Airbus A321, D-AIRE

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Aircraft Type and Registration:	Airbus A321, D-AIRE
No & Type of Engines:	2 IAE V2530-A5, turbofan engines
Year of Manufacture:	1995
Date & Time (UTC):	9 October 2000 at 1545 hours
Location:	Runway 27 Left, London Heathrow
Type of Flight:	Public Transport
Persons on Board:	Crew - 8 - Passengers - 170
Injuries:	Crew - None - Passengers - None
Nature of Damage:	Tailscrape between frame 64 and frame 68 in the area of the rear fuselage
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	46 years
Commander's Flying Experience:	7,390 hours (of which 2,700 were on type) Last 90 days -150 hours Last 28 days - 65 hours
Information Source:	AAIB Field Investigation

History of the flight

The flight crew were on the second day of their rostered cycle. The previous day was the first occasion on which the commander and First Officer (FO) had flown together. Prior to the first departure a normal briefing and discussion took place, which included the operating experience of the FO, who had acumulated some 1,236 hours on the A300 series operated by the company. This included the A319, A320 and A321. The FO and commander both had approximately one third of their hours on each variant of the type.

On 8 October 2000, the day before the incident, the crew flew an A320 on three sectors, departing from Frankfurt for Oporto, returning to Frankfurt and then continuing to their overnight stop in Stuttgart. The FO flew the first and third sectors with the commander conducting the second. The flights were uneventful and the commander considered the FOs' handling of the aircraft to be of a good standard.

On 9 October 2000 the crew flew an A320 from Stuttgart to Frankfurt with the commander handling. At Frankfurt the crew changed aircraft to the A321 for the flight to London. The flight was uneventful with the only difference from that planned was a change of cruising level due to turbulence. Prior to arrival at the Lambourne hold the commander obtained ATIS information 'India' which for Runway 27 Left was: surface wind 180°/18 gusting 27 kt, 5,000 meters in rain with cloud FEW at 1,100 feet, BKN at 1300 feet, OVC at 1,800 feet, temperature +12°C, dew point +11°C and QNH 992 runway wet. The FO briefed the approach and the crew discussed the conditions. It was agreed that the FO would fly the approach and make a positive landing given the wet runway surface. The aircraft's landing weight was 72,999 Kg.

Radar vectors were provided by ATC to position the aircraft onto the final approach for Runway 27 Left. The crew used the autopilot coupled to the Flight Director in managed speed mode. At about 1,000 feet the FO de-selected the auto-throttle and, with the approach stabilised at 570 feet, the auto-pilot was disconnected. At approximately 500 feet the commander called that they were 'coming low' meaning below the glide path, to which the FO reacted by slightly increasing nose up pitch and thus reducing the rate of descent. The commander estimated the height to have been 300 feet when he saw the Visual Approach Slope Indicator (VASI) displaying three white lights and one red light and shortly afterwards he noticed the rate of descent was high. He looked inside the flight deck and saw a rate of descent of 1,100 feet per minute and called 'sink rate'. Almost immediately the Ground Proximity Warning System (GPWS) sounded a Mode 1 alert of 'sink rate'. Seeing the rate of descent was still high the commander applied full aft sidestick to cushion the landing. He did not depress the takeover push button on his sidestick but, as the aircraft bounced, he neutralised his sidestick and as the aircraft touched down a second time, he again applied a large amount of aft sidestick to lower the nose landing gear gently. At that point he noticed that the Primary Flight Display (PFD) showed a nose up attitude of some 10°. Neither pilot recalled hearing the normal voice height calls from 50 feet or the voice call of 'RETARD'.

Believing there may have been a tail scrape the commander asked the rear cabin attendants if they had noticed anything. They described a rattling noise but thought that it had come from the galley. After shut down the commander inspected the tail area and discovered the damage caused by the tail scrape.

