2.4 LOW ALTITUDE WINDSHEAR AT MAJOR AUSTRALIAN AIRPORTS AND THE RISKS TO AVIATION

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1. INTRODUCTION

Low altitude wind shear and its potential impact on aircraft during landing and takeoff is well understood. In general, the wind shear events that present the greatest risk to aircraft are those associated with convective activity, specifically gust fronts and microbursts, and such events have resulted in several major accidents involving large transport aircraft internationally (National Research Council 1983). In Australia there have been few aircraft accidents attributed to this type of wind shear. This is largely because these events are small scale and only affect the approach/departure flight corridor for a short period of time; the traffic density has been relatively low and air traffic control policies have been conservative. As a result the perceived level of risk associated with low level wind shear by the aviation industry has been low. However, in the past two years there have been two serious air safety incidents attributed to wind shear associated with convection, so demonstrating there are significant risks. This paper gives some background on past studies, describes the two air safety incidents and briefly describes plans to better assess the level of risk associated with wind shear at major airports.

2. BACKGROUND

In Australia there has been one major documented accident in the past attributed to a downburst encounter. This was in 1974 when a Fokker F-27 aircraft crashed while attempting to land at Bathurst, NSW, fortunately with no loss of life (Department of Transport 1977). There have also been several studies looking at the incidence of wind shear and the potential risks to aviation. This includes Anderson and Clark (1981) who surveyed a large number of military and civilian pilots on experiences with wind shear; Spillane and Lourenz (1986) who assessed the incidence of wind shear at Sydney airport using single station anemograph data; and Grace and Hancy (1988) who report on a 'dry' microburst observed by a glider pilot in South Australia. Observing the wind shear associated with gust fronts and microbursts really requires an appropriate network of anemometers reporting at an appropriate frequency, or a suitably configured Doppler radar and because there is a lack of such systems in Australia the level of risk to aircraft is not well known. The exception is in Darwin where BMRC has been operating a Doppler radar for a number of years. Potts (1991) examined these data for a limited period and describes the characteristics of microbursts that were observed. BMRC has also been operating an experimental low level wind shear alert system in Darwin for several years, based on the Phase III LLWAS operating at many airports in the USA (Stoll, 1991). Operational trials of the system were conducted in 1997 and the utility was demonstrated but the system has not been fully commissioned due to the lack of any specified requirement from the aviation industry.

3. CASE 1. PERTH AIRPORT, 2 SEPTEMBER 1999, B747

At around 0428 UTC, 2 Sep 1999 (1228 LST, 2 Sep 1999) the outside left engine on a Boeing 747 aircraft struck the ground while the aircraft was landing on Runway 24 at Perth Airport, fortunately with no other damage. At the time of the accident Perth was under the influence of a strong to gale force west-northwest airflow as a result of a complex low pressure system situated to the south of Western Australia. A series of fast moving cold fronts were embedded in the airstream and there were scattered showers and isolated thunderstorms.

Radar data for the period showed a line of showers passed across Perth Airport around 0412 UTC and moved to the east at 20-25 ms^{-1}. Scattered showers were present behind the line and these were moving to the east-southeast at 25-30 ms^{-1}. The Bureau of Meteorology (BoM)

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records wind data from an anemometer located on the airport but approximately 1200 m west of the Runway 24 threshold. The wind direction and speed are sampled at 1 second intervals and 1-minute means are calculated and recorded. Fig 1 shows the 1-minute mean wind direction and speed for the period of interest with the dashed lines showing the range. The arrow indicates the time at which the aircraft landed. At 0412 UTC, as the line of showers moved across the airport, the wind direction backed more westerly and the wind speed increased sharply. The speed then eased gradually and by 0426 UTC the mean wind was a westerly of 7 ms^{-1} with gusts to 9 ms^{-1}. A heavy shower (radar reflectivity 34 dBZ) then moved across the airport and the mean wind speed increased sharply to 12 ms^{-1} with gusts to 18 ms^{-1}. This lasted until approximately 0430 UTC. The wind direction remained steady at around 270 degrees during the period.

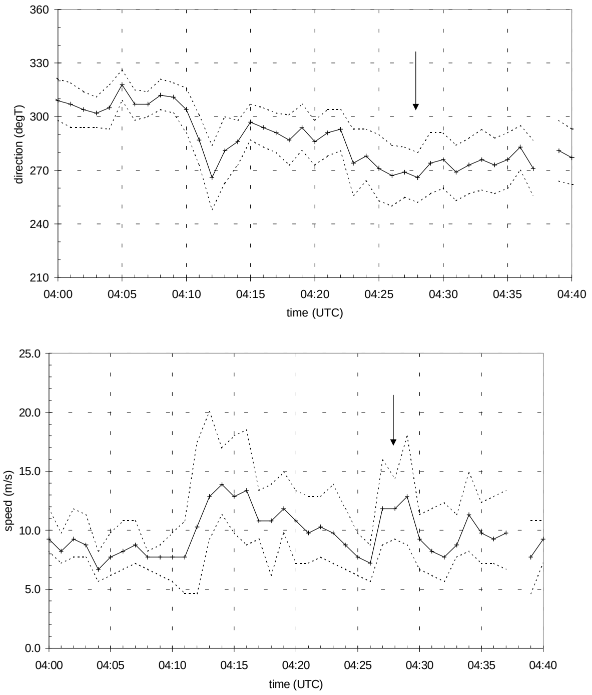

Fig.1 One-minute-mean wind direction (a) and wind speed (b) for Perth Airport for period 0400-0440 UTC, 2 September 1999. Dashed lines show minimum and maximum values observed for each minute.

