ACCIDENT

Aircraft Type and Registration:	Avro RJ100, HB-IYU
No & Type of Engines:	4 Honeywell ALF507-1F turbofan engines
Year of Manufacture:	2000
Date & Time (UTC):	18 August 2007 at 0940 hrs
Location:	Runway 28, London City Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 5 Passengers - 88
Injuries:	Crew - None Passengers - None
Nature of Damage:	Significant structural damage to the lower rear fuselage
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	47 years
Commander's Flying Experience:	9,000+ hours (of which 1,340 were on type) Last 90 days - 118 hours Last 28 days - 25 hours
Information Source:	AAIB Field Investigation

Synopsis

The commander was carrying out an ILS approach to Runway 28 at London City Airport, with the approach stabilised from the glideslope capture at 3,000 ft. At between 50 and 30 ft above the runway the pilots felt the aircraft 'dropping' and the commander, who was the pilot flying, pulled back on the control column to prevent a hard landing. The pitch attitude of the aircraft increased to a maximum of 9.3º and the lower aft fuselage briefly contacted the runway, causing significant damage.

History of the flight

The aircraft was operating a scheduled service from Zurich to London City Airport (LCY) with the commander as the pilot flying, which was in accordance with the operator's requirements for landings at LCY. The weather forecast indicated southerly winds of 10 kt, with short periods of rain.

The aircraft was fully configured for the landing, prior to intercepting the glideslope for the ILS approach to Runway 28. The glideslope was intercepted at 3,000 ft and the autopilot was disconnected at 1,300 ft. The last surface wind reported by the tower before landing was from 190º at 10 kt.

As the automated radio altitude calls were announced at 50 and 30 ft the pilots sensed that the aircraft was dropping suddenly. The commander pulled the control column back and the aircraft touched down on the aft fuselage with a bump, before landing on the mainwheels.

Neither the pilots nor the cabin crew were aware that there had been a tailstrike, although the rear cabin crew member reported that there had been a loud noise on touchdown.

Aircraft information

The BAE 146/RJ100 aircraft were first certified for operations into LCY in 1995 following a number of test flights. During the tests it was concluded that, when flown on the 5.5º glidepath at V_{REF} -5kt, a pitch-limiting attitude of 7º was attained. The body angle clearance at landing for the RJ100 is approximately 7º, depending on the touchdown parameters.

The aircraft's calculated landing mass was 37.8 tonnes (T). The V_{REF} for flap 33º, from the landing performance card for 38 T, was 119 kt. The calculated landing distance for a 37.8 T aircraft from a steep approach was 640 m, and the required runway length for a dry runway was 1,066 m.

The approach speeds published in the Operations Manual (OM) and the corresponding target speeds for this approach were:

Operations Manual	HB-IYU target speeds
When stabilised on the approach V_{REF} + 5kt	124 kt
Below 200 ft to the threshold reduce to V_{REF}	119 kt
Touchdown, V_{REF} -7 kt	112 kt

There have been a number of previous tailscrape events recorded for this aircraft type at LCY. The manufacturer carried out investigations into some of these and concluded that the key factors were:

'Approach at speeds below VREF, requiring a high angle of attack

High rate of descent in latter stages leading to a higher pitch attitude in the flare

Excess speed leading to float and high pitch attitude on touchdown.'

Meteorological information

A meteorological aftercast was obtained from the Met Office. The synoptic situation showed there was a low pressure area centred over Northern Ireland, resulting in a fresh to strong south-westerly flow across southern England. Visibility was very good. The airmass was unstable and contained various layers of cloud, with the lowest layer being convective cloud between 1,800 and 2,500 ft.

An AMDAR-equipped (Aircraft Meteorological Data Reporting) aircraft which departed from London Heathrow (19 nm to the west) at 0939 hrs recorded a wind profile which showed there was a reduction of wind strength, from the wind at the surface of 11 kt, to 5 kt at 300 ft aal, followed by an increase again at 600 ft aal. This is indicative, at the 300 ft level, of a combination of mechanical and convective turbulence.

The ATIS information 'Uniform' for LCY reported at 0936 hrs was:

'Surface wind from 190º at 11 kt, visibility 16 km, scattered cloud at 2,200 ft, broken cloud at 4,500 ft, temperature 18ºC, dewpoint 15ºC and pressure 1012 mb.'

