Airbus A321-200, F-GTAA

AAIB Bulletin No: 3/2003	**Ref: EW/C2001/2/3**	**Category: 1.1**
Aircraft Type and Registration:	Airbus A321-200, F-GTAA	
No & Type of Engines:	2 CFM56-5B3 turbofan engines	
Year of Manufacture:	1997	
Date & Time (UTC):	8 February 2001 at 1455 hrs	
Location:	Runway 09L, London Heathrow Airport	
Type of Flight:	Public Transport	
Persons on Board:	Crew - 8	Passengers - 44
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Damage to left wing fence, wing tip and aileron	
Commander's Licence:	Airline Transport Pilots Licence	
Commander's Age:	Not known	
Commander's Flying Experience:	13,000 hours (of which 4,600 were on type)	
	Last 90 days - Not known	
	Last 28 days - Not known	
Information Source:	AAIB Field Investigation	

Summary

The aircraft was landing on runway 09L with the surface wind from 020° at 10 kt. No windshear had been reported up until this time. Only light turbulence was experienced during the final approach. As the aircraft descended below 200 feet, there was a sudden loss of airspeed of 10 to 15 kt. In response, thrust was increased to maintain the airspeed at VAPP+10 kt.

At 100 feet agl, the left wing dropped suddenly. The commander applied opposite roll sidestick. There followed three cycles of roll oscillation, which culminated in the left wing tip (winglet) touching the runway, coincident with touchdown on the left main landing gear. A go-around was executed and the aircraft returned for an uneventful landing.

Subsequent analysis of the DFDR data indicated that the roll oscillation had occurred coincident with the cyclic application of rudder, in conjunction with cyclic lateral sidestick inputs.

Subsequent landing aircraft noted that there was a sudden reduction in wind speed at about 100 feet agl, from 20 kt over the threshold to 10 kt at the surface, with the direction being steady. The landing threshold was downwind of several multi-storey buildings that could have given rise to the vertical wind shear.

History of the flight

The aircraft was landing on Runway 09L after a scheduled public transport flight from Paris Charles de Gaulle Airport. The commander was the handling pilot. The aircraft configuration was Flap Full, following a manually flown approach with the Flight Directors on and manual thrust.

The crew had noted the arrival Automatic Terminal Information System (ATIS) information V timed at 1350 hrs, which gave a surface wind from 010° / 13 kt, variable in direction between 340° and 040°, visibility 25 km, cloud Few at 1,800 feet, Broken at 2,000 feet, Overcast at 4,000 feet, Temperature +5°C, Dew Point +2°C, QNH 999 mb.

The Heathrow Tower controller cleared the aircraft to land at 1453 hrs and passed the surface wind as 020° at 10 kt. No windshear had been reported by landing aircraft up to this time and only light turbulence was experienced during final approach. The commander reported that as the aircraft descended below 200 feet, there was a sudden loss of airspeed of about 10 to 15 kt. In response to this, thrust was increased in order to maintain the airspeed at VAPP + 10 kt. At about 100 feet, the left wing dropped unexpectedly. The commander then applied opposite roll sidestick input and opposite rudder. Figure 1 *(jpg 153kb)* shows the data recorded on the DFDR covering the event. There followed three divergent cycles in roll. During the third cycle, full left sidestick input was achieved on one occasion. The roll oscillation culminated in the left wing tip striking the runway just prior to the left main landing gear touchdown.

At this point, the commander assessed that the landing could not be safely completed so he elected to execute a go-around. He applied additional thrust and the aircraft became airborne again immediately and climbed away.

After the go-around, the aircraft was positioned by radar vectors for a second approach to Runway 09L. During the downwind leg, the flight deck crew were advised by a passenger that the left wing tip had suffered tip strike damage and the winglet was bent out of its usual position. The handling characteristics of the aircraft were not noticeably affected by the damage. The commander elected to carry out the subsequent approach using Flap 3. The aircraft landed uneventfully at 1510 hrs.