Engineering investigation

Examination of the damage to the aircraft was carried out at London Heathrow Airport whilst the aircraft was being temporarily repaired prior to an unpressurised ferry flight to a maintenance facility in Ireland. Damage was confined to severe abrasion of the aircraft's skin longitudinally from just forward of frame 64 to just aft of frame 68 and laterally over the lowermost four stringers and drain mast close to this area (see Figure 1). There was no apparent damage to the fuselage frames. The damage was biased slightly to the right side of the fuselage, indicating that the aircraft had been rolled slightly to the right at the time of contact. Also, geometrical considerations indicated that the damage had occurred over a pitch attitude range of 9.65° to 10.65° referenced to the horizontal aircraft datum. Data from the aircraft manufacturer indicated that tail scrape damage would occur over a pitch attitude range of 9.7° (with the main landing gear oleos fully compressed) to 11.4° (with the main landing gear oleos uncompressed, but with the tyres in ground contact).

The aircraft's maintenance computer was read out but no defects of any significance had been recorded. However, during the inspection of the aircraft by the operator's maintenance personnel at

London Heathrow after this event, slight leaks from two fuel couplings in the wing root area were noticed. This is a known problem that can occur following a firm landing. Rectification of this defect was deferred in the aircraft technical log and was carried out at the repair station.

Flight Recorders

Recorded information was available from the solid state Flight Data Recorder (FDR) fitted to the aircraft. The 30 minute tape based Cockpit Voice Recorder (CVR) had recorded over the period of the landing.

Accident Landing

An ILS approach was made to Runway 27L at Heathrow with both the autopilot and autothrottle engaged. The aircraft was established on the localiser at 3,200 feet agl and glideslope established at 3,000 feet agl. Landing configuration was achieved by 1,400 feet agl with full flap and gear down selected.

A stable ILS approach was flown with airspeeds varying between 150 kt and 160 kt down to 1,000 feet agl at which point the autothrottle was disconnected. Glideslope and localiser stability was maintained as the aircraft descended with an approximate pitch attitude of 1.5° nose up and at a manually controlled airspeed of approximately 150 kt. During this phase of the approach the autopilot had maintained a drift angle in the order of 12° to counter the effects of a crosswind from the left. Typical wind values were recorded as being 185° / 32 kt during the latter stages. At 570 feet agl the autopilot was disconnected and movements in the right sidestick position only indicated that it was the First Officer flying the manual section of the approach.

Throughout the approach and landing phase, sidestick movements resulted in corresponding changes in elevator deflection. As the aircraft descended through 500 feet agl it became low on the glideslope and reached a maximum deviation of 0.76 dots low by 320 feet agl before the nose was raised to regain the correct profile. Movement of the power levers ceased at this point with N_1 values on both engines remaining constant at 68% until just before touchdown.

By 174 feet agl, airspeed had reduced to 141 kt as the aircraft flew through the glideslope neutral point and became progressively higher than the desired flightpath. By 145 feet agl the aircraft was 0.6 dots high and forward sidestick was applied to lower the nose towards 1.75° nose up. At 100 feet agl the aircraft was at its maximum above the glideslope by 1.8 dots and had a calculated vertical speed in the order of 900 ft/min. Forward sidestick was applied again, lowering the nose to a level pitch attitude and increasing the descent rate to 1,000 ft/min. At 62 feet agl, aft sidestick movement (25% aft of neutral) was recorded at the start of the flare and, one second later at 41 feet agl, an additional small amount of aft movement of the commander's sidestick was observed. By 21 feet agl, the aircraft was descending at 1,200 ft/min and the activation of a GPWS Mode 1 ('Sink Rate') warning was recorded. The aircraft was pitching up through 2.1° nose up with the commander's and the first officer's sidestick at 56% and 79% aft of neutral respectively at that time. Both power levers were closed at approximately 15 feet agl and the commander's sidestick position was recorded as being 96% aft of neutral; that of the first officer was 69% aft.