Based on the speed of the cells from the radar the sharp increase in wind speed would take around a minute to move from the BoM anemometer site to the threshold of Runway 24 and the aircraft would have encountered this change in the final stage of its approach, shortly before 0428 UTC when the aircraft had landed. Immediately prior to touchdown the aircraft experienced a sharp roll to the right of around 8 degrees followed by a similar sharp roll to the left, the latter causing the outer left engine pod to strike the ground. The response is consistent with a sudden increase in crosswind component from the right, and likely presence of turbulence that would have been associated with the change as it moved across the airport. Unfortunately the flight data recorder information from the aircraft did not include wind so the surface based observations cannot be substantiated.

4. CASE 2. BRISBANE AIRPORT 18 JANUARY 2001

At approximately 2129 UTC, 17 January 2001 (0729 LST 18 January) a Boeing 737 aircraft was approaching Runway 19 at Brisbane Airport and aborted at an altitude of around 60 m (200 ft) when heavy rain and hail was encountered. The direction of flight was maintained, the power was increased to go-round thrust and the aircraft began to climb. Soon after initiating the climb-out the airspeed rapidly decreased, the nose pitched down several degrees and the rate of climb decreased markedly. Although the power was increased to maximum thrust at this time the aircraft remained at around 300 m (1000 ft) for approximately 17 seconds before climbing rapidly. The aircraft then landed after a second approach.

Weather radar data for 17/2122 UTC and 17/2132 UTC showed an intense multicellular storm near Brisbane Airport which was moving northeast at a speed of approximately 17ms^{-1}. The two main reflectivity cells in this storm are shown in Fig 2 at A and B, together with the location of Rwy 01/19. Maximum radar reflectivies to 61 dBZ were observed in these cells. By 2132 UTC new core development was evident at the surface on the northern flank of the leading cell and this is shown at C in Fig 2b. Cells A and B passed just south of Rwy 19 and the new cell development would have occurred over the runway in the period 2122-2132 UTC. An examination of the volumetric radar data for 2122 UTC showed evidence of this with a reflectivity core developing at upper altitudes on the north flank of cell A. By 2142 UTC the storm

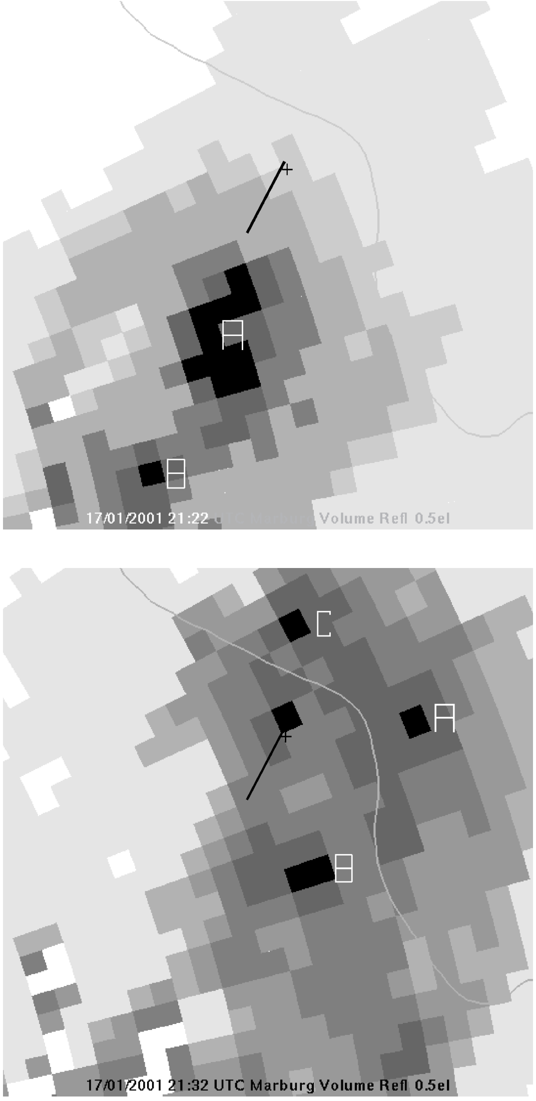

Fig 2. Brisbane weather radar data for elevation angle 0.5 deg and times (a) 2122 UTC and (b) 2132 UTC, 17 January 2001. Solid black line shows location of Runway 01/19 and + symbol shows location of BoM anemometer.

was well northeast of the airport.

