# CONTENTS

## SPECIAL BULLETINS



## COMMERCIAL AIR TRANSPORT

### FIXED WING



### ROTORCRAFT

None

## GENERAL AVIATION

### FIXED WING



### ROTORCRAFT

## CONTENTS (Continued)

### SPORT AVIATION / BALLOONS (Cont)



### ADDENDA and CORRECTIONS

None



**(ALL TIMES IN THIS BULLETIN ARE UTC)**

**SERIOUS INCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Airbus A340-313, G-VAIR |
| **No & Type of Engines:** | 4 CFM56-5C4 turbofan engines |
| **Year of Manufacture:** | 1997 |
| **Date & Time (UTC):** | 27 April 2008 at 0218 hrs |
| **Location:** | Nairobi Airport, Kenya |
| **Type of Flight:** | Commercial Air Transport (Passenger) |
| **Persons on Board:** | Crew - 14 Passengers - 108 |
| **Injuries:** | Crew - None Passengers - None |
| **Nature of Damage:** | Minor scratches to left aft lower fuselage |
| **Commander's Licence:** | Airline Transport Pilot's Licence |
| **Commander's Age:** | 50 years |
| **Commander's Flying Experience:** | 14,250 hours (of which 9,667 were on type)<br>Last 90 days - 108 hours<br>Last 28 days - 41 hours |
| **Information Source:** | AAIB Field Investigation |

**The investigation**

The Air Accidents Investigation Branch (AAIB) was informed of this serious incident at 0808 hrs on the 27 April 2008. Following consultation with the Air Accident Investigation Department (AAID) of the Kenyan Ministry of Transport it was agreed that the UK AAIB would conduct the investigation under the provisions of ICAO Annex 13 with Kenya appointing an Accredited Representative. The UK investigation commenced on the 28 April 2008 with the return of the aircraft and pilots to the United Kingdom. The Chief Inspector of Air Accidents has ordered an Inspector's Investigation to be conducted into the circumstances of this event under the provisions of The Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 1996.

In accordance with established international arrangements, the Bureau d'Enquetes et d'Analyses (BEA) of France, representing the State of Design and Manufacture of the aircraft, has appointed an Accredited Representative to participate fully in the investigation. The BEA Accredited Representative is supported by advisors from Airbus the aircraft manufacturer, and the operator is also providing assistance as required.

**History of the flight**

G-VAIR was scheduled to operate a London Heathrow (LHR) to Nairobi (NBO) passenger flight. The crew reported for duty at 1745 hrs at London Heathrow and the flight was uneventful until the landing.

The 0100 GMT ATIS obtained for Nairobi before the top of descent reported the wind to be from 040° at 3 kt with 7 km visibility, broken cloud at 1,600 ft, temperature and dewpoint 15°C and QNH 1020. The crew carried out an RNAV (Area Navigation) approach for Runway 06 at Nairobi. The ATIS weather was confirmed with ATC during the early part of the approach. Later during the approach ATC passed information to G-VAIR that an aircraft ahead had reported the landing visibility as 3,000 m with a cloudbase of 300 ft agl. The first officer, who was pilot flying (PF), rebriefed the initial go-around actions and the approach was continued with the autopilot and autothrottle engaged.

The crew stated that they became visual with the runway at a height of between 300 ft and 200 ft. At the decision height of 200 ft, both pilots could see all the approach lights and a good section of runway lights. The autopilot was disconnected at 100 ft radio altitude and the PF began to flare the aircraft between 75 ft and 50 ft radio altitude. The aircraft floated at around 20 ft for a few seconds before it entered an area of fog and the PF lost sight of the right side of the runway and the runway lights. The commander also lost sight of the right side of the runway. The aircraft touched down normally on the main gear only; the body and nose gear did not contact the ground throughout the event. The commander became aware of the left runway edge lights moving rapidly closer to him before he lost the lights completely and was only aware of their position by the glow of the lights illuminating the fog. The commander called “GO AROUND” and the PF immediately advanced the thrust levers from idle to full thrust within one second. G-VAIR became airborne after a period of just under five seconds on the ground. The gear retracted normally and the crew continued with the go-around, climbing to 9,000 ft to enter the hold. The crew suspected that the aircraft might have departed the left side of the runway. An inspection by airport staff confirmed the presence of a single set of landing gear marks off to the left of the paved surface. With the first officer remaining as PF, the crew carried out an uneventful diversion at FL230 to Mombasa followed by a normal, day VMC landing.

