BAe 146-300, G-OINV

AAIB Bulletin No: 7/2004	Ref: EW/C2003/03/04	Category: 1.1
INCIDENT		
Aircraft Type and Registration:	BAe 146-300, G-OINV	
No & Type of Engines:	4 Lycoming ALF 502R-3A turbofan engines	
Year of Manufacture:	1990	
Date & Time (UTC):	2 March 2003 at 1055 hrs	
Location:	In the cruise, near Carlisle, Cumbria	
Type of Flight:	Public Transport	
Persons on Board:	Crew - 5	Passengers - 95
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Fuselage insulation entwined in aileron control run	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	34 years	
Commander's Flying Experience:	4,700 hours (of which 3,200 were on type)	
	Last 90 days - 160 hours	
	Last 28 days - 25 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot and other enquiries made by the AAIB	

Synopsis

The aircraft suffered a lateral flight control restriction as a result of loose insulation material becoming trapped in the aileron control circuit. The crew carried out the memory items for the 'AILERON JAM OR UNCOMMANDED ROLL' checklist, but did not realise that in addition to pulling the Aileron Disconnect Handle there was also a need to apply a breakout force to the control wheel to achieve the disconnect. One safety recommendation has been made.

History of flight

The aircraft was operating a scheduled flight from Inverness Airport, Scotland, to London (Gatwick) Airport. While established in the cruise at FL250, with the autopilot engaged, ATC gave instructions for the aircraft to turn right through 10°. The heading bug was used to select the right turn and the flight director bars indicated a right turn. The autopilot started to respond to the command but only

achieved 2º to 3º angle of bank (AOB) to the right and failed to turn onto the required heading. An "AIL" caption then illuminated on the Master Warning Panel (MWP). The crew applied aileron trim in an attempt to clear the caption, but it persisted. The commander then disconnected the autopilot and attempted to make the right turn manually. He found that lateral flight control was restricted; he described the controls as feeling very heavy and found that the maximum AOB attainable was 10 to 15º. The two pilots also established that both control columns were similarly restricted.

The Aileron Disconnect Handle was pulled, as a memory item, and the crew then referred to the checklist for 'AILERON JAM OR UNCOMMANDED ROLL'. The actions carried out did not make any appreciable difference to the observed handling characteristics. The commander, in consultation with the company operations department, decided to divert the aircraft to Manchester Airport. During the descent a low speed handling check with the landing gear extended and flap 24º was carried out between 8,000 and 7,000 feet. The subsequent approach and landing with flap 24° was uneventful, with the crew commenting that the lateral control forces gradually returned to normal during this period.

Meteorological conditions

The commander reported that the whole flight was performed under visual meteorological conditions.

Operating procedures

The BAe 146-300 Abnormal and Emergency checklist contains procedures, which supplement the normal operating procedures. Memory items for the relevant procedures are limited to the immediate vital actions, and are contained within a box for identification. 'AILERON JAM OR UNCOMMANDED ROLL' procedures appear on Card 32A (Figure 1) and 'FLIGHT FOLLOWING BREAKOUT OF AILERON CONTROL CIRCUIT' on Card 32B (Figure 2).

