as a result of pressure differentials, temperature changes, and the Coriolis force (the force created by the rotation of the Earth). High winds rarely cause issues for airlines on the ground. When there are thunderstorms in the vicinity, flights may be delayed to avoid encountering sudden and abrupt changes in wind speed and direction, known as wind shear. When it's especially windy, airports may temporarily close crosswind runways because airplanes have trouble accelerating or decelerating when buffeted by winds blowing sideways, and the distances required for taking off and landing increase when an aircraft is heading against the wind. If there's snow on the ground, high winds may cause it to blow and drift across runways, resulting in flight delays.

Headwinds and Tailwinds

Commercial airlines frequently encounter headwinds and tailwinds. Headwinds occur when an airplane is flying against the direction of the wind, leading to a longer flight. Tailwinds occur when the winds are blowing in the same direction the aircraft is flying, cutting down on the overall flying time. Headwinds and tailwinds also have an effect on takeoffs and landings. Airplanes fly based on airspeed rather than ground speed; the stronger the headwind, the shorter the distance required to travel down the runway to reach the proper airspeed. Conversely, a tailwind will make the ground speed faster but have no effect on the airspeed.

Low ceiling and visibility

Visibility refers to the greatest horizontal distance at which prominent objects can be viewed with the naked eye. Visibility is affected by factors such as precipitation, fog, and haze. For aviation purposes, a ceiling is defined as the lowest layer of clouds reported as being broken or overcast, or the vertical visibility into an obscuration like fog. Low ceiling and poor visibility are not just a safety issue. They can also severely degrade the efficiency of commercial and military aviation. Reduced ceiling and/or visibility can severely reduce the capacity of an airport and lead to airborne or ground delays that result in diversions, cancellations, missed connections, and extra operational costs.

Turbulence

Turbulence is the movement of unstable air and can be caused by many factors. During mid-flight, high winds aloft often cause turbulence. While some passengers grow nervous when their airplane flies erratically, there is little danger associated with turbulence, so long as fliers remain seated and buckled in. Airplanes are built to withstand stresses far stronger than those encountered during most turbulent episodes, and pilots are trained to avoid dangerous thunderstorms. Turbulence caused by high winds is most common at higher altitudes and on flight paths near the current jet stream.

Icing

When the air temperature is 0 degrees Celsius or less and moisture is present, ice can form on an aircraft structure. The most significant hazard of structural icing is the disruption of airflow over aircraft surfaces. The disruption in airflow reduces lift and increases drag, causing the aircraft to stall at a lower angle of attack and higher speed than normal. Ice also can form in the engine
intake, blocking the flow of air to the engine, which can cause engine failure. Many light aircraft are not certified for flight into known icing conditions. Larger aircraft are equipped with anti-icing systems, which prevent the formation of ice, or deicing systems, which remove ice from the aircraft. In-flight icing is not only dangerous, but also has a major impact on the efficiency of flight operations. Rerouting and delays of commercial carriers, especially regional carriers and commuter airlines, to avoid icing conditions lead to late arrivals and result in a ripple effect throughout the NAS. Diversions en route cause additional fuel and other costs for all classes of aircraft.

Thunderstorms and Other Convective Weather

Hazards associated with convective weather include thunderstorms with severe turbulence, intense up- and downdrafts, lightning, hail, heavy precipitation, icing, wind shear, microbursts, strong low-level winds, and tornadoes. Thunderstorms and related phenomena can close airports, degrade airport capacities for acceptance and departure, and hinder or stop ground operations. Convective hazards en route lead to rerouting and diversions that result in excess operating costs and lost passenger time. Lightning and hail damage can remove aircraft from operations and result in both lost revenues and excess maintenance costs.

3 WEATHER AND REGULARITY

We know the reason for a flight being late or cancelled because of since June 2003, the airlines that report on-time data also report the causes of delays and cancellations to the Bureau of Transportation Statistics. Reported causes of delay are available from June 2003 to the most recent month. The airlines report the causes of delay in broad categories that were created by the Air Carrier On-Time Reporting Advisory Committee. The categories are Air Carrier, National Aviation System, Weather, Late-Arriving Aircraft and Security. The causes of cancellation are the same, except there is no late-arriving aircraft category.

How are these categories defined?

Air Carrier: The cause of the cancellation or delay was due to circumstances within the airline's control (e.g. maintenance or crew problems, aircraft cleaning, baggage loading, fueling, etc.).

Extreme Weather: Significant meteorological conditions (actual or forecasted) that, in the judgment of the carrier, delays or prevents the operation of a flight such as tornado, blizzard or hurricane.

National Aviation System (NAS): Delays and cancellations attributable to the national aviation system that refer to a broad set of conditions, such as non-extreme weather conditions, airport operations, heavy traffic volume, and air traffic control.

Late-arriving aircraft: A previous flight with same aircraft arrived late, causing the present flight to depart late.

Security: Delays or cancellations caused by evacuation of a terminal or concourse, re-boarding of aircraft because of security breach, inoperative screening equipment and/or long lines in excess of 29 minutes at screening areas.