## Ground marks

Nairobi Airport staff measured a set of ground marks, believed to be from G-VAIR’s main gear, which started 800 m from the threshold of Runway 06. They continued on the runway for 160 m before the left set of marks passed over a runway light and then continued off the paved surface before running approximately parallel with the runway for 180 m. The right set of marks did not leave the paved surface although they were off the declared runway surface on the paved shoulder; these marks stopped 5 cm from the edge of the paved surface.

## Airfield information

Runway 06 at Nairobi is declared as 4,117 m long by 45 m wide. It consists of a grooved asphalt surface 45 m wide with 7.5 m asphalt shoulders either side to give a total paved width of 60 m. An AAIB inspector in conjunction with the Kenyan Accredited Representative conducted a visual inspection of the runway condition. The touchdown zone area of Runway 06 appeared heavily contaminated with rubber deposits, partially obscuring the runway centreline markings. It is considered that these rubber deposits may reduce the available friction and braking action for landing aircraft on Runway 06, whilst aircraft conducting a rejected takeoff on Runway 24 in wet conditions could suffer a significant loss of braking capability.

The Runway 06 edge lighting is set at the edge of the paved area, a distance of 7.5 m from the declared runway strip. This appears to be at variance with the ICAO Annex 14 standard which requires a maximum of 3 m from the edge of the runway. The runway had no centreline lighting, nor was it required by ICAO Annex 14.

**Damage to aircraft and infrastructure**

Aircraft inspections were carried out in accordance with the aircraft Approved Maintenance Manual (AMM). During initial inspections mud spray was noted on the fuselage and left horizontal stabiliser. After washing the aircraft, minor scratches were discovered on the lower left fuselage. These were assessed as paint chips and minor abrasions within the limits laid down in the AMM. The outboard left aft wheel on the left main gear had slight damage to the sidewall but was within AMM limits; as a precaution this wheel assembly was replaced on return to London Heathrow.

One runway edge light was destroyed.

**Weather reporting**

An Automated Weather Observation System (AWOS) is installed at Nairobi. This system has the capability to provide instant Runway Visual Range (RVR) to the ATC tower as well as other weather information. It operates from a single sensor located near the touchdown zone of Runway 06. Following this event the memory of this system was downloaded. The system recorded a minimum RVR of 550 m at the time of arrival of G-VAIR.

**Recorded data**

Flight Data Recorder and Quick Access Recorder data was successfully recovered from G-VAIR and is currently being analysed. Despite a request by the AAIB and attempts by the operator to preserve the recording of the event on the Cockpit Voice Recorder (CVR), information from the incident landing was overwritten.

**Background information**

The AAIB is aware of the recent Safety Recommendation made by the National Transportation Safety Board (NTSB) to the Federal Aviation Administration regarding the training of pilots for rejected landings below 50 ft following rapid reduction in visual cues. (NTSB: A-08-16)

**Continuing investigation**

The investigation will continue towards establishing the runway surface condition, the visibility of the markings and condition of the lighting to quantify what, if any, contribution they may have made to this incident. Further enquiries will be made regarding the difference between the RVR recorded by the AWOS and that passed to the crew of G-VAIR, and the effect on RVR of light luminescence of the runway edge lighting for Runway 06. The investigation will also consider the effect on flight crew of a loss of visual references at a critical phase of flight including the ability of crew to conduct rejected landings from very low heights in degraded visual environments. Reasons for the loss of the CVR recording will also be assessed.

