Uncommanded yaw on climb, Airbus A300B4- 605R, N14065

Micro-summary: This Airbus A300 experienced what appeared to be an uncommanded yaw on climb.

Event Date: 2000-06-27 at 1547 UTC

Investigative Body: Aircraft Accident Investigation Board (AAIB), United Kingdom

Investigative Body's Web Site: http://www.aaib.dft.gov/uk/

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Airbus A300B4- 605R, N14065

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Aircraft Type and Registration:	Airbus A300B4- 605R, N14065
No & Type of Engines:	2 CF6-80C2A5 turbofan engines
Year of Manufacture:	1989
Date & Time (UTC):	27 June 2000 at 1547 hrs
Location:	10 nm North East of Filton, Gloucestershire, UK
Type of Flight:	Public Transport
Persons on Board:	Crew - 13 - Passengers - 191
Injuries:	Crew - None - Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	52 years
Commander's Flying Experience:	10,500 hours (of which 3,426 were on type)
	Last 90 days -178 hours
	Last 28 days - 62 hours
Information Source:	AAIB Field Investigation

History of the flight

The aircraft was planned to operate a scheduled flight from London (Heathrow) to New York (J F Kennedy). The aircraft mass at take off was 377,738 lb with the centre of gravity (CG) calculated to be at 32·5% of mean aerodynamic chord; this represents an aircraft operating close to its maximum mass at an aft CG. The serviceable aircraft had a flight deck complement of three pilots, of whom the first officer (FO) was the handling pilot. The aircraft took off at 1534 hrs from Runway 09R and was cleared to follow the Compton Five Juliet standard instrument departure prior to routing to the west.

During the departure and climb the FO flew the aircraft manually. As the aircraft was approaching FL220, at a reported airspeed of 325 KIAS, the aircraft experienced an abrupt disturbance which was perceived by the flight crew to be a disturbance in yaw with no attendant lateral motion evident in the resulting manoeuvre. They believed that the yawing motion had been caused by an uncommanded rudder input. The disturbance was accompanied by a loud bang which was noted by both the flight crew and some of the cabin attendants. They all reported the noise as being coincident with the disturbance. At the time of the event the aircraft was configured as follows: flaps and slats 'IN', landing gear 'UP', auto pilot 'OFF', pitch trim (systems 1 and 2) 'ON' and yaw damper (systems 1 and 2) 'ON'. The aircraft was clear of cloud and there were no other aircraft reported in the vicinity.

Following the disturbance the aircraft appeared to behave normally. However, the commander decided to return to London (Heathrow) rather than commence a transatlantic flight following a suspected an uncommanded flight control input. An uneventful, overweight landing on Runway 09L was completed at 1624 hrs.

Flight recorders

The 30 minute, tape based, CVR had overwritten the recording of the event. However, the solid state FDR was successfully replayed at the AAIB and the data were available for analysis.

Following the departure from Runway 09R at London (Heathrow) the aircraft turned towards the west and climbed. Thirteen minutes later, with the aircraft being flown manually and climbing through FL220 at 327 kt, the values of normal and lateral acceleration, which were recorded from the accelerometer mounted at the aircraft's centre of gravity, showed a small disturbance. There were no observable changes in the recorded values of heading or rudder deflection but the aircraft rolled from wings level to 2.4° left wing down. All engine parameters remained constant.

Within one second of the onset of the disturbance roll, right aileron was applied and the discrete parameters for right roll spoiler panels 4 to 7 indicated deployment for one second. (It should be noted that the roll spoiler panels only have to extend by approximately 2° for the FDR discrete parameters to indicate deployment.) The aircraft rolled to 1.4° right wing down before roll left aileron was applied with simultaneous deployment of left roll spoilers 3 to 7 being recorded. The recorded value of rudder position showed a momentary deflection of 0.3° left from its normal position, indicative of yaw damper operation. The nose up pitch attitude increased by 1° to 3.5° during this time. The roll to the left continued to 4.2° left wing down before corrective roll right aileron was applied and right spoiler panels 6 and 7 indicated deployment. Rudder deflection of 0.3° right from normal position was recorded and a small amount of down elevator was applied to reduce the nose up pitch attitude back to 2.5°. All of the control surface deflections recorded after the initial disturbance were consistent with the control inputs demanded by the crew. The complete event lasted no more than seven seconds,

The aircraft continued to climb on its heading of 284°M at a reduced speed of 310 kt. It levelled off at FL280 and the autopilot was engaged before a left turn back towards London (Heathrow) was initiated. After landing ground spoiler deflection on all 14 panels was recorded as the aircraft slowed during the rollout.