The aircraft taxied to the parking stand and the passengers were deplaned normally. There were no injuries sustained during the event. No debris from the incident was deposited on the runway surface.

Engineering inspection

Damage to the aircraft was confined to the winglet and wing tip. Contact with the runway had abraded the lower edge of the winglet and pushed it upwards, splitting apart the upper and lower skins of the wingtip. The winglet, whilst still loosely located, could be pushed up and down by hand. Following replacement of the entire wingtip/winglet assembly, the aircraft was returned to service.

Flight Recorders

The two solid state recorders fitted to the aircraft retained information from the period of the incident. The recorders were downloaded by the Bureau Enquêtes-Accidents in France and the resulting information was provided to the AAIB for analysis. All quoted altitudes are above mean sea level unless otherwise stated.

The commander was the handling pilot of the aircraft at the start of the descent from FL80. The autopilot and autothrust systems were disconnected, Flap 1 was selected and ground spoilers were armed. Flap 2 was selected at 4,300 feet and the aircraft became established on both localiser and glideslope whilst level at 2,000 feet. As the ILS was captured, engine power was reduced and airspeed started to decrease from 180 kt towards a target of 130 kt. The landing gear was lowered at 1,700 feet and further flap was extended; Flap 3 at 1,400 feet followed by Flap Full at 1,250 feet. The descent profile had been initially slightly high on the glideslope but this had been corrected by the time the aircraft had descended to 1,080 feet (1,000 feet agl). Typical wind speeds and directions of 010?/20 kt, together with aircraft drift angles of between +6? and +9?, were recorded during this initial phase. Aircraft roll attitudes of ±3.5? and corrective sidestick inputs in the order of ±8? (out of a maximum travel of ±20?) were also recorded.

During the time that the aircraft had descended from 1,000 feet agl to 400 feet agl, the nose of the aircraft had been raised slightly to an average of 1.5? nose up and engine power had been increased to maintain the airspeed between 130 kt and 140 kt. It was observed that, although the roll attitude variations were of the same order of magnitude as before (±3.5?), they were more regular in oscillatory period and larger amplitude sidestick inputs had been applied (±10? of movement) to counter them.

Whilst descending through 360 feet agl, the start of a temporary increase in the values of wind speed was recorded (from 20 kt to a peak of 27 kt), although there was no change in the wind direction. It was from this point that the first, initially small, rudder pedal movements were recorded and sidestick roll inputs increased in amplitude still further; ranging from 13? left to 15? right. Aircraft pitch attitude also increased slightly to an average of 2.5? nose up.

From 200 feet agl to 120 feet agl, an average bias of 2.5? right rudder pedal application was recorded and aircraft drift angle started to reduce. Wind speed also started to reduce towards a recorded surface wind speed of 6 kt. Engine power was increased symmetrically to 71% N1 for five seconds before being brought back to 62%. During this period the amplitude of the sidestick roll inputs increased to range between maximum travel right and 16? left. The nature of the rudder pedal application also changed in that a relatively steady right pedal bias became an oscillatory application in the same sense as that of the sidestick movement.

From 73 feet, rudder pedal input and roll attitude variations increased in amplitude rapidly, culminating in pedal inputs of ±12? and successive roll attitude maxima of 10.5? left wing down, 14.8? right wing down and then 20? left wing down. This last roll attitude occurred at a recorded radio altitude of two feet and is considered to be the point at which the left wing tip contacted the ground. Compression of the left main gear was recorded at the time of ground contact together with a small normal acceleration spike of 1.24 g. Over the last 50 feet, pitch attitude had increased to 6.3? nose up as the aircraft flared. No windshear warnings were recorded on the FDR and none were audible on the CVR recording at any time during the approach, but automatic height calls from 1,000 feet and, in the latter stages, one hundred ..... fifty ......twenty ...... retard, retard, retard were recorded.