*Published July 2008*

**INCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Airbus A319, CS-TTK |
| **No & Type of Engines:** | 2 CFM56-5B5P turbofan engines |
| **Year of Manufacture:** | 1999 |
| **Date & Time (UTC):** | 23 November 2007 at 2110 hrs |
| **Location:** | Shortly after departure from London (Heathrow) Airport |
| **Type of Flight:** | Commercial Air Transport (Passenger) |
| **Persons on Board:** | Crew - 6 Passengers - 91 |
| **Injuries:** | Crew - None Passengers - None |
| **Nature of Damage:** | None |
| **Commander's Licence:** | Airline Transport Pilot's Licence |
| **Commander's Age:** | 36 years |
| **Commander's Flying Experience:** | 7,010 hours (of which 4,926 were on type)<br>Last 90 days - 142 hours<br>Last 28 days - 22 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB |

**Synopsis**

Shortly after departure, dense smoke appeared in the rear passenger cabin accompanied by a smell of burnt plastic. The flight crew declared a MAYDAY and were vectored for a return to land. During the approach the smoke cleared and an uneventful landing was made. The source of the smoke has not been identified.

**History of the flight**

The aircraft was on a scheduled passenger service flight from London Heathrow to Lisbon. Shortly after takeoff from Runway 09L, the chief purser reported to the flight crew that there was dense smoke in the rear passenger cabin and a smell of burnt plastic. There were no caution or warning captions in the flight deck indicating a problem. The flight crew radioed ATC to declare a MAYDAY and reported that they had smoke in the cabin and were requesting a return to land. ATC instructed the crew to "Squawk 7700" and issued vectors for an approach to Runway 09R. During the approach the smoke in the cabin disappeared and a normal landing, taxi and shutdown were carried out. The passengers disembarked normally and the fire service carried out an inspection of the aircraft but found no evidence of burning.

**Operator investigation**

The aircraft operator carried out an investigation to determine the source of the smoke. The entire cabin, the galleys, ovens, toilets and cabin lights were inspected but no evidence of burning was found. The engines and APU were inspected and no anomalies were found. The cargo bays were also inspected and no source of smoke was found. The operator is no longer hopeful of being able to determine the source of the smoke and the cause of the incident.

**INCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Airbus A319-131, G-DBCI |
| **No & Type of Engines:** | 2 International Aero Engines V2522-A5 turbofan engines |
| **Year of Manufacture:** | 2006 |
| **Date & Time (UTC):** | 18 April 2007 at 0944 hrs |
| **Location:** | Amsterdam Schiphol Airport, The Netherlands |
| **Type of Flight:** | Commercial Air Transport (Passenger) |
| **Persons on Board:** | Crew - 5 Passengers - 112 |
| **Injuries:** | Crew - None Passengers - None |
| **Nature of Damage:** | None |
| **Commander's Licence:** | Airline Transport Pilot's Licence |
| **Commander's Age:** | 53 years |
| **Commander's Flying Experience:** | 11,123 hours (of which 3,493 were on type)<br>Last 90 days - 132 hours<br>Last 28 days - 44 hours |
| **Information Source:** | AAIB Field Investigation |

**Synopsis**

The Dutch Safety Board delegated the investigation to the UK AAIB.

The aircraft was departing Amsterdam, in good weather and light winds, on a flight to London. During the latter stages of the takeoff roll the aircraft yawed rapidly to the right and took off over the side of the runway on a heading that was 18° to the right of the runway centreline. It lifted off at a speed 5 kt below $V_1$ before reaching the edge of the runway. It was then manoeuvred back onto the runway centreline and it continued on its assigned Standard Instrument Departure (SID) as it slowly accelerated.

Recorded data showed that the rapid yaw during the ground roll had been caused by a deflection of the rudder. The evidence indicated that there had been no malfunction of the aircraft, nor significant wake vortex effects from the preceding heavy aircraft, and that the rudder deflection had been in response to rudder pedal movements.

The reasons for the right rudder pedal inputs could not be positively determined. The speed at which the aircraft began its turn to the right was such that it would have been appropriate to abort the takeoff, albeit at a late stage in the takeoff roll. It was possible that under-arousal, in the benign operating conditions that prevailed, may have affected the performance of both flight crew.

As a result of miscommunication, the aircraft remained in service for a period after the incident without comprehensive checks being carried out to determine if an aircraft malfunction might have been responsible for the rapid yaw.