There were no landings at LCY for the 50 minutes preceding the accident but another aircraft landed 20 minutes afterwards. The commander of that aircraft reported that, considering the reported wind of 10 kt at the surface, he had found the approach more turbulent and difficult than he expected. He also reported that, after landing, he had required an input of 'into wind' aileron to prevent the left wing from lifting, until he had slowed to taxi speed.

Aerodrome information

London City Airport has a single concrete Runway 10/28, which is 1,508 m long and 30 m wide. The Landing Distance Available (LDA) from both directions is 1,319 m. Runway 28 is provided with an ILS approach which has a glidepath of 5.5º. PAPIs are located on the right side, set at 5.5º. There are two pairs of white high-intensity lights placed on either side of the runway at 336 m from the touchdown point; these mark the end of the touchdown zone. A 'missed approach' is required if an aircraft is not expected to touch down before the end of the zone.

There are two anenometers located on the airfield, situated on the north side of the runway, approximately abeam the end of each touchdown zone. Information from the anenometers is relayed to the ATC tower and is presented on a switchable side-by-side display. The display is normally selected to show each source separately, giving an instantaneous wind and a two-minute average value.

London City Airport is located in a built-up area and in unstable meteorological conditions, and crosswinds, there is a strong possibility of building-induced turbulence. There is no windshear detection system at the airfield but pilot reports of windshear are incorporated into the ATIS.

Flight recorders

The aircraft was fitted with a Flight Data Recorder (FDR) and a Cockpit Voice Recorder (CVR). They were successfully downloaded and had both 'captured' the event. The following description is based on the FDR and CVR recordings; all times refer to UTC.

The aircraft took off from Zurich at 0822 hrs, climbed and cruised at FL 280. During the cleared descent to 4,000 ft the flight crew were joined by a third person, a senior member of cabin crew approved by the operator, who remained in the cockpit for the rest of the flight. Communication of operational information and checks continued smoothly between the pilots.

The final descent into London City Airport from 3,000 ft amsl was initiated at glideslope capture, with the landing gear down, 33° of flap and the airbrake deployed. The autopilot and approach FDR parameters indicate a CAT 1 autopilot approach, with dual localiser and dual glideslope capture. The airspeed varied between 117 and 128 KCAS. Passing through 1,300 ft agl the 'AP FD' mode switched from autopilot to flight director. At this point the comment was made between the pilots that they needed to concentrate. Whilst further comments were made by the pilots to the third person, these were all related to the actual landing process. Soon after the autopilot was switched off there was a wind check from ATC of 10 kt from 190ºM and the non-handling pilot began periodic reading of airspeed relative to a reference speed. In the space of 23 seconds, whilst passing 500 ft agl, relative speeds of +7, +3, +1, +3 and +4 were called.

Figure 1 shows the salient parameters from the FDR, covering the approach from approximately 350 ft agl. This also shows the relevant target speeds for comparison.