The Bureau of Meteorology anemometer on Brisbane Airport is located close to the threshold of Rwy 19 (Fig.2) and Fig 3 shows the variation in direction and speed of the 1-minute-mean winds at this location. This shows a weak southeasterly drift up to 2121 UTC when the wind direction shifted to 180 deg and the speed increased. This increase occurred in two stages, firstly to 4 ms^{-1} and then from 2126 UTC it increased further to around 10 ms^{-1} with gusts to 13 ms^{-1}. The temperature dropped by 1.5 deg C in this second stage after previously remaining constant. The increase in the wind is consistent with the initial passage of a gust front from the main storm and then the development of a strong outflow associated with the new cell development. Subsequent to this the speed decreased rapidly to around 2 ms^{-1} by 2136 UTC while the direction remained a southerly.

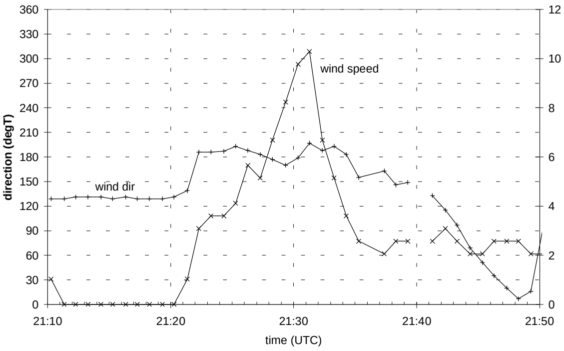

Fig 3. One-minute-mean wind direction and wind speed for BoM anemometer at Brisbane Airport.

Flight recorder data was available for this event (not shown) and this included radar altitude, wind direction, wind speed and computed air speed. For the period of interest the aircraft maintained a flight path closely aligned with the runway and the lowest altitude the aircraft reached following the decision to abort the approach was 50 m (171 ft). The recorded wind direction was around 180 degrees true and the wind speed increased quite rapidly to 12-15 ms^{-1}, consistent with the observations recorded by the BoM anemometer.

After aborting the approach the aircraft initially climbed at a calculated rate of 10-15 ms^{-1} (2000-3000 ft/min) with the engine set to go-round thrust. At this time the wind speed decreased rapidly to around 2 ms^{-1}, the direction shifted from south through west to northwest, the airspeed dropped by 15 ms^{-1} and the rate of climb decreased to less than 2.5 ms^{-1} (500 ft/min). Although the engine thrust was immediately increased to maximum the aircraft remained at an altitude of around 300 m (1000 ft) for 17 seconds before then climbing rapidly. Heavy rain was experienced during this time.

The observations indicate an encounter with an asymmetric microburst associated with the development of the new storm cell. In part the failure of the aircraft to climb after aborting the approach resulted from the marked reduction in airspeed and the heavy precipitation but it is evident that there was also a strong downdraft. The horizontal extent of the downdraft was estimated to be around 1000-1500 m..

5. DISCUSSION AND CONCLUSIONS

The available information indicates the two air safety incidents resulted from wind shear encounters by the aircraft involved. In the first case the aircraft encountered a sharp increase in winds and likely turbulence associated with an outflow or gust front from a convective cell. The second case involved an encounter with a microburst from an active thunderstorm. In both cases a lack of supporting information with the required spatial and temporal resolution limits the ability to be more conclusive in the details.

The air traffic control agency, Airservices Australia, operates multiple anemometers on all the primary airports in Australia to support ATC requirements. High resolution data from this network would have aided the investigation of these events but the data was not routinely recorded. The Bureau of Meteorology has now made arrangements to record the data, initially at Perth and Sydney airports, to support future safety investigations and also to support studies on the level of risk associated with wind shear. The Bureau of Meteorology also installed a Doppler radar in Sydney in 1999 and studies on the incidence of wind shear are in progress.

Ground-based systems are available to automatically detect the wind shear associated with gust fronts and microbursts and provide timely warnings in an appropriate format. However, there are no operational systems in Australia although there is an experimental wind shear alert system in Darwin. Aircraft-based wind shear detection systems are also available but few aircraft operating in Australia have these installed. In practice the only warnings provided are those based on pilot reports and passed on by ATC personnel, although the effectiveness of these is limited. The cost of automated wind shear alert systems is significant and although the potential losses associated with an accident are very large the cost effectiveness needs to be demonstrated.

The air safety incidents described here demonstrate that wind shear associated with convection, namely gust fronts and microbursts, presents a risk to aircraft operations in Australia. They also highlight a need for the industry as a whole to review current practices relating to wind shear to minimise the risk of more serious encounters in the future. This includes a better understanding of the level of risk associated with wind shear at the major airports; current operational procedures relating to wind shear; the role and responsibility of the relevant agencies; issues associated with the education and training of pilots and ATC personnel; better use of current systems and information and the possible introduction of new systems.

6. REFERENCES

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