One second later, with the commander's sidestick neutralised and the first officer's at 53% aft, the aircraft touched down at a pitch attitude of 7.4° nose up and 1.4° right wing low. A normal

acceleration of 2.08g was recorded at this first touchdown, a descent rate for which was calculated to be approximately 850 ft/min. The sampling rate of normal acceleration was eight times per second and, with the sharp rise and fall of the 'g spike', it is possible that the peak value was slightly higher than that recorded. Both left and right main gear 'weight on wheels' switches closed and ground spoiler deployment was initiated. Immediately following the first touchdown, pitch attitude reduced to 5° nose up and the aircraft became light on the oleos, momentarily rolling 4.5° right wing down and opening the left main gear 'weight on wheels' switch. During the low bounce, the application of 89% aft commander's sidestick and 52% aft first officer's sidestick resulted in the aircraft beginning to pitch up.

At the second touchdown, which was two and a half seconds after the first and during which a normal acceleration of 1.94g was recorded, pitch attitude was increasing rapidly through approximately 8° nose up. The first officer applied 27% forward sidestick and the commander's sidestick was neutralised over the next second as the aircraft pitch attitude reached a maximum of 10.5° nose up. The aircraft's roll attitude at that point was between 1° and 2° right wing down. During the initial stages of pitch attitude reduction (from 10.5° to 9.8° nose up), as the nose gear was lowered towards the runway, a normal acceleration spike of 1.3g was recorded. It is likely that this was the point that the tail came into contact with the runway surface.

The aircraft was slowed using reverse thrust before it vacated the runway. No evidence was found of any significant windshear during the landing although it was noted that the wind parameters recorded on the FDR indicated an almost pure crosswind from the left of 15 kt.

Weather

At 1529 hrs the weather at London Heathrow was given on the ATIS with Runway 27 Left in use for landing with wind shear forecast. The surface wind was 180°/16 kt, gusting 26 kt, visibility 5km in moderate rain with cloud, FEW at 1,100 feet, BKN at 1,300 feet and OVC at 1,800 feet. The temperature was +12° C and dew point+11° C, QNH 992 mb. The surface wind passed by ATC to D-AIRE with the landing clearance was 180°/13, gusting 27 kt.

Sidestick authority

Each pilot has a sidestick, which is used to control the aircraft manually in pitch and roll. The left seat pilot has the sidestick on the left side and the right hand seat pilot has the sidestick on the right. The sidesticks are not mechanically linked and do not both move together. They are spring loaded to the neutral position. When only one pilot operates the sidestick, it sends control signals to the flight control computers. If both pilots move their sidesticks simultaneously in the same or opposite direction and neither takes priority, the system adds the signals of both pilots algebraically. The total is limited to the signal that would result from the maximum deflection of a single sidestick. A green takeover light is located on the glare shield in front of each pilot that flashes when both pilots operate their sidesticks together. A 'DUAL INPUT' voice message is also given every 5 seconds as long as both pilots operate their sidesticks simultaneously.

A pilot can deactivate the other sidestick and take full control by pressing and keeping pressed the takeover button on the sidestick. For latching the priority condition, it is recommended to press the takeover button for more than 40 seconds, this allows that pilot to release the push button without losing priority. Either pilot can reactivate or deactivate the priority by momentarily pressing the takeover push button on either stick. If both pilots press their takeover buttons, the pilot that presses last gets priority. In a priority situation a red light comes on in front of the pilot whose stick is

deactivated and a green light illuminates in front of the pilot who has taken control. This only occurs for as long as the non-priority sidestick is not in the neutral position.

Aircraft tail strike limits

Flight Crew Operating Manual (FCOM) Bulletin Number 22/2 dated April 1999, promulgated by the manufacturer, gives guidance for the avoidance of tail strikes. In the case of this incident where the landing gear oleo was fully compressed, a tail strike limit is given of 9.7° nose up aircraft attitude. The limit with the main landing gear wheels on the ground and landing gear oleo fully extended is 11.4° nose up aircraft attitude.

The landing technique requires a stabilised approach as essential to achieve consistent successful landings and it is described as imperative to reach the flare height at the appropriate speed and flight path which is given as -3°.