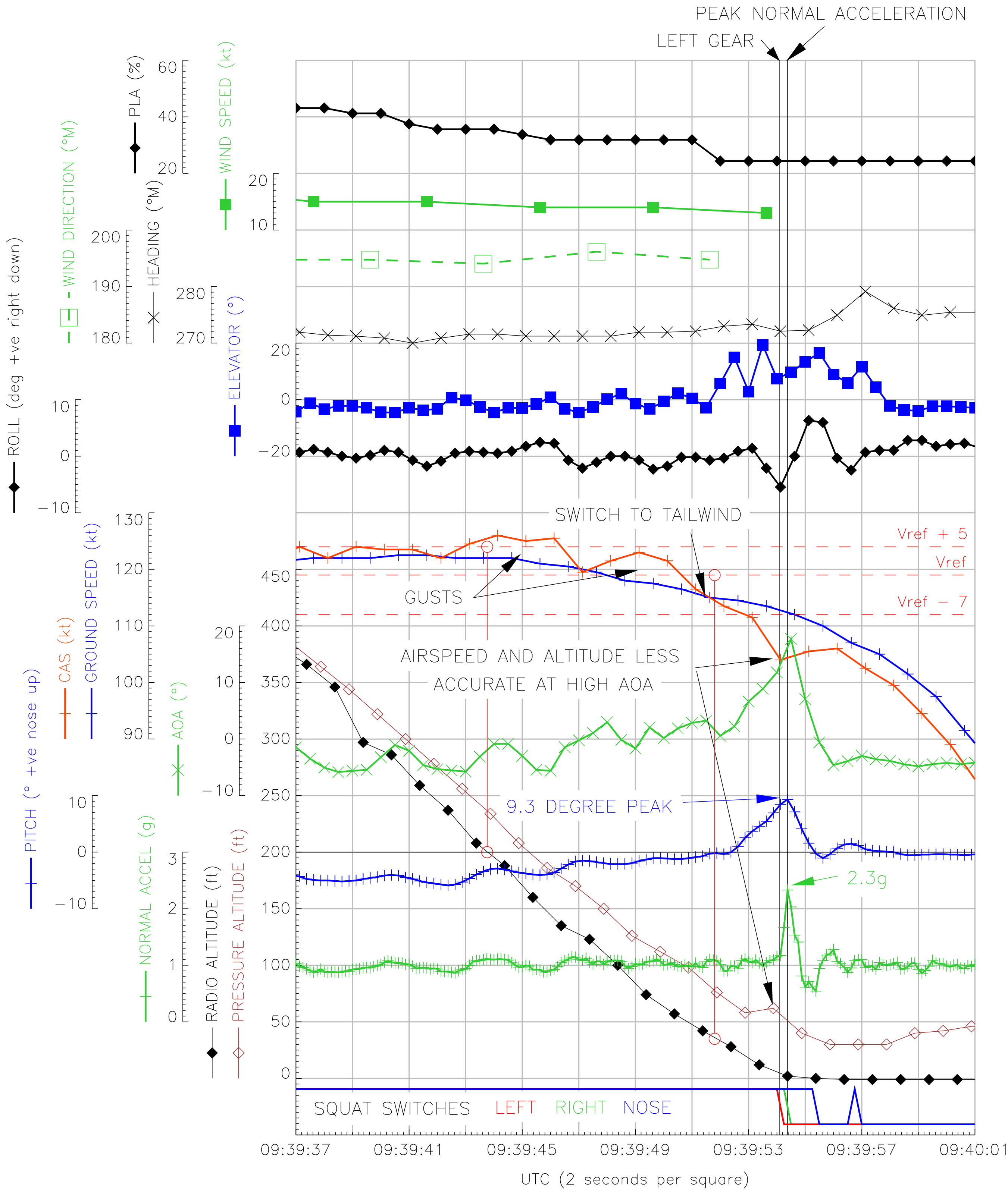

Figure 1

Salient FDR Parameter
(Accident to HB-IYU on 18 August 2007)

Referring to the PAPIs, the crew observed that they were slightly high, which was then corrected. At the point the EGPWS issued a "MINIMUMS" automatic callout, the non-handling pilot issued a "+2" speed update, shortly followed by a "+1" call, just after the EGPWS "FIFTY" callout.

With a radio height of between 50 ft and 30 ft agl, the power levers were retarded. A comparison of calibrated airspeed and groundspeed indicates that the aircraft had a variable and slight headwind component until approximately 50 ft agl, at which point it became a variable and slight tailwind. At this point the descent rate was approximately 900 ft/min and reducing smoothly. The FDR data showed no sudden drop in altitude, though the sample rate could be a limitation in capturing a short duration event.

Prior to 50 ft agl the aircraft had a nose-down pitch attitude that was slowly being brought level. As the power levers were moved back, large elevator inputs were recorded and during this period of increased elevator activity the aircraft developed an average nose-up pitch rate of 4.5º/sec. A left roll was also recorded; as this reached 5º, the left main gear weight-on-wheels sensor activated, and the roll direction reversed. At touchdown the pitch attitude reached 9.3º nose up and a 2.3g normal acceleration was recorded.

After the spike in normal acceleration at touchdown, the aircraft's pitch rate reversed to 10º/sec nose-down, with the nose gear registering weight-on-wheels 1 second later.

