Tailstrike on landing, Airbus A320, C-GTDK

Micro-summary: **Tailstrike involving this A320 on landing.**

Event Date: **2003-06-16 at 1339 UTC**

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

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

Note: **Reprinted by kind permission of the AAIB.**

Cautions:

1. Accident reports can be and sometimes are revised. Be sure to consult the investigative agency for the latest version before basing anything significant on content (e.g., thesis, research, etc).

2. Readers are advised that each report is a glimpse of events at specific points in time. While broad themes permeate the causal events leading up to crashes, and we can learn from those, the specific regulatory and technological environments can and do change. ***Your company's flight operations manual is the final authority as to the safe operation of your aircraft!***

3. Reports may or may not represent reality. Many many non-scientific factors go into an investigation, including the magnitude of the event, the experience of the investigator, the political climate, relationship with the regulatory authority, technological and recovery capabilities, etc. It is recommended that the reader review all reports analytically. Even a "bad" report can be a very useful launching point for learning.

4. Contact us before reproducing or redistributing a report from this anthology. Individual countries have very differing views on copyright! We can advise you on the steps to follow.

Aircraft Accident Reports on DVD, Copyright © 2006 by Flight Simulation Systems, LLC
All rights reserved.
www.fss.aero

Airbus A320, C-GTDK

AAIB Bulletin No: 11/2004	Ref: EW/C2003/06/02	Category: 1.1
Aircraft Type and Registration:	Airbus A320, C-GTDK	
No & Type of Engines:	2 IAE V2500-A1 turbofan engines	
Year of Manufacture:	1992	
Date & Time (UTC):	16 June 2003 at 1339 hrs	
Location:	Bristol Lulsgate Airport, Bristol	
Type of Flight:	Public Transport (Passenger)	
Persons on Board:	Crew - 7	Passengers - 178
Injuries:	Crew - None	Passengers - None
Nature of Damage:	20 foot long scrape on fuselage underside, skin penetrated adjacent to pressure bulkhead, APU inlet damaged	
Commander's Licence:	Airline Transport Pilot's Licence (Canadian)	
Commander's Age:	32 years	
Commander's Flying Experience:	6,685 hours (of which 1,497 were on type)	
	Last 90 days - 146 hours	
	Last 28 days - 66 hours	
Information Source:	AAIB Field Investigation	

Synopsis

The aircraft and pilots were normally based in Canada but were operating for a six month period over the summer from Bristol Airport as part of a wet-lease agreement. The inexperienced co-pilot had been undergoing a protracted period of line training and had been rostered to fly on four consecutive days with the same line-training captain. They had agreed that should a suitable opportunity present itself, the co-pilot would practise flying the aircraft without the autopilot, autothrust and flight directors being engaged. On the third day the co-pilot flew an ILS approach to Runway 09 at Bristol with the aircraft configured in this condition. At touch down the aircraft bounced and on touching down a second time, the tail contacted the ground.

Factual Information

History of flight

The flight crew reported for duty on the day of the accident at 0530 hrs UTC for their return flight from Bristol Lulsgate to Corfu. The commander was the handling pilot on the first sector and, having

briefed the co-pilot, he carried out the landing at Corfu with the autopilot, flight director and autothrust disengaged in order to demonstrate the correct technique for landing in this configuration. This approach and landing were uneventful and after a normal turnaround the aircraft departed for the return sector to Bristol, this time with the co-pilot acting as the handling pilot.

On nearing London the pilots were able to check Bristol's ATIS (Automated Terminal Information Service), which notified the runway in use as Runway 09 with a light crosswind from the south-east. The pilots asked London ATC if it would be possible to land on Runway 27 instead as this would give them a straight in approach. After a short interval London ATC informed them that they were clear to self-position for an approach to Runway 27. Accordingly they briefed for an approach and landing to Runway 27, to be performed with the autopilot, autothrust and flight directors disengaged. The flight management system was programmed using the wind given on the ATIS of 160°/07 kt. They were then cleared to descend and when the aircraft was at about FL250 the commander suggested the co-pilot disengage the autopilot and autothrust in order to give himself time to settle in to flying the aircraft in this configuration. The co-pilot disengaged the autopilot and autothrust, at which point the commander turned off both flight directors.