Percentage of delays caused by weather

That category consists of *extreme* weather which prevents flying. There is another category of weather within the NAS category. This type of weather slows the operations of the system but does not prevent flying. Delays or cancellations coded "NAS" are the type of weather delays that could be reduced with corrective action by the airports or the Federal Aviation Administration. During 2011, 75.5 percent of NAS delays were due to weather. NAS delays were 24.8 percent of total delays in 2011. A true picture of total weather-related delays requires several steps. First, the extreme weather delays must be combined with the NAS weather category. Second, a calculation must be made to determine the weather-related delays included in the "late-arriving aircraft" category. Airlines do not report the causes of the late-arriving aircraft but an allocation can be made using the proportion of weather related-delays and total flights in the other categories. Adding the weather-related delays to the extreme weather and NAS weather categories would result in weather's share of all flight delays.

4 WEATHER AND SAFETY

Accident statistics and trends show from 2003 through 2007, there were 8,657 aviation accidents. Weather was a cause or contributing factor in 1,740 of these accidents. The study identified the following weather conditions as causes or contributing factors to weather-related accidents: wind, visibility/ceiling, high density altitude, turbulence, carburetor icing, updrafts/downdrafts, precipitation, icing, thunderstorms, windshear, thermal lift, temperature extremes, and lightning. The weather condition most often cited as a cause or contributing factor in accidents was wind, followed by visibility/ceiling and high density altitude, respectively. According to the NTSB data, aviation accidents, including weather-related accidents, have shown an overall downward trend since 1994. There was a decrease of 21.8 percent to 18.6 percent (2003 through 2007). For the purposes of injury level, each of the 1,740 accidents in this study is classified as none, fatal, serious, or minor based on the highest level of injury in the accident (see figure 1). Of the accidents studied, 48.7 percent resulted in no injuries to passengers or crewmembers, while 24.1 percent resulted in at least one fatality.

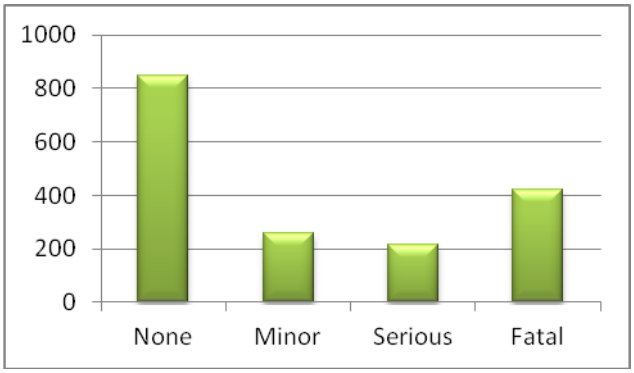

Figure 1. Weather-related Accident Injury Levels 2003–2007

The weather factors that caused or contributed to weather-related accidents are wind, visibility/ceiling, high density altitude, turbulence, carburetor icing, precipitation, updraft/downdraft, icing, thunderstorms, windshear, temperature extremes, other, and lightning (see figure 2).[3]

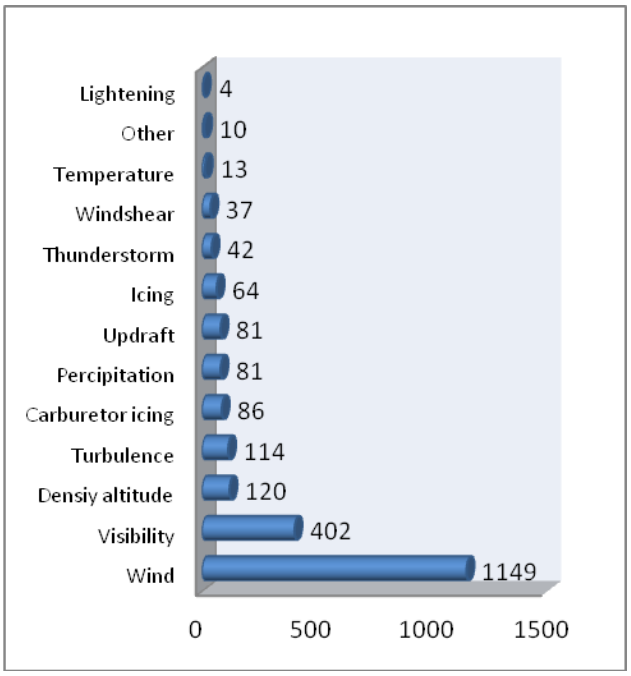

Figure 2. Breakdown of Weather-related Accident Citations 2003–2007

5 CONCLUSION

By Analysis of meteorological elements and phenomena impact the safety and regularity of aviation, I can say that every element or phenomena can rapidly effect aircraft performance during flight even at the worst scenario cause an disaster. By Analysis of the available data in the database of civil aviation accidents and incidents (NTSB) is clearly defined, that wind was the overall leading cause or contributing factor of weather-related accidents from 2003 through 2007. Wind has contributed to over half of all weather-related accident. From the available information about the number of accidents and incidents caused by or affected by adverse weather is designed the ranking for the most risky factors. During processing of work I encountered problems with obtaining information about incidents and accidents. The biggest problem was to get relevant information and classification according to the circumstances and cause of those events. Therefore, I focused on the analysis of available information from U.S.

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AUTHOR(S)´ ADDRESS(ES)

Gajdoš Tomáš, Bc
Technical University of Košice, Faculty of Aeronautics
gajdy007@gmail.com

Fábry Ľubomír, PhD Ing.
Technical University of Košice, Faculty of Aeronautics
lubomir.fabry@tuke.sk