The wind direction and wind speed, shown in Figure 1, are derived within the aircraft from other parameters. They are only sampled by the FDR every 4 seconds and do not appear to reflect gusty conditions. The wind direction shown during the final approach was just less than 90º from the left, providing only a small headwind component.

Ground marks

Scrape marks on Runway 28 indicated that the aircraft touched down adjacent to the PAPIs and slightly to the right of the runway centreline. The first contact with the runway was made by the rear galley drain pipe, which left a mark approximately 5 m long. A second scrape mark, made by the lower rear fuselage, started 2 m after the first mark and ran for approximately 11 m.

Aircraft damage

An inspection of the aircraft was carried out by the manufacturer[1] and the AAIB. The inspection revealed that significant structural damage had occurred to the lower fuselage in the area of the aft cargo hold between frames 35 to 43 and stringers 27 port to 27 starboard (Figure 2).

Scrape marks ran along the lower fuselage for approximately 3.9 m and were aligned approximately 4° to the left of the aircraft centreline (Figure 3).

The composite fairing around the rear galley drain pipe had been damaged and the pipe had been distorted upwards. The tailscrape indicator had mostly worn away and the skin panels were extensively abraded and distorted. There was also a crack running fore-and-aft just outboard of stringer 34 port.

Footnote

[1] BAE Systems structural survey ART/RJ/1766-07 dated 23/Aug/07.

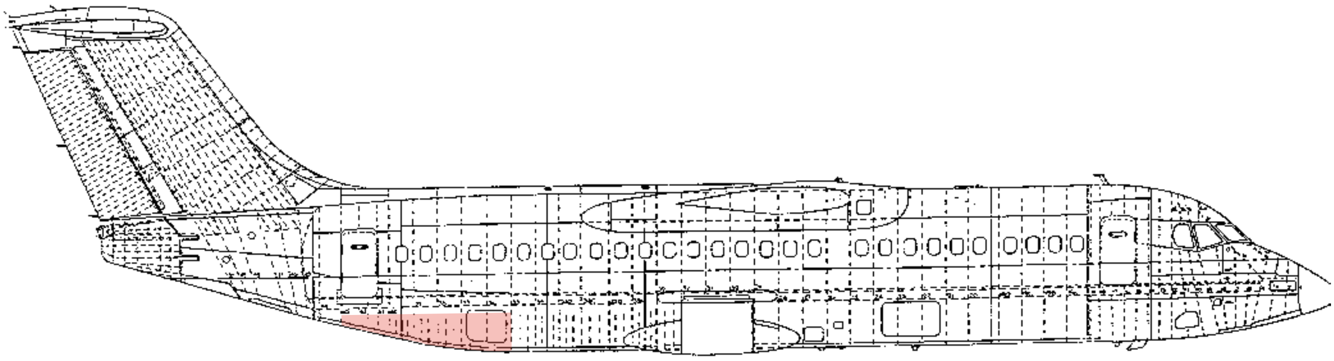

Figure 2
Area of damage to the lower fuselage

Figure 3
Damage to the rear of the aircraft

Nine frames had sustained various amounts of cracking and most of the frames in the damaged area had sustained some buckling or distortion. All the stringers in the damaged area showed distortion of the skin attachment flange.

Testing of the Air Data Computer system

A functional test of the Air Data Computer[2] (ADC) system was carried out by the aircraft operator and witnessed by the AAIB. In addition, the airspeed just prior to the aircraft touching down was replicated by setting the altitude in the ADC test equipment at 100 ft and the airspeed at 100, 105, 110, 115 and 120 knots. The airspeed indicated on the pilots' displays was then checked against the airspeed set in the test equipment. The tests established that the ADC system was serviceable and the airspeeds indicated on both pilots' displays were identical and agreed with the data set in the test equipment.

Organisational and management information

The operator's flight operations were conducted in accordance with the requirements of JAR-OPS. Special approval was held, as required by UK regulation, for operations into LCY. The operator had categorised LCY as a Category C aerodrome and special crew qualification and training were required. All landings were to be carried out by the aircraft commander.