Air traffic control of the aircraft was transferred to Bristol with the aircraft level at FL110, at a range of about 65 nm from the airport. On hand over Bristol ATC apologised but informed the crew that due to another aircraft positioning for a landing on Runway 09 (the active runway), the aircraft would now be vectored for a landing on Runway 09. This was acknowledged and the captain re-programmed the flight management system for a landing on that runway.

The flight followed ATC vectors until the aircraft was established on the Runway 09 ILS localiser. The co-pilot continued to fly solely by reference to the instruments and flew the ILS approach whilst the commander configured the aircraft for landing. Although the co-pilot followed the ILS localiser indications, the commander was aware that the aircraft had in fact become slightly displaced to the right of the runway centreline. On making the standard call when the aircraft was 100 feet above the decision altitude of 814 feet (and at a height equivalent to 300 feet above touchdown elevation), the commander immediately instructed the co-pilot to look up in order to allow more time to correct the aircraft's track back onto the centreline. This the co-pilot did and both pilots estimate the aircraft was wings-level and on the centreline by the time the aircraft had descended to a height equivalent to 100 feet above the runway threshold.

The co-pilot commenced the flare at 50 feet agl and retarded the thrust levers at 30 feet agl, but it became apparent that the aircraft was descending more rapidly than normal. He maintained back pressure on his sidestick but, in an attempt to cushion the landing, the commander also applied back pressure to his sidestick. When making his control input the commander did not press his sidestick priority takeover pushbutton. The aircraft made a firm touchdown on its main wheels and bounced once before touching down again. As the aircraft slowed on the runway, the pilots were informed by ATC that the aircraft had scraped its tail on the runway. No abnormal indications were apparent on the flight deck and the crew continued taxiing to stand, completing the normal after landing checks and starting the APU. When parked, they shut down the engines and disembarked the passengers as normal before inspecting the damage. None of the cabin crew realised the aircraft had suffered a tail strike until they were informed by the commander.

Engineering investigation

The aircraft was inspected on the apron during the evening of the same day. There was a scrape on the centreline of the rear fuselage approximately 20 feet long. Most damage had occurred at frames 68, 69 and particularly 70, where a temporary repair was required in order to ferry the aircraft. In all, the skins showed evidence of heavy abrasion at six or more frame locations. From an internal inspection, the pressure bulkhead appeared intact. However at frame 70 where the rear pressure bulkhead interfaces with the external skins, those skins were abraded through to the underlying structure which itself showed signs of damage. In addition, the APU inlet duct was abraded and two drain masts had been damage by ground contact.

A scrape mark about 40 feet long was found on the runway within the normal touchdown zone. The mark was a colouration only; there was no debris and no runway damage. The mark was mainly blue in colour, with a brownish colour in the areas of heaviest contact.

A heavy landing check was carried out, and an approved temporary repair scheme for the pressure bulkhead frame was completed. At the AAIB's request, a pitot static leak check was carried out in accordance with the Aircraft Maintenance Manual (AMM). During this test the indicated airspeeds are observed. The test results were within AMM limits. Subsequently the aircraft was cleared for a single non-revenue unpressurised flight, to enable it to be returned to the manufacturer in Toulouse for permanent repairs.

Flight recorders

The aircraft had flown a stable ILS approach to Runway 09 although it had become slightly right of the runway centreline by 300 feet above airport level (aal). At this point the commander instructed the co-pilot to look up from his instruments and continue flying visually.

The co-pilot then corrected the aircraft's track to the left but over-corrected, requiring a further correction to be made back to the right. This corresponded with a short change in the aircraft's pitch from 4° to 7° nose up, before returning to a pitch of 5° nose up by 70 feet aal. The aircraft then started to descend below the glidepath.

The calculated approach speed V_{APP} was 131 kt. The airspeed was seen to decrease towards the end of the approach from 134 kt at 200 feet through 130 kt at 100 feet aal to 119 kt at touchdown. During this period the groundspeed remained constant at 136 kt between 300 feet and 200 feet and then gradually decayed to 130 kt at touchdown. There were only slight changes in the thrust lever angle during this time but these had little if any effect on the engine N1 which remained at about 66%.