Two Safety Recommendations are made.

**History of the flight**

The crew had reported at 0450 hrs at the company's Manchester Airport offices for a four-sector duty. The commander was Pilot Flying (PF) on the first sector to London Heathrow and the co-pilot was PF on the second sector to Amsterdam. Both flights were completed without incident and the co-pilot continued as PF, as planned, for the third sector back to London Heathrow.

The conditions at Amsterdam were good; visibility was greater than 10 km, there were a few cumulus clouds between 3,200 ft amsl and 8,000 ft amsl and the temperature was 12°C. The aircraft pushed back off stand at Amsterdam at 0924 hrs and taxied a distance of 7.4 km for a departure from Runway 36L. The co-pilot was PF for the taxi, which lasted approximately 14 minutes. G-DBCI was cleared to line up on the runway after a departing Airbus A330. ATC cautioned the flight crew against wake turbulence from the A330, and advised them that the surface wind was from 350º at 7 kt. G-DBCI commenced a rolling takeoff at 0944:20hrs at a weight of 58,124 kg. At that weight, $V_1$ and $V_R$ were calculated to be 143 kt and $V_2$ was 147 kt.

The commander reported that the takeoff was normal up to 100 kt, when he, as the pilot not flying (PNF), made the standard '*one hundred knots*' call. At approximately 130 kt he stated that the aircraft yawed about 30° to the right, and he called "engine failure" as the aircraft rotated. The co-pilot's recollection was that, at the same speed, he felt the right rudder pedal move forward and the aircraft 'slew' to the right, without any corresponding input from him. He applied corrective left rudder pedal and heard the PNF call "$V_1$ engine failure". With the aircraft heading towards the right edge of the runway, the co-pilot rotated the aircraft and it became airborne at 0944:57 hrs, before reaching the grass area to the side of the asphalt runway surface. He manoeuvred the aircraft back towards the runway centreline and it continued on the assigned SID. This involved maintaining the extended centreline to a point 4.4 nm from the AMS VOR, which is located abeam the Runway 36L threshold, before turning left. The departure was unencumbered by obstacles and the surrounding terrain was flat.

Both pilots realised that the engine indications were normal and that an engine failure had not occurred. They considered that wake turbulence from the preceding aircraft may have been another possibility and mentioned this to the ATC tower controller. He had observed the takeoff and had seen a small amount of smoke/dust appear as the aircraft took off over the right shoulder of the runway. However, he advised the crew of G-DBCI that the A330 was 8 nm ahead of them.

During the takeoff roll, the commander, as was his practice, had placed his feet lightly on the rudder pedals, more lightly during the latter part of the takeoff roll, and his left hand near his sidestick. He commented that the takeoff had been normal up to the point the aircraft started to yaw, with light movements on the rudder pedals.

G-DBCI continued on its flight-planned route to London Heathrow and the commander and co-pilot discussed whether the co-pilot could have made an inadvertent rudder input. This was discounted and they concluded that the cause lay in the 'atmospheric conditions'. Towards the end of the flight, the crew understood from ATC that tyre debris had been found on the runway at Amsterdam and there was a concern that the aircraft's right main landing gear was 'locked'. The flight crew had no indications to confirm this and the cabin crew had not been aware of anything during the takeoff, other than that the aircraft had 'swung' to the right. However, concerned at the possibility of damage to one or both of the tyres on the right main landing gear, which could have explained the yaw to the right, the commander and co-pilot agreed to carry out an emergency landing and informed the cabin crew of their intentions.

The commander advised the passengers that the crew would carry out a 'precautionary' landing and that the aircraft may veer slightly to the right during the landing. He then took control as PF and the cabin crew prepared the passengers and cabin. The flight crew declared a 'MAYDAY', completed the relevant abnormal and emergency checklists and decided to land with the autobrake selected off, using idle reverse and gentle braking on the left main landing gear. As it transpired, the landing was uneventful with only a slight rumbling noise audible during the latter part of the landing roll. The Airport Fire Fighting and Rescue Service attended the landing and observed nothing unusual when the aircraft was stopped on the taxiway. The aircraft then continued to taxi slowly on to a stand and the passengers were disembarked normally.