At the time of the contact, the thrust levers were advanced, initially to the climb detent and then, three seconds later, fully forward to the TOGA detent. ATC were informed that the aircraft was going around. Pitch attitude continued to increase towards a target attitude of 14? as the aircraft climbed away on runway heading.

At 79 feet, the gear was selected up followed by selection of Flap 3 at 640 feet agl. As the flap setting was changed, the crew received a TCAS traffic advisory and the warning Traffic....Traffic was heard on the CVR recording. Whilst climbing through 1,500 feet agl, the aircraft began a left turn onto 040? in accordance with the published go-around procedure. During the turn, the thrust levers were brought back to the climb detent allowing the autothrust system, which had been armed when TOGA was selected, to become active. Following an enquiry from ATC as to the reason for the go around the crew stated that they had encountered windshear.

The flaps were brought back up to Flap 1 and then fully retracted as the aircraft leveled off at 3,000 feet. Following radar vectors from ATC, the aircraft was flown in a left hand circuit prior to making an uneventful ILS approach and landing on Runway 09L in Flap 3 configuration. The recorded wind parameters for this second approach were very similar to that of the first. Roll attitude and sidestick input variations were of a comparable magnitude to those of the initial stages of the first approach. However, rudder pedal movements were less oscillatory in nature and a smoother right pedal bias was progressively applied to reduce drift angle prior to touchdown.

At all stages during the two approaches the aircrafts observed response to the applied control inputs was as expected.

Anemometry

The Runway 09L threshold anemometer recorded data was obtained for the period around the incident time. The two minute average surface wind was passed as 020°M at 10 kt as the aircraft was cleared to land at 1454 hrs. The two minute average wind covering the incident time was 016° at 8 kt. The ten minute average covering the incident time was 019° at 10 kt, variable in direction between 345° and 041°, with wind speeds of 4 kt minimum to 19 kt maximum.

Subsequent landing aircraft noted that there was a sudden reduction in wind speed at about 100 feet agl, from 20 kt over the threshold to 10 kt at the surface, with the direction being steady. The Heathrow ATIS broadcast was subsequently amended to include this information.

The terrain to the north north east of the Runway 09L threshold is relatively flat, but several multi storey buildings are situated just outside the airfield boundary. Such obstacles are likely to generate some vertical shear and turbulence downstream in strong wind conditions. However, the conditions that existed at the time of this incident were fairly benign and should not have presented the crew with any significant handling problems.

Manufacturers Recommended Crosswind Landing Technique

The manufacturers recommended crosswind landing technique for the A320 series was contained in the Flight Crew Operating Manual Volume 3, Standard Operating Procedures. The Landing procedures section contained the following advice to crews:

Crosswind landings

The preferred technique is to use rudder to align the aircraft with the runway heading during the flare while using lateral control to maintain the aircraft on the runway center line. Routine use of into wind aileron is not recommended, because sidestick deflection commands roll rate until touchdown.

In strong crosswind conditions, small amounts of lateral control may be used to maintain wing level. This lateral stick input must be reduced to zero at first main landing gear touchdown.

Ground clearance

Avoid flaring high,

A tail strike occurs if the pitch attitude exceeds 11° (9.5° with the landing gear compressed).

A wing tip or engine scrape occurs if the roll angle exceeds 18° (16° with the landing gear compressed).

Be aware of pitch up tendency with ground spoiler extension.

A320 Lateral Control response

The Airbus A320 family of aircraft operate by means of a fly by wire control system, controlled by digital flight control computers with electrically signalled, hydraulically actuated control surfaces in pitch, roll and yaw axes. High level control laws programmed into the flight control computers offer efficient flight operation combined with flight envelope protection. Each pilot is provided with a sidestick to signal the pilot's pitch and roll commands to the flight control computers. In flight, in Normal Law, the sidesticks command pitch rate (normal g) and/or roll rate, not attitudes. No control position tactile feedback is provided for the pilots. Conventional rudder pedals are provided.