The co-pilot commenced a flare at 50 feet aal by which time the aircraft's rate of descent was about 900 ft/min. The commander then rapidly applied full back stick on his side stick controller when the aircraft was at 15 feet aal. It is probable that the elevators then reached their maximum nose up deflection.

The main landing gears touched down with a vertical load factor of about +2.3'g' at a calibrated airspeed of 119 kt. The aircraft's pitch attitude was 9° nose up. The spoilers then deployed, with the pitch continuing to increase at a rate of about 3°/sec. The commander made a nose down stick input (+6° then +9°) whilst the co-pilot retained a nose up stick input (-7.5° then -2.5°). Neither pilot had their sidestick priority takeover pushbutton depressed, as a result of which the inputs were summated to give an initial nose up input followed by a nose down input.

The aircraft then bounced, the main landing gear touching down for a second time with a vertical load factor of about +1.5'g'. The aircraft pitch attitude was then at its recorded maximum of 13.4° nose up. The pitch attitude was then gently decreased until the nose gear was on the ground and subsequently the aircraft was slowed to a taxi speed.

Weather

The weather recorded by the pilots from the recorded broadcast for Bristol Airport at 1220 hrs UTC gave a visibility in excess of 10 km and cloud cover at 5,000 feet. The wind was reported as 160°/7 kt but varying in direction between 130° and 210°. The meteorological observation covering the time of the accident recorded a visibility in excess of 10 km with no cloud below 5,000 feet. The wind was given as 150°/7 kt varying in direction between 120° and 190°. FDR evidence suggests that the aircraft was in fact subject to a slight tailwind component of between 4 and 6 kt at touchdown.

The airfield charts in use at the time carried the following information:

> *CAUTION: Pilots may experience windshear/turbulence, especially if the wind is strong Southeasterly (rwy 09) or strong Westerly (rwy 27).*

Runway 09 topography

The airfield charts illustrate a runway length of 2,011 metres with a threshold elevation of 614 feet. The runway then slopes upwards over the first quarter of its length by some 10 feet before levelling off and finally sloping back down to an elevation of 603 feet at the threshold of Runway 27.

The ground rises rapidly just prior to the threshold of Runway 09 by approximately 50 feet and this, combined with the sloping surface, may well have an adverse affect on the visual cues presented to a pilot during the critical phases of a landing on this runway.

Training and experience

The operator's line indoctrination programme was approved in accordance with Canadian Air Regulations which define items that must be completed to a satisfactory standard prior to recommendation for a line check. The regulations call for a minimum of 25 hours line training prior to the line check.

For a number of valid reasons, the operator had a policy of extending the minimum flight time for line training to 50 hours. After completing type training the operating company's pilots underwent a structured period of line training designed to be completed within the 50 flying hours. This may however be extended beyond this time should it be felt that further training is required. At the time of the accident the co-pilot had completed 327 hours of line training.

The co-pilot had been flying the A319 and A320 with the company for approximately five months. His previous commercial flying experience was exclusively on the Jetstream 31 and he had a total flying experience of 840 hours. He was undergoing a protracted period of line training on the Airbus A319 and A320 due to his relative inexperience. On this occasion he had been rostered to fly on four consecutive days with the commander, a line-training captain. The accident had happened on the third day, however on the first day of the series the commander had recommended the co-pilot for his final line check on his next flight with the base training captain.

The commander had only recently been appointed as a line-training captain, having been selected on the basis of his previous flying performance. He had received no training on carrying out his function as a training captain other than a verbal briefing from the company Flight Training Manager. However, he had conducted two line indoctrination flights with a first officer undergoing re-qualification training prior to his arrival at Bristol some six weeks before the accident.

The decision to carry out the manually flown approach was an exercise in line indoctrination driven by suggested training scenarios and recent in-flight failures experienced by the commander and other fellow training captains. The two pilots had agreed that, should a suitable opportunity present itself, the co-pilot would practise flying the aircraft without the autopilot, autothrust and flight director being engaged. The commander, however, wished to undertake any such flying by building up to it in stages. Thus, on their second day together, the co-pilot had successfully carried out an ILS approach to Runway 27 at Bristol Lulsgate with only the autopilot and flight director disengaged. On the third day it was agreed that should the conditions again prove suitable, the co-pilot would carry out a further approach and landing, this time with the autothrust, autopilot and flight director all disengaged. The commander had demonstrated the technique to the co-pilot by carrying out the landing at Corfu on the previous sector with the aircraft in this configuration.