Later, the commander had a telephone conversation with Amsterdam ATC. They advised him that the crew of the aircraft which was departing behind G-DBCI had observed the takeoff and had reported skid marks on the runway. A runway inspection was carried out, the skid marks were confirmed and it was considered that G-DBCI's right main landing gear may have become 'blocked'. This had been interpreted by the commander during the flight as the landing gear being 'locked', preventing the wheels from rotating.

**Surface wind recordings**

Anemometers are located at each end of Runway 18R/36L, which is 3,800 metres long and orientated 184º/004ºM. One anemometer is positioned 414 metres south of the Runway 18R threshold, 105 metres west of the runway centreline and the other is positioned 315 metres north of the Runway 36L threshold, also 105 metres to the west of the runway centreline.

Snapshots of the instantaneous wind speed and direction readings, which were recorded every 12 seconds from these two anemometers, showed the variation in wind velocity between 0943:12 hrs and 0946:12 hrs. The anemometer near the threshold for Runway 36L indicated a variation in wind direction between 325º and 005º, with the speed varying between 4 kt and 8 kt. For the same period, the anemometer near the threshold for Runway 18R indicated the wind direction varying between 285º and 330º, with wind speeds between 7.5 kt and 9.5 kt. At 0945:00 hrs, the instantaneous readings from the Runway 36L anemometer and the Runway 18R anemometer were 325º/5 kt and 320º/8.5 kt respectively.

**Aircraft description**

The A319 is a member of the A320 family of aircraft (A318, A319, A320 and A321). The aircraft is of conventional layout, with two underwing engines and tricycle landing gear. Each landing gear has twin wheels. A Tyre Pressure Indicating System (TPIS), providing flight deck indication of tyre pressures, is an option on the A319 but was not fitted to G-DBCI (Manufacturer's Serial Number 2720).

On the ground, aircraft yawing moments can be produced by nose landing gear steering, differential wheel braking, asymmetric engine thrust, crosswind effects and rudder deflection.

The rudder is controlled by three hydraulic Powered Flight Control Units (PFCUs) in the fin, each fed from a different hydraulic system and signalled mechanically (Figure 1). A transducer mechanically linked to the rudder surface provides rudder position signals. Commands from the pilots' rudder pedals are transmitted by a cable-pulley system to a mechanical differential unit in the fin and thence to the PFCUs via a rod and bellcrank system. The input to each PFCU is in the form of a spring-centred rod that allows continued rudder operation in the event of one of the PFCUs ceasing to function. The two pairs