Engineering investigation

Over the following three days the aircraft was examined for damage and any failure or defect that could have been implicated in the in-flight disturbance. The aircraft completed a test flight before re-entering service.

An external examination showed that nothing had detached from the aircraft and there was no evidence of anything having struck the aircraft. Detailed inspections of the ailerons, spoilers and rudder and their attachments found no damage. One spoiler actuator rod end was found to have excess play and its liner was replaced. A BITE (Built in Test Equipment) fault was reported from one of the two Electrical Flying Control Units (EFCU). This concerned the '5 ft' warning from the Flight Warning Computer involved in the arming of the ground spoilers. This was found to have cleared on further inspection and did not re-occur. Given the behaviour of the spoilers during the incident this was not considered to be relevant. Functional checks of the primary and secondary flying controls and BITE tests of the associated computers revealed no anomalies.

Special equipment was installed to mimic the in-flight conditions to the aircraft flight control systems. The control systems were operated and the electrical looms serving the flying control computers were shaken and manipulated in an attempt to reveal any break in a conductor or connector fault. The looms were examined for any indication of possible screening defects. Mobile telephones and a laptop computer were operated close to the avionics racks but this is acknowledged as not being a systematic or scientific test of the vulnerability of the aircraft's systems to such effects. Current avionics installations do not necessarily provide protection against radio frequency emissions from mobile telephones. Close attention was paid to the rudder system and the yaw damper but no defects were found. No movement of the rudder was seen when it was operated from a single hydraulic supply or when switched between systems and there was no sign that the input mechanism on any of the three actuators was stiff in operation (which could cause the input spring strut to collapse).

The loud bang reported by the crew could have been directly associated with the cause of the upset or could have been a secondary result of the movement of the aircraft. In trying to identify the source of the noise, which was heard on the flight-deck and in the cabin, the freight and baggage holds were examined for any sign that a load had been unsecured or had moved. The ground crew who unloaded the freight reported that there was no sign that any freight had moved. The equipment areas alongside the holds were opened and examined for anything, such as the disconnection of an air conditioning duct, which could have caused such a noise but none was found.

No anomalies in the operation of the aircraft were found on the test flight during which it was manoeuvred vigorously whilst being operated in the same manner as on the incident flight.

Air traffic control

The London Area and Terminal Control Centre was controlling the aircraft during its standard routing from London (Heathrow) prior to the flight across the North Atlantic. As it approached the Bristol area, climbing through FL220, it was directly behind a Boeing 777 (B 777) that had passed through exactly the same airspace (as derived from radar data) some 4 minutes and 18 seconds earlier. When it passed through this point the B 777 had been at FL229 and was at an estimated mass of 243 tonnes. No other aircraft had recently passed this location, close to this level, either along the same track or across it.

Meteorological conditions

The disturbance experienced by the aircraft could be attributed to a localised severe turbulence event. Assistance was requested from the Meteorological Office at Bracknell for an analysis of the atmospheric conditions in the area of the disturbance encountered by the A-300 aircraft. The synoptic situation at 1200 hrs on 27 June 2000 indicated that an area of high pressure was centered to the north of Scotland with a substantial ridge of high pressure extending over all of the United Kingdom. Radio sonde ascents indicated a subsidence inversion associated with the ridge of high pressure. Above this inversion the air was dry and relatively stable until at very high altitude where some cirrus cloud may have been encountered. A comparison of the visible and infra red satellite photographs confirmed that any low cloud was well broken and there was some cirrus at high level. However, satellite photographs taken at 1424 hrs indicated that in the area of interest there was little or no high cloud. The local wind at altitude was estimated to be a light westerly between 10 to 20 kt, wind data from the inertial navigation system recorded on the FDR was 280°/08 kt at the time of the disturbance.

In order to define what may have caused the localised turbulence the following meteorological phenomena were considered:

Clear Air Turbulence. Clear air turbulence is often associated with large horizontal wind shears in the vicinity of jet streams. In this instance the nearest jet stream was over the North Sea and the horizontal wind gradients in the area in which the disturbance was encountered were very small.