Airbus Flight Crew Operating Manual (FCOM) Bulletin 22/3: Avoiding Tail Strikes

This document dated May 2001 states that for an A320 a tail strike will occur at a pitch attitude of 13.5° with the main landing gear oleos fully extended and at a pitch attitude of 11.7° with the oleos fully compressed. It further states that there is an 8 kt deceleration during the flare and that should the approach speed be decreased by 5 kt, the pitch attitude will increase at touchdown by approximately 1.3°.

It highlights the main cause of tail strikes on landing being deviation from normal landing techniques, but also states that *"some are associated with such external conditions as turbulence and wind gradient"*. The sections of the Bulletin relevant to this accident are reproduced below:

a) Allowing speed to decrease well below VAPP before flare

Flying at too low speed means a high AOA and high pitch attitude, thus reducing ground clearance. When reaching flare height, the pilot will have to significantly increase the pitch to reduce the sink rate. This may lead the pitch to go beyond the critical angle.

d) Too high a sink rate, just prior reaching the flare height

In case of too high sink rate close to the ground, the pilot may attempt to avoid a firm touchdown by commanding a high pitch rate. This action will significantly increase the pitch attitude and, as the resulting lift increase may be insufficient to significantly reduce the sink rate, a firm touchdown may occur. In addition, the high pitch rate may be difficult to control after touchdown, particularly in case of bounce.

e) Bouncing at touchdown

In case of bouncing at touchdown, the pilot may be tempted to increase the pitch attitude so as to ensure a smooth second touchdown. If the bounce results from a firm touchdown associated with a high pitch rate, it is important to control the pitch so that it does not further increase beyond the critical angle.

APPROACH AND LANDING TECHNIQUES

The VAPP should be determined with wind corrections, given in FCOM/QRH, using FMGS functions.

As a reminder, when close to the ground, the wind intensity tends to decrease and the wind direction to turn (direction in degrees decreasing in northern latitudes).

During flare, the pilot should not concentrate on the airspeed, but only the attitude with external cues. Note: Airspeed indication during flare is influenced by the static error due to the ground effect.

The PNF should monitor the pitch attitude on the PFD and call "PITCH", whenever the following pitch value is reached: For A320:10°

After touchdown, the pilot must "fly" the nosewheel smoothly, but without delay, on to the runway, remaining prepared to counteract any residual pitch up effect of the ground spoilers. Note: The main part of the spoilers' pitch up effect is compensated by the fight control laws.

BOUNCING AT TOUCHDOWN

In case of a light bounce, maintain the pitch attitude and complete the landing, while keeping thrust at idle.

Do not allow the pitch attitude to increase, particularly following a firm touchdown with a high pitch rate.

In case of a high bounce, maintain the pitch attitude and initiate a go-around.

Conclusions

The accident was caused by an accumulation of factors. The sequence was initiated when the aircraft was manoeuvred to regain the centre-line between 300 feet and 100 feet aal. The overall change in airspeed during this manoeuvre was minimal but the rate of descent increased slightly. During the last 100 feet of the descent, there was a shift in wind direction which introduced a tailwind component of

some 4 to 6 kt. This late change in the wind component reduced the aircraft's airspeed and flare potential, thereby introducing the need for an abnormally high pitch angle to arrest the rate of descent. Unfortunately, with the aircraft manoeuvring to regain the centreline at a late stage in the approach, it is likely that both pilots had stopped monitoring airspeed just before the wind changed direction and so no corrective power change was applied. (The co-pilot was manually controlling thrust and so the airspeed protection available from the autothrust system was inactive.) Next, the visual cues for both pilots relating to the aircraft's speed and height may well have been masked by the terrain and the slope of Runway 09 until the aircraft was almost over the threshold. In the last few seconds of the approach the co-pilot's initial flare was too gentle and the commander's corrective input at 15 feet agl was too late to have the desired effect. Since neither pilot had their sidestick priority takeover pushbutton depressed at this point, both of their control inputs were summated. However, as the commander had effectively demanded maximum elevator deflection, the fact that he had not pressed his side stick override button made no difference to the elevator position achieved during the flare. The combination of commanded elevator deflection and low airspeed meant that the aircraft pitch on touchdown was 1.4° higher than normal.