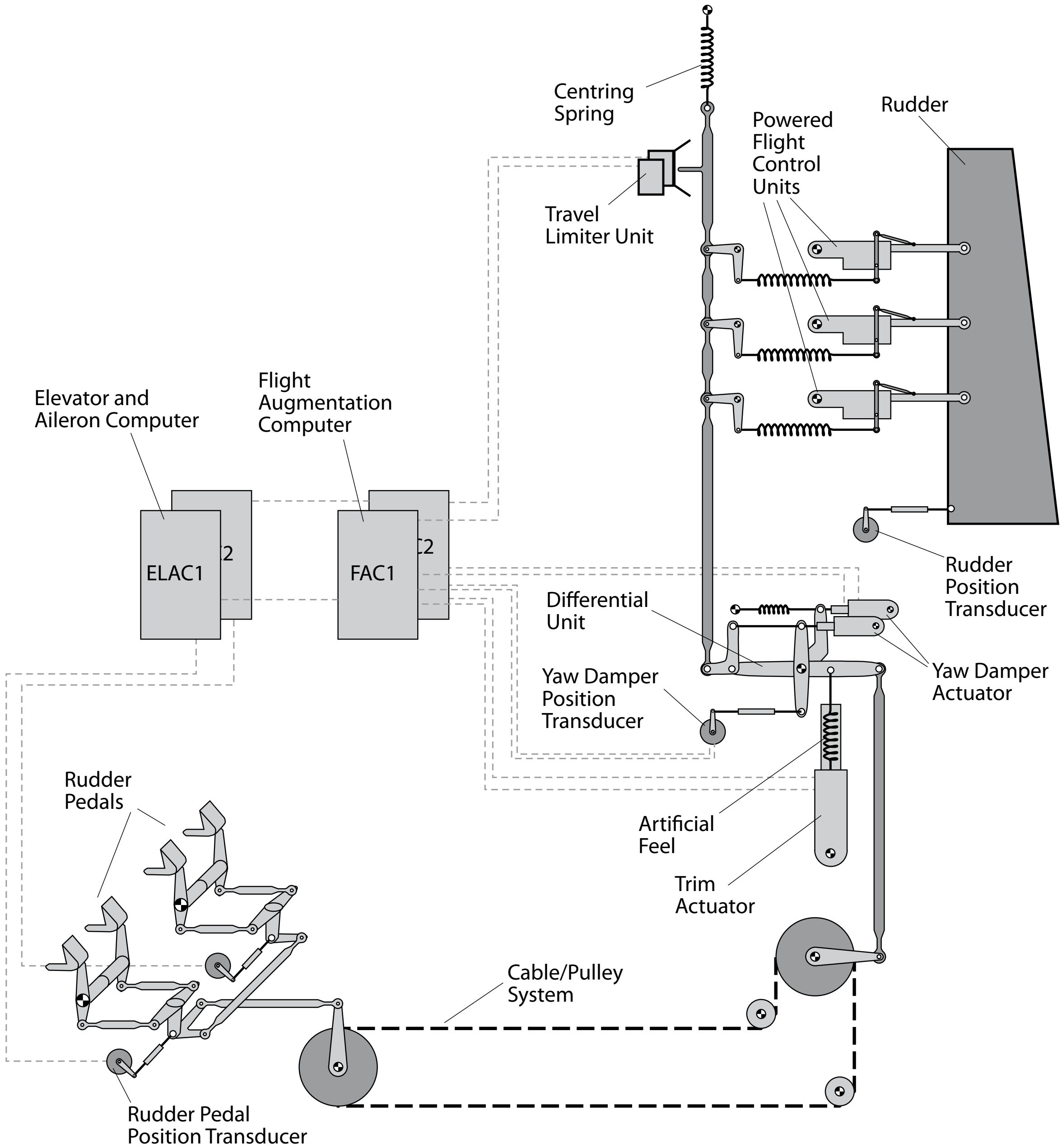



**Figure 1**

A319 Rudder Control System Schematic

of rudder pedals are mechanically linked and do not have a separation facility. Each pair of pedals drives a transducer which supplies pedal position information to the respective Elevator and Aileron Computer (ELAC) and thence to the respective Flight Augmentation Computer (FAC).

The maximum rudder deflection is controlled by a Travel Limiter Unit (TLU), signalled by the FACs, that restricts the range of movement of the PFCU input linkage as a function of aircraft calibrated airspeed (CAS). Maximum rudder deflection is ±30º at low speeds and progressively reduces with CAS above 160 kt.

Artificial feel for the pedals is generated by a feel spring acting on the mechanical input system in the fin. A centring spring also acts on the input mechanism for the upper two PFCUs to prevent rudder runaway in the event of disconnection of the input system. The arrangement provides a constant pedal force/displacement characteristic irrespective of the flight conditions. Pedal force/deflection characteristics for the A319 are shown in Figure 2.