The flare should be started at approximately 20 feet and thrust reduction should be between 20 feet and 15 feet. It should be co-ordinated with pitch rate especially during cross winds. The attitude increase between the start of the flare and touchdown is given as approximately 4.5°, assuming the correct airspeed decay of 8 kt and the reduction in flight path of -1° (3 feet/second) is achieved.

Discussion

The crosswind at the time of the landing was within the aircraft operating limits. Although the crew had experienced some moderate turbulence in the early stages of the approach, they considered that after passing approximately 1,000 feet the turbulence reduced significantly. Whilst there had been no reports of windshear experienced by landing aircraft prior to the approach of D-AIRE, an A300, which was the seventh aircraft on the approach after D-AIRE, carried out a go-round due to windshear. The landing winds advised to the intervening six aircraft were similar to that passed to D-AIRE and were generally 180°/13kt, gusting 27. The A300, which carried out the go-round was advised of a wind of 190°/12 kt. Given that the anemometer display only records gusts of 10 kt or more above the mean wind speed over the previous two minutes it was not known what, if any, gusts were being experienced by the A300.

The approach flown by the FO was initially stabilised with auto thrust and autopilot selected, these were manually disconnected. The FO continued to fly the aircraft manually carrying out an ILS instrument approach to Runway 27 left. At 500 feet the aircraft descended below the glideslope, and this was corrected. The aircraft gradually regained the centre of the glidepath by 174 feet but then passed through it to become high. The FO had flown solely by reference to instruments down to 200 feet and then used a combination of visual and instrument cues referring to the ILS display until commencing the flare using visual reference. On passing through the glideslope the FO progressively increased the nose down pitch inputs in order to recover the normal approach path, which led to the high rate of descent and the 'SINK RATE' warning.

The commander considered that the change in aircraft attitude was subtle and, given the rain and visibility, he first became aware of the developing situation by noticing the apparent increase in the rate of descent which was confirmed on his PFD screen. Whilst he estimated this was at about 300 feet it was probably much lower at about 100 feet. At 55 feet the commander applied aft sidestick, which progressed to nearly full aft sidestick by a height of 10 feet, in order to arrest the rate of descent but he did not activate his sidestick takeover push button. The only voice warning recalled

by both pilots was the Mode 1 'SINK RATE' heard immediately after the commander had said it. The normal voice height and 'RETARD' calls were not heard during the final part of the landing.

Conclusions

Following the incident, the manufacturer's technical experts agreed that when the aircraft had descended below the glide path the approach had become unstable in its final stage. There was evidence of turbulence during the latter stages of the approach and a variation of headwind component from -4 kt loss at about 500 feet followed by a 10 kt increase at 400 feet. Whilst the Calibrated Air Speed (CAS) shown on the FDR read out provided by the manufacturer averaged 144 kt in the last 400 feet, the air speed fluctuated by some 4 kt either side of this due to the gusty wind conditions.

The primary reason for the high rate of descent was the attempt by the FO to regain the normal glideslope when 1.8 dots above at 100 feet. Two dots above the glideslope represents a height difference of 26 feet from normal and, given the inertia of the aircraft, once the nose down pitching moment was initiated at such a low height, a correspondingly large movement aft of the sidestick would be required to arrest it.

As with other such incidents the commander could not see the control inputs of the FO and his first indication was a high rate of descent at about 40 feet shortly after the flare was initiated. He did not activate his sidestick takeover button and, given the circumstances, this action would not have prevented the tail of the aircraft contacting the runway. This occurred following the bounce on the second touch down when the commander was using aft sidestick to prevent the nose wheel coming down heavily.

Summary

The aircraft suffered a tailscrape whilst landing in gusty cross wind conditions. The latter stages of the approach included significant changes in pitch. The rate of descent resulting from a final pitch down correction applied by the FO could not be arrested in time, although the commander applied almost full aft sidestick.

A similar incident involving an A321, EI-CPE, occurred on 21 June 2000 at London Heathrow. A report on this incident containing a safety recommendation that is relevant to both occurrences is published elsewhere in this bulletin.