All these factors contributed to a firm landing but their combined effect was still insufficient to cause a tail strike. It was the attempt to control the bounced landing that directly caused the physical damage.

When the aircraft bounced the commander did not consider going around but instead applied a nose-down sidestick input. The co-pilot retained, all be it a reducing, nose-up sidestick command. On this occasion because the pilots were ordering elevator positions in the opposite sense, the fact that the commander had not pressed his sidestick takeover pushbutton meant that the summated control inputs did not achieve the reduction in pitch attitude that the commander had intended. When combined with the increasing pitching moment caused by spoiler deployment, the pitch of 13.4° achieved on the second touchdown was sufficient to result in the tail strike.

It has not been possible to determine what pitch attitude would have been achieved had the commander pressed his sidestick priority takeover pushbutton when he attempted to reduce the aircraft's pitch attitude after the initial bounce.

Safety Recommendations

Conversion training

The wish to practise manual flying skills is understandable but degrading the aircraft's systems in order to do so is something that should be approached with great caution. The decision to practise such an approach to a runway that had additional challenging features in terms of topography, visual aspect and low-altitude wind effect placed additional demands on the handling pilot.

This accident demonstrates well the requirement for both pilots to monitor all phases of flight whether or not they are the handling pilot. Whilst this will include the information displayed on the flight instrument displays, during the final stages of the landing there is a greater reliance on external visual cues. It is realistic to assume, therefore, that this is where both pilots' attention will be drawn especially if, as on this occasion, either pilot is unhappy with the situation and wishes to take control. As a result, visual cues on the pilots' flight instrument displays of the aircraft losing airspeed and over-pitching are likely to be missed.

Having been informed of the tail strike the crew taxied to their allocated stand and whilst doing so started the APU. There is no checklist to complete in the event of a tail strike. However, because the APU or its intake (as in this event) may be damaged, it would be prudent to leave it shut down after a reported tail strike.

At the time of the accident the co-pilot had completed 327 hours of line training. The greatly extended nature of his line training seems to conflict with the intention of this phase of training which

is to consolidate a pilot on the normal operation of the aircraft. If the company felt he would only have achieved the appropriate line pilot standard after considerably more than the training hours allocated to other pilots, then the decision to retain him on the aircraft must be called into question. If, as seems more likely, their intention was only to increase his experience whilst being appropriately supervised, the co-pilot should still have passed his final line check within the time determined by the company to be commensurate with the standards expected of pilots operating the A320. Therefore, it was recommended that:

Safety Recommendation 2004-55

Skyservice Airlines should review its policy for pilots' competency and experience requirements both before and during conversion training.

The commander was ill prepared to undertake his new role as a line-training captain. The airline was not subject to any regulatory requirements concerning the training of line-training captains. However, it is unlikely that a verbal briefing alone is sufficient 'training' to qualify a line pilot with no previous experience as a pilot trainer adequately to undertake the role. At the very least, therefore, he should have undergone some practical training, either in the aircraft itself or in a simulator, followed by a line assessment. Therefore it was recommended that:

Safety Recommendation 2004-56

Skyservice Airlines should review its procedures for the training and supervision of training captains.

Intervention training

Whilst it has not been possible to ascertain whether the tail strike would have occurred had the commander used his sidestick takeover pushbutton, this must be considered a strong possibility. Use of the takeover pushbutton is not instinctive and previous accidents investigated by the AAIB have revealed instances involving Airbus fly-by-wire aircraft types where non-handling pilots have failed to use the button when making control inputs to correct those of the handling pilot. The Civil Aviation Authority also has other evidence where failure to use the takeover button has caused additional aircraft control problems.

The Airbus fly-by-wire aircraft types are unique in commercial aviation in that it is not possible for one pilot to feel what the other pilot is doing with his or her sidestick. In brief, there is no force or position feedback from one sidestick to the other and in the air, there is no stick position information on the flight instrument displays. Consequently there is no practical method of 'assisting' the handling pilot by making a control input on the other sidestick, particularly if the handling pilot is also moving his or her sidestick at the time. The result of two sidestick inputs is a blend of both and, since the aircraft's reaction is inconsistent with its normal 'manoeuvre demand' response, the resultant response cues may seem abnormal for both pilots which in turn, can provoke more extreme sidestick inputs.