Figure 1 - Card 32A

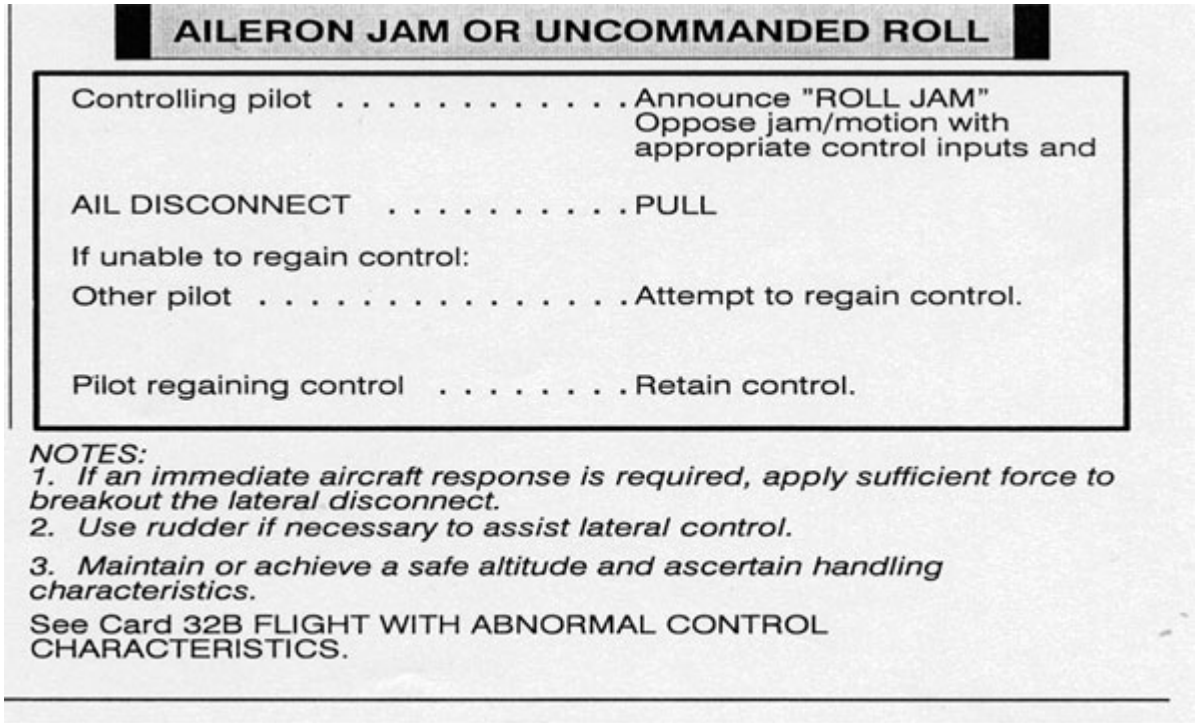

Figure 1 - Card 32A

Figure 2 - Card 32B

Figure 2 - Card 32B

The aileron disconnect handle was pulled in accordance with the checklist but the crew did not consider that Note 1 was applicable because an '*immediate aircraft response*' was not required. They therefore continued with the items on Card 32B and completed a safe landing.

Crew experience

The commander had 3,200 hours of experience on the BAe 146 aircraft, representing a considerable number of years, whereas the first officer had only recently qualified on the type. The commander had completed the procedure to breakout the lateral disconnect on three separate occasions during simulator training. However, in each instance there had been a definite 'Roll Jam' to overcome as opposed to the control restriction with which he was now faced.

Description of lateral flight control system

Lateral flight control is provided by aerodynamically and mass balanced ailerons, each operated by a servo tab, in conjunction with roll spoilers (one per wing) powered by the yellow hydraulic system. A geared trimming tab is also fitted to each aileron.

Normally the lateral control circuits in the left and right wing are coupled, but a disconnect device is provided so that, in the event of a jam occurring in either circuit, they may be operated separately.

Two separate conventional cable and rod circuits, one connected to each pilot's hand wheel, provide control over the respective aileron servo tab and roll spoiler in each wing. An interconnect cable links both ailerons, and a 'break-out' detent strut links both hand wheels. A spring operated 'feel-unit' complements the natural servo tab feel at large inputs, and provides a hand wheel centering force at small hand wheel angles. The feel unit is in the captain's aileron servo tab control circuit. Another conventional cable and rod circuit drives the aileron trim tabs, each through a screw jack. An aileron trim wheel and trim indicator are fitted on the pilot's centre console. Each servo tab circuit has a blow-back spring (torsion bar) which limits the authority of the tab in accordance with the airspeed.

An autopilot servo is connected in parallel with the aileron servo tab circuit of the right wing so that autopilot inputs move the handwheels and tab circuits. Each roll spoiler is controlled by an output from the aileron cable quadrant of the upward moving aileron, which controls the hydraulically powered actuator operating the spoiler. Displacement of the spoiler is harmonised with the operation of the aileron servo tab but, for the first few degrees rotation of the handwheel from neutral, the spoiler remains closed. Roll spoiler position indicators are fitted to the pilot's centre instrument panel. Gust dampers prevent excessive aileron movement when the aircraft is parked in windy conditions.

Roll control disconnect system

If a jam occurs in one lateral control circuit the application of a heavy rotational pressure to the handwheel of the other circuit will cause the rigid detent strut to 'break-out' and transform to a sliding strut; the free circuit will then be operable independently, allowing control to be maintained.