The Operations Manual (OM) contained guidance and information on general approach and landing techniques. There was also specific information provided for steep approach and landings and the possible problems associated with them. Some extracts from the OM are reproduced below:

General landing technique:

> *'When gusts are reported, the approach speed shall be adapted to a maximum of VREF plus 10kts*
>
> *'The thrust levers must be at idle position at the beginning of the landing flare*
>
> *'Touchdown speed for all landings should be 7 kt less than the speed flown over the threshold'*

Steep approach technique:

> *'It is essential to maintain the correct speed on final approach.*
>
> *'The high descent rate during a steep approach can increase the effect of a windshear. The lower power settings during approach increases the need for anticipation and windshear awareness.*
>
> *'Pitch attitude should not exceed plus 7° during the flare.*
>
> *'For the last flight phase of a steep approach onto a short runway, the PIC may order the COPI to read out the actual speed in regard to VREF (e.g. in short intervals: plus 2, REF, minus 2, minus 5..), this technique will allow the PIC focusing on outside visual reference.'*

Since this event the operator has conducted its own internal investigation and made the following internal recommendations:

> *'It is recommended that the AVRO Fleet consider amending the flight procedures for speed management for the "Steep Approach" to fly the approach until the begin of the landing phase with a minimum speed of Vapp*
>
> *'It is recommended to amend the flight procedures for the "Steep Approach" to require a call-out by the PNF for any pitch attitude above 5°*

Footnote

2 AMM 34-18-00 501 Air Data System, Part 2, air data computer functional test.

> *'It is recommended that the AVRO fleet provide some additional guidance material on the conduct of the steep approach and highlight the most likely causes of tail strikes.'*

Analysis

Engineering

The damage to the lower rear fuselage and the marks on the runway indicated that the aircraft touched down 'left wing low' whilst yawed to the left by approximately 4º. Using the touchdown ground speed of 113 knots, the rear section of the aircraft would have been in contact with the runway for approximately 0.24 seconds.

The engineering investigation could identify no fault with the aircraft, or its systems, which would have contributed to the accident. Whilst the rear of the aircraft was damaged during the landing, the aircraft remained structurally intact and decelerated and taxied to the stand normally.

Operational factors - general

From the manufacturer's analysis of previous tailstrike events on landing it can be seen that there is not one single factor which causes these events, they are the result of differing circumstances which lead to excessive pitch attitudes at touchdown. On a steep approach the thrust setting will tend to be lower than usual. Should a high rate of descent develop, a higher pitch attitude than normal will be needed to arrest it. The previous events at LCY show that for a successful steep approach onto the relatively short runway, a high degree of accuracy needs to be achieved.

The meteorological conditions on the approach were turbulent, but the aircraft was stable in good time and remained so until the landing phase. The surface wind was also likely to have been gusty, although the gusts were not reported on the ATIS. There was an indication from the recorded data that there was a wind shift, from headwind to tailwind, when the aircraft was below 50 ft.

The co-pilot made a number of calls in the latter stages of the approach with reference to the target V_{REF}. These indicated that the aircraft was generally below the target speed and this is confirmed by the recorded data. Figure 1 shows that at 50 ft and 35 ft the aircraft was some 4 kt below target speed. At this point the thrust levers were retarded to idle and the recorded groundspeed reduced, without a corresponding decrease in the airspeed, indicating a loss of headwind or an increased tailwind component. The aircraft was already in a low energy state; then thrust was reduced and this reduction, and the loss of headwind component, both made the situation worse. A combination of these factors reduced the energy of the aircraft, which was felt as a 'sink' by the pilots, and the commander responded by pulling back to prevent a hard landing. It was this, probably instinctive, pull back on the column that caused the pitch attitude to increase to 9.3º at the point of touchdown.

Another operator of this aircraft type, who had previously experienced several tailstrikes at LCY, introduced revised training and procedures for their pilots. One element of this was to introduce an SOP monitoring call of 'ATTITUDE' if a pitch angle of 5º or greater is seen during the flare. If this call is made, then the pilot flying must not increase pitch but is required either to accept the pitch attitude for landing or to go around.

Safety action

Since this accident the operator has undertaken a re-assessment of the risk level of its operations into LCY. A further review of procedures and training requirements for LCY has also been completed. Some changes to SOPs have been implemented and an additional training programme for LCY has been incorporated into the recurrent simulator schedule.