Breaking Gravity Waves. Clear air turbulence can also be associated with breaking gravity waves. Gravity waves can be generated by surface topography or convection and then require suitable stability conditions to allow the waves to break. In this case the surface winds were extremely light and the atmosphere very stable, it is therefore considered to be unlikely that gravity waves will have been generated. Furthermore, there was no evidence from the satellite photographs of the presence of gravity waves.

Convective Turbulence. Turbulence can also be associated with strong updrafts in convective conditions. The atmosphere was stable in this instance and there was no evidence of any convective activity.

Turbulence at Cloud Tops. On occasion moderate turbulence can be encountered at the top of layer clouds. This is normally widespread and not localised. There was no evidence of any such clouds that may have affected the aircraft in this manner.

Wake Vortex Encounter. In the prevailing conditions of stability and light winds the wake vortices from heavy aircraft can be relatively long lived. Furthermore, the vortices would be expected to slowly sink and decrease in altitude. It is therefore considered that the most likely meteorological reason for any localised turbulence would be an encounter with a wake vortex generated by another aircraft.

Wake vortex encounters

All aircraft in flight leave behind them wake vortices with characteristics that are a function of the generated lift and are thus dependent upon: gross weight, wing planform, airspeed, configuration and attitude. These characteristics are then altered by interaction between the vortices and the ambient atmosphere. Studies suggest that, at medium level and in still air, the shed vortices tend to drift slowly downwards at a rate of approximately 400 feet per minute and level off, usually not more than 1,000 feet below the flight path of the aircraft. However, their behaviour is not predictable, particularly in the aspects of their trajectory and decay.

In general wake vortex encounters tend to occur close to airports where the density of operations is high and where aircraft are manoeuvring after take off or prior to landing on prescribed tracks at relatively slow speeds. Suitable separation minima are applied in these areas with the aim of reducing the probability of a vortex wake encounter to an acceptably low level, and to minimise the magnitude of the upset when an encounter does occur.

Wake vortex encounters during the climb or cruise are relatively rare since the airspeed is high and it is less likely that aircraft will be directly behind each other. Furthermore, with a standard vertical separation of 2,000 feet it is unlikely that the vortex will descend far enough to disturb the following aircraft. Finally, vortices require specific atmospheric conditions to enable them to persist. However, the use of modern navigation aids increases the likelihood that aircraft will follow specific tracks more accurately and thus the possibility of flying directly behind another aircraft is increased. Also, the introduction of Reduced Vertical Separation Minima can reduce the vertical separation to 1,000 feet. It is therefore possible that wake vortex encounters during the cruise may become more prevalent.

The Boeing Commercial Airplane Group have conducted extensive wake turbulence research during which a B 737 was purposely flown through the wake of a B 727 in order to study the behaviour of the aircraft during a wake vortex encounter. During this research a sound was sometimes associated with the wake encounter when the aircraft centreline intercepted the descending wake. It was estimated that the sound (described by the flight test crew as a 'thump') can occur when the fuselage of the aircraft touches the centre of the vortex where the pressure is at its lowest. Research is continuing into a system that could disrupt the vortices generated by the wing. This might be achieved by moving some of the flight control surfaces in order to interrupt the flow over the wings but without diminishing the wing's lifting ability. At present this research is concentrating on the approach profile where the problem of wake turbulence is currently at its most intrusive.

Discussion

The aircraft was established in the climb, in seemingly quiescent air, with no aircraft apparently in the vicinity when it encountered a sudden disturbance, which the flight crew perceived as a yaw excursion. The value of the lateral acceleration, recorded from the accelerometer mounted at the aircraft's centre of gravity, showed a small disturbance but it is probable that the flight crew, being seated in the cockpit, perceived a higher level of lateral acceleration, which they interpreted as uncommanded rudder input. Extensive engineering investigation did not find any reason for the disturbance to have occurred and no anomalies in the operation of the aircraft were found during the test flight. Furthermore, there was nothing from the engineering investigation that could explain the loud noise reported by both the flight crew and the cabin attendants. A number of meteorological phenomena were considered. It is most probable that the reason for any localised turbulence was an encounter with the wake vortex generated by a B 777 aircraft which had passed through the same airspace some four minutes and 18 seconds earlier. Research into wake vortex encounters indicates that a loud noise can be associated with entry into the core of the vortex if the geometry is appropriate.