The AAIB is aware of a customer modification option for the A320 aircraft series (Airbus SB A320-31-1115) which introduces a synthetic voice warning when both sidesticks are being moved simultaneously. Such a warning would be very helpful in some circumstances but the likely time delay in mentally processing such a verbal warning would probably be too great to have a beneficial effect in the bounced landing case. On occasions when the need to intervene without delay is paramount, the non-handling pilot should announce the fact with the time honoured phrase of "I HAVE CONTROL" whilst at the same time pressing his sidestick priority button, thereby inhibiting the potentially erroneous input of the other pilot.

The importance of using the sidestick takeover pushbutton during rapid intervention is not implanted in pilots during their initial training. This is reasonable because during conversion training, pilots are far more likely to be mishandling than intervening and so intervention (other than in a case of incapacitation) is not expected of them. However, when pilots graduate to command, they must be prepared to intervene when necessary, particularly if they have line or base training captain duties. The need to press the takeover button has to be trained since a written instruction and/or verbal

briefing are not sufficient to alter instinctive behaviour. The correct time and place to receive such training is in the simulator at an appropriate stage of a pilot's refresher training, command course or during the training course that precedes becoming a trainer of other pilots. Since the problem of not using the takeover pushbutton seems common to all Airbus fly-by-wire aircraft types, the aircraft manufacturer is best placed to instigate such training and, where necessary, to encourage all Airbus operators to introduce such training. Therefore it was recommended that:

Safety Recommendation 2004-57

Airbus should highlight to airlines the need for pilots to press the sidestick priority button when intervening to correct an erroneous control input by the handling pilot.

On 2 July 2004 Airbus responded to this recommendation by stating "This is written in the FCOM (Flight Crew Operating Manual), SOPs (Standard Operating Procedures), Chapter 3.3.1. It is also emphasized during training". Airbus further stated that the company did not send a letter to operators on this issue but a presentation on tailscrape avoidance was foreseen for the next flight safety conference in October 2004 where it will be emphasised.

Pitch attitude alerting

The tailscrape might not have occurred if the co-pilot had received a timely aural warning that the pitch attitude was too high after the first touchdown and thereby had been alerted to the need for more nose-down sidestick.

The aircraft manufacturer's operating procedures call for the non-handling pilot to monitor the pitch attitude on the Primary Flying Display and call "PITCH" if the attitude exceeds a certain value. Such reliance placed on the non-handling pilot to warn of the aircraft over-pitching during landing is unrealistic, particularly when the co-pilot is handling. To be effective it would require the non-handling pilot to be looking in at the very moment when he ought to be looking out, especially in the case of a commander supervising a trainee pilot. Therefore, it is recommended to Airbus Industrie that an aural warning be introduced to its fly-by-wire aircraft types to alert pilots of excessive pitch angle or excessive pitch rate during landing.

Safety Recommendation 2004-58

Airbus should introduce an aural warning to its fly-by-wire aircraft types to alert pilots of excessive pitch angle or excessive pitch rate during landing.

On 2 July 2004 Airbus responded to this recommendation by stating: "We developed, on the A340-500 and A340-600, a system giving a visual indication on the PFD and an aural warning in case of excessive pitch angle. We are now studying the feasibility of extending this on all other fly-by-wire aircraft types".

Safety Actions taken by the operator

Following its own preliminary investigation into this accident, the operator implemented several safety actions in order to prevent a recurrence. These included:

1. A Flight Operations Bulletin issued to address:

   Use of Autothrust

   Speed Monitoring

   Use of the Takeover Pushbutton

2. Pilot training (ground and simulator) to include increased emphasis on:

   Bounced landing recovery

Flight control takeover

Low energy awareness

Pitch and airspeed monitoring during approach and landing

3. The Training Pilot program was modified to include increased training and oversight.
4. Implementation of a new pilot recruitment standard.
5. Investigating the application of Airbus SB A320-31-1115 to its aircraft fleet.