INCIDENT

Aircraft Type and Registration:	Avro 146-RJ100, G-CFAA
No & Type of Engines:	4 Lycoming LF507-1F turbofan engines
Year of Manufacture:	2000
Date & Time (UTC):	7 January 2005 at 1335 hrs
Location:	London City Airport, London
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 5 Passengers - 53
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to Ground Strike Indicator
Commander's Licence:	Airline Transport Pilots Licence
Commander's Age:	35 years
Commander's Flying Experience:	7,100 hours (of which 880 were on type) Last 90 days - 133 hours Last 28 days - 33 hours
Information Source:	AAIB Field Investigation

Synopsis

During a landing in blustery conditions on Runway 28 at London City Airport, the aircraft's tail struck the ground, causing damage limited to the Ground Strike Indicator.

History of flight

The crew reported for duty after a night stop in Geneva and carried out planning for a scheduled public transport flight to London City. The flight crew obtained the London City Terminal Aerodrome Forecast (TAF) for the period 1000 to 1900 hrs, which predicted wind from 220° at 20 kt gusting to 30 kt with a 30% probability of temporary periods of stronger wind from 220° at 30 kt gusting to 40 kt throughout the period. Visibility was forecast to be more than 9 km throughout the period and the lowest predicted cloudbase was 1,400 ft. In light of the blustery conditions, they elected to load additional fuel for the flight.

The flight progressed normally and as the aircraft crossed the English coast, the flight crew received the London City ATIS Information Romeo, which stated that Runway 28 was in use and the surface wind was from 230º at 7 kt, and later Information Tango, which reported the wind as from 230º at 21 kt gusting 32 kt.

The crew briefed that the co-pilot would fly the approach and that the commander would take control at an appropriate moment and carry out the landing. The commander briefed that he would not add any speed increment for the gusts during the approach, as positive

windshear had been experienced just prior to touchdown in similar wind conditions on the previous two days[1]. The landing weight was calculated at 35.3 tonnes and the reference speed for the approach (V_{ref}) was determined to be 116 kt. In benign conditions, the approach speed is normally 5 kt above V_{ref} but increments may be added for strong or gusty winds.

The aircraft was directed by ATC towards the approach, and the Aerodrome Controller at London City cleared the aircraft to land. The controller stated that the wind was from 240º at 25 kt gusting 33 kt, minimum 9 kt, adding that a previous landing aircraft had reported "*JUST STRONG CROSSWINDS"* with no negative windshear, and that the conditions had been smoother below 200 ft. The flight crew acknowledged this information.

The co-pilot, who was flying the aircraft using the autopilot and autothrottle, set the speed bug at 121 kt and the aircraft was established on the glideslope from level flight at 3,000 ft in the landing configuration (Flap 33, the landing gear 'DOWN', and airbrake fully deployed). The controller transmitted updated wind information to the crew as from 230º at 22 kt gusting 33 kt.

The aircraft broke cloud at about 2,000ft above the runway and the commander stated to the co-pilot that he was content to leave the speed bug set at 121 kt but would carry an extra 5 or 10 kt of speed, with the intention of reducing to V_{ref} over the threshold. At about 1,300 ft above the runway the commander took control and, shortly afterwards, disconnected the autopilot and autothrottle.

As the aircraft approached 500 ft above the runway, the controller transmitted further instantaneous wind information as from 240º at 23 kt. As the aircraft passed 500 ft, an automatic callout alerted the flight crew to this height, and the co-pilot responded to the automatic callout stating "STABLE AS IT'S GOING TO BE TODAY".

The commander reported that the approach was *'pretty much in the slot'*. He stated that the company procedures required that the flare manoeuvre should begin at 100 ft above the runway, and that he began the flare at that height. At about 50 ft, he described feeling the aircraft sink slightly, but stated that he decided not to apply additional thrust as the acceleration time of the engines would have made an increase in thrust ineffective in combating the sink. The commander described the landing as being *'firm, as intended, in the right place and at the right speed'*. After landing, the commander taxied the aircraft to the parking stand, the engines were shut down and passengers disembarked.

Once the aircraft had parked, an engineer conducted a routine walk-around inspection and noticed that the Ground Strike Indicator (GSI) under the aircraft's tail had sustained damage. He reported this to the flight crew and the aircraft was grounded until a detailed inspection had been carried out. The flight crew were unaware that the tail had contacted the runway until the engineer advised them of the damage.

Aircraft damage

The GSI is a 2.3 m long aluminium strip secured lengthwise to the centreline of the aircraft's tail underside. It has a U-shaped cross-section with a width of 5.5 cm and a height of 1.5 cm. The strip forms a hollow channel and is designed to crush and absorb some of the impact energy during a tail strike. Any damage to the strip also serves as a clear indication that the tail has been struck

Footnote

[1] A positive windshear adds speed or energy to the aircraft, and may result in too high a touchdown speed, or a touchdown further along the runway length than is desirable.