During its transition to the sliding state, the 'break-out' detent strut closes a microswitch which causes a solenoid operated disconnect device to operate separating the aileron interconnect cable circuit. As a secondary back-up, the solenoid operated disconnect device may be operated by way of another microswitch which closes when the AIL PULL DISCONNECT handle (on the centre control pedestal) is pulled. (Pulling the AIL PULL DISCONNECT handle has no effect on the 'break-out' detent strut linking the two handwheels). Before the AIL PULL DISCONNECT handle can be pulled out, a button in the centre of the handle must be depressed.

When the solenoid operated disconnect device has operated its micro-switches cause the MWS (Master Warning System) amber caption AIL/EL UNCPLD to light. After their operation, both the solenoid operated disconnect device and the detent strut cannot be reset in flight.'

The most significant conclusion arising from the above is that, to complete the separation of the aileron circuits, it is necessary to apply a '*breakout force'* to the control column as described in Note 1 Card 32A (Figure 1).

Engineering investigation

Examination of the aircraft at the operator's maintenance facility showed that a section of insulation on the rear wing spar at Frame 29 on both the left and right sides had become entwined with the aileron cables where they passed through pressure bungs (see Figure 3).

Figure 3 - Photograph showing dislodged insulation bag interfering with aileron cable

G-OINV - Photographs showing (above) dislodged insulation bag interfering with aileron cable and (below) with bag removed, the pressure bungs (note retaining button)

Figure 3

The insulation bags had become dislodged from their retaining buttons but it appeared that the particular zone had not been disturbed during recent maintenance, how long this condition had existed was not known. Other aircraft in the operator's fleet were inspected and loose bags were found, however none were actually touching the cables.

The manufacturer has stated that they intend to revise the Maintenance Manual for the aircraft to include more comprehensive inspection and securing information for insulation in this area.

Previous occurrence

A previous occurrence of an aileron control restriction on a BAe 146-300 aircraft was reported on in AAIB Bulletin 7/2001. On that occasion the cause of the control restriction was different, but there was a similar lack of understanding of the checklist and failure to complete the aileron disconnect procedure by the crew. As a result of this Safety Recommendation No 2001-27 was made to BAE Systems in July 2001 as follows:

> *'It is recommended that BAE Systems (formerly British Aerospace) reviews those entries relating to the aileron disconnect systems in all sections of the Avro RJ and BAe 146*

Manufacturer's Operating Manuals (MOMs) with a view to clarifying the systems operation and associated procedures.

BAE Systems responded to the recommendation in the following manner:

"BAE Systems accept the recommendation and will continue to review the contents of all checklists to ensure clarity and understanding of procedures."

A review was subsequently conducted by BAE Systems after which they deemed that the manual entries and checklists were satisfactory.

Analysis

The pilots were correct to action the memory items of the appropriate checklist when they discovered there was a significant restriction in the aileron circuit. The restriction did not however lead to a loss of immediate control nor was there any need for the handling pilot to oppose the restriction in level flight. The Aileron Disconnect Handle was pulled in accordance with the checklist but the crew did not consider that Note 1 was applicable because an *'immediate aircraft response'* was not required. They therefore continued with the items on Card 32B. To achieve the disconnection of the aileron circuit it is necessary to apply a *'breakout force'* to the control column as described in Note 1, but the checklist does not make this sufficiently clear to operating crew. If all of the disconnect actions had been completed then the two sides would have operated independently. In this case the insulation would then have prevented one side from moving and this may have led to a constant roll input from one aileron. However, the other side would have been free to travel and have had sufficient authority to counteract the residual rolling moment.

The recurrence of the misunderstanding of the checklist and failure to complete the disconnection of the lateral flight control system indicates that BAE Systems have not ensured adequate clarity in the checklists for this procedure. This is despite the fact that this particular problem of understanding the checklist was highlighted by a previous event. Therefore the following safety recommendation is now made:

Safety Recommendation 2004-13

It is recommended that the Civil Aviation Authority ensure that BAE Systems make a suitable revision to the entries relating to the aileron disconnect systems in all sections of the Avro RJ and BAe 146 Manufacturer's Operating Manuals to clarify the systems operation and associated procedures.