In normal flight operations, the roll control system operates in Normal Law. This is blended in a few seconds after lift off and this mode remains active until touchdown. In Normal Law, lateral deflection of either pilots sidestick will signal a roll rate demand to the flight control computers. The computers will calculate the degree of deflection required for aileron and/or spoiler surfaces, dependant upon the ambient flight conditions at the time of the input. The Normal Law also provides roll stabilisation, such that if a gust were to disturb the aircraft while in wings level flight with no roll sidestick input, the flight control system would signal appropriate control deflections to return the aircraft to the original wings level attitude. This correction does however take a finite time to achieve, which may be longer than the time which could be taken by a pilots manual inputs to achieve the same result.

In circumstances where the pilot is close coupled, such as at low altitudes on final approach, the natural reaction in response to a gust disturbance is for the pilot to apply a manual corrective input, without waiting for the automatic correction from the flight control system. It is possible for these types of input to become out of phase with the natural response of the aircraft's flight control system and for a pilot induced oscillation to occur.

This phenomenon was apparent in this case, and was exacerbated by the cyclic nature of the rudder inputs applied. The secondary effect of rudder is to induce the aircraft to roll in the direction of the rudder input and, as with all swept wing aircraft, the rolling moment due to rudder is very powerful. It is possible that the flight control system may not have had sufficient authority to oppose the rudder induced roll in these circumstances.

Confidential Reports

The United Kingdoms Confidential Human Factors Incident Reporting Programme (CHIRP) received two confidential reports regarding lateral control of A320 aircraft in crosswinds and turbulence. The first report was received in September 1999, followed by the second in April 2000. Unfortunately, both occurrences came to light too late to obtain any Flight Recorder data that could have given valuable information about the occurrences. A reference to lateral control problems in turbulence was included in the CHIRP Feedback publication in July 2000, but reference to aircraft type was not included. This prompted two further confidential reports, again from A320 pilots about the apparent lack of control response in crosswinds and turbulence.

Safety action

There was no information provided in the crosswind landing techniques section of the Flight Crew Operating Manual, FCOM 3, regarding the avoidance of cyclic rudder inputs and the avoidance of manually induced oscillations in turbulent flight conditions. In February 2002, the manufacturer issued a Flight Crew Operating Manual Bulletin, number 54/1, entitled Aircraft Handling in Final Approach which gave detailed guidance about aircraft handling in the lateral axis and highlighted the need to avoid the use of rudder in addition to roll control, except for de-crabbing during a crosswind landing.

Subsequent to the Confidential Reports detailed above, the aircraft manufacturer raised the subject of potential lateral handling difficulties to an audience of A320 series operators during the annual Flight Safety Conference in April 2002. No similar lateral control difficulty reports were forthcoming from the operators representatives.

Airbus Flight Safety Department actively encourages all operators of its aircraft to feedback operational difficulties via the Airbus Confidential Reporting Scheme (CRS) where they will analyse the DFDR/Quick Access Recorder data on behalf of the airline concerned and provide them with a final report of their analysis. This CRS is active and the manufacturer will take all necessary action if events are detected.

Many airlines now operate Operational Flight Data Monitoring (OFDM) programmes, where data from every flight of an appropriately equipped fleet is analysed automatically, and any exceedences from normal flight profiles can be automatically brought to the attention of the operator.

The monitored parameters can be set up at the discretion of the operator. One set of parameters that may be of use in the case of turbulence and windshear encounters is the degree of control column (sidestick) deflection but, currently, this may not be part of every OFDM programme. The following Safety Recommendation is therefore made:

Safety Recommendation 2003-08

It is recommended that the CAA encourage all operators using Operational Flight Data Monitoring programmes to include the application of large manual control inputs as part of the automated parameter exceedence monitoring process.