The aircraft was not equipped with a tail strike indicator in the flight deck.

The damage to G-CFAA was confined solely to the GSI. The forward 1 m section of the GSI had sustained scraping and crushing damage but the damage had not penetrated the aircraft structure.

Flight Recorders

The aircraft was fitted with a solid state Flight Data Recorder (FDR) capable of recording a range of flight parameters. The aircraft was also fitted with a Cockpit Voice Recorder (CVR) which recorded crew speech and area microphone inputs. Both recorders were removed from the aircraft and successfully replayed at the AAIB facilities.

A time-history of the relevant parameters during the incident is shown in Figure 1.

The final descent into London City was from 3,000 ft (radio height), and began 3 minutes 40 seconds before touchdown. At that time, the aircraft was in the landing configuration with flaps extended to 33º, landing gear 'DOWN' and the airbrakes 'OUT'. The speed during the descent was 120 kt (V_{ref} +4 kt) ±10 kt calibrated airspeed (CAS). Autothrottle was engaged throughout the descent until about 1,100 ft, about 75 seconds before touchdown.

The data presented for the incident landing starts just over 16 seconds before the touchdown with the aircraft on the glideslope; 245 ft above the ground; at 125 kt (ie V_{ref} +9 kt); with a descent rate of about 750 ft/min and a fan speed (N1) of about 57% on each of the engines. For clarity, the Power Lever Angle (PLA) and N1 are shown for engine No 4 only; these are, however, representative of those of the other three engines.

The figure shows two points during the descent (Points A and B of Figure 1) at which additional thrust was applied. The first thrust increase was from 57% to 63% N1, at about 150 ft and 9 seconds before touchdown. This increase in thrust followed an increase in aircraft pitch attitude from -5º to 0º and coincided with a decrease in airspeed from V_{ref} +6 kt to V_{ref} -2 kt.

The second thrust increase was from 60% to 69% N1, at about 85 ft and 5 seconds before touchdown. This occurred as the aircraft pitch decreased slightly and the airspeed increased from V_{ref} -2 kt to V_{ref} +6 kt. As the N1 began to increase, the airspeed reduced by 16 kt to V_{ref} -10 kt over 3 seconds, at a peak deceleration of 7 kt per second; the aircraft pitch attitude remained nominally level and the ground speed only increased by 2 kt to 94 kt. The aircraft height when the airspeed reached V_{ref} -10 kt was 35 ft and the airspeed remained at V_{ref} -10 kt until touchdown.

At touchdown the recorded pitch attitude peaked at 6.6º and the descent rate was 600 ft/min (10 ft/sec).

Ground marks

The runway was examined shortly after the accident. A line of paint deposits and scrape marks, some 4 m long, was found approximately 50 cm to the right of the centreline of Runway 28, its easterly end being some 80 m from the beginning of the available runway length. The colour of the paint deposits was consistent with the paint on the remaining part of the aircraft's underside in the area of the GSI.

The Airport and the Operator's Operations Manual

London City Airport is built on a narrow strip of land between two docks, and is surrounded by tall buildings. The statutory requirements regarding runway dimensions and the available building space result in the runway being both narrow and short.

The Operator's Operations Manual describes London City Airport as follows:

> *'The Airport, in the Docklands, East London, is 19 miles east of, and lies beneath the approach path, to Heathrow. The approach glide slope are steep at 5·5° and the strip is short and narrow at 1199m x 30m. The obstacles for the approach, go-around and take off are significant and numerous.'*

and also stated:

> *'Speed control during the approach and landing must be accurate'*

The Operations Manual included specific requirements regarding operations into London City, specifying amongst other things that monitored approaches (during which one pilot flies the approach until the other pilot takes over control to accomplish the landing) were to be used at London City. All landings there were to be carried out by captains, who had to receive a briefing, steep approach training (including a training detail in an aircraft) and an airport familiarisation visit before becoming qualified to operate into London City. Co-pilots were required to receive training in the form of a briefing and steep approach simulator training before becoming qualified to operate into London City.

The Operations Manual contained other advice and instructions regarding steep approaches and flying technique. It placed emphasis on accurate speed control and in particular, the importance of avoiding too high an airspeed on the approach.

The operator had also published a Flight Operations Bulletin and a two-part article on tail strikes with a covering letter. The article was written by a very experienced BAe 146 pilot who had been responsible for some of the production test flying of the aircraft. These both gave further advice concerning correct techniques.

Analysis

The operator's training requirements reflected an acknowledgement of the demanding nature of London City Airport. The Operations Manual contained generic advice about steep approaches and advice specific to London City; the operator had also issued both a Bulletin and an informal article to amplify this advice to its pilots.

The flight proceeded normally until the final stages of the approach, where the conditions at London City were very gusty. The commander bore in mind the positive windshear he had encountered in similar gusty weather over the previous two days and elected not to add an increment to the final approach speed. His decision also reflected consideration of the comment from the previous landing aircraft, passed on by ATC.

As the aircraft approached, at about 85 ft, the commander increased thrust from 60% to 69% N1 and decreased the pitch attitude slightly. Both of these actions should, in still air, have resulted in an increase in airspeed. However, the airspeed decreased by 16 kt over 3 seconds, although the ground speed increased slightly. By 35 ft, the speed was 10 kt below V_{ref}, making a normal touchdown difficult to achieve, with any attempt to flare the aircraft for touchdown causing a further reduction in speed. During the flare, the pitch attitude increased to 6.6° nose up and the tail contacted the runway. This evidence is consistent with an encounter with significant negative windshear immediately prior to touchdown.

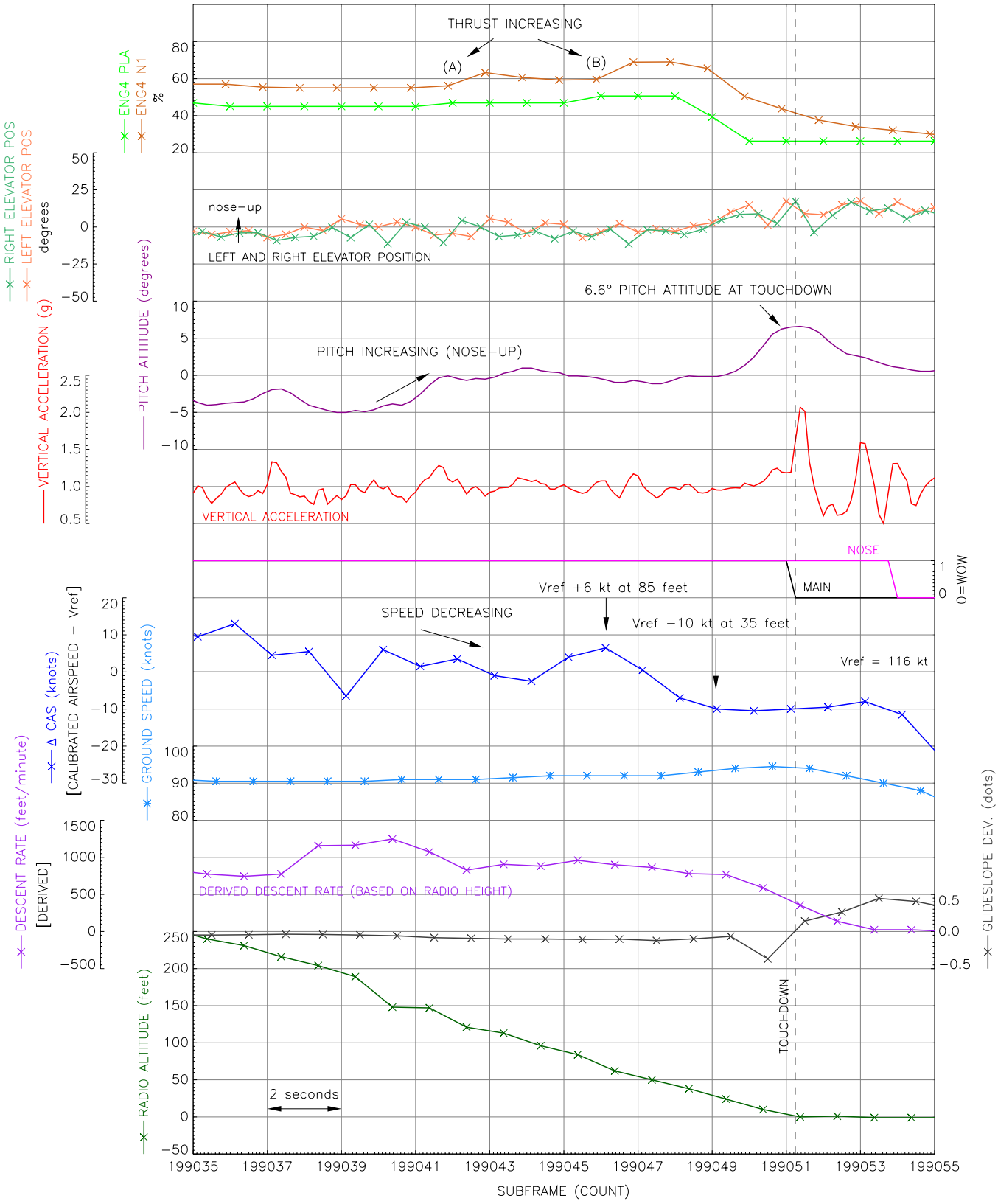

Figure 1

Salient FDR Parameters
(Incident to G-CFAA on 7 January 2005)