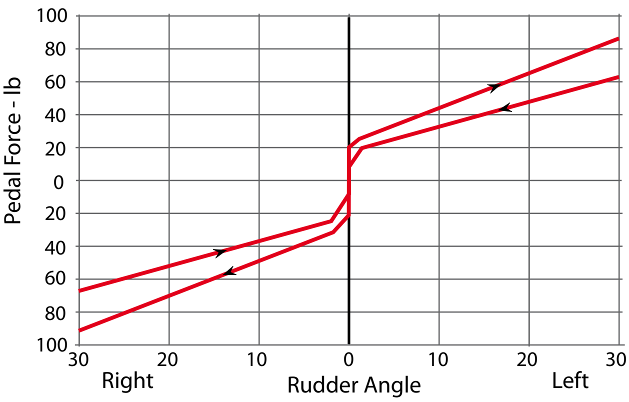



**Figure 2**

A319 Normal Rudder Pedal Force vs Rudder Deflection

Rudder trim is effected by an electrically motorised actuator controlled by a flight deck selector via the FACs. The actuator alters the datum position of the artificial feel spring; deflection of the rudder by the trim system thus causes corresponding displacement of the pedals. Trim authority below the TLU threshold speed is limited to ±20º rudder deflection; trim rate is 1.2º/second.

An automatic aircraft yaw damping system also acts on the PFCU input linkage to oppose changes in aircraft yaw rate. The system has two yaw damper actuators, one active and the other on standby, each controlled by a FAC. A transducer driven by the linkage supplies the FACs with information on yaw damper displacement. Pedal and yaw damper commands are additive, such that the yaw damping system tends to oppose the pedal commands. Yaw damper signals are input to the differential unit, which acts such that yaw damper activity does not displace rudder pedals. Yaw damper authority is limited to ±5º rudder deflection, at a maximum rate of 40º/second.

The system transducers provide information to the Flight Data Recorder (FDR) on pedal displacement, rudder angle and the extensions of the rudder trim actuator and yaw damper actuators. An Electronic Centralised Aircraft Monitor (ECAM) displays aircraft condition, caution and warning messages to the flight crew. A Centralised Fault Display System (CFDS) registers component and system faults and exceedences detected, which can be printed as a post-flight report (PFR) for maintenance purposes, and enables Built-In Test Equipment (BITE) testing of the aircraft's systems on the ground. Rudder trim and yaw damper faults should generate messages for display on the ECAM and recording on the PFR. No flight deck or PFR failure messages are provided for either the mechanical system linking the rudder pedals with the PFCUs or with the PFCUs themselves.

In an attempt to rule out the possibility that a rudder system malfunction had resulted in rudder pedal deflection, the AAIB requested that the aircraft manufacturer conduct a detailed assessment of the system, including consideration of spring rates and geometry. Information from the aircraft manufacturer confirmed that, in the absence of a failure in the rudder control mechanical system, hydraulic pressure in the PFCUs would prevent the rudder from being back-driven by external forces. The manufacturer also conducted testing, using a ground rig, that it confirmed was fully representative of G-DBCI's rudder system. The tests indicated that, with all three hydraulic systems depressurised, a full deflection of the rudder (measured at approximately 32º) resulted in a maximum pedal displacement of 15º, because of the combined action of the centring spring and the PFCU input spring-rods.

**Aircraft examination**

Following its arrival and inspection at Heathrow after the incident, G-DBCI flew two further sectors on 18 April 2007, with no reports of yaw control anomalies, before it was taken out of service for further examination. The AAIB was notified of the incident at around 1640 hrs on 19 April 2007 and began an examination of the aircraft that evening at Heathrow. No abnormalities with the landing gears, including the tyres, were apparent, and no relevant aircraft faults or exceedences were recorded on the PFR. Inspection of the rudder control linkage in the fin revealed no anomalies and rudder operation in response to both pedal and trim inputs was normal. Rudder operation was checked both with all three hydraulic systems pressurised and with each system alone pressurised in turn. With all three hydraulic systems pressurised, the rudder deflected from neutral to full travel in approximately one second following rapid full pedal deflection. The rudder response to trim selections was normal.

The operator reported that the records for G-DBCI did not suggest that any yaw control problems had been experienced with the aircraft prior to the incident. The aircraft returned to service on 20 April 2007; after several months in service no further yaw control anomalies had been reported.

**Runway examination**

Inspection of Runway 36L at Amsterdam by the Dutch authorities shortly after the incident identified two pairs of tyre track marks that appeared likely to be associated with G-DBCI's takeoff ground roll deviation. The Dutch Safety Board supplied photographs of the marks and their approximate dimensions and AAIB subsequently examined the runway. The marks were found to consist of pronounced black rubber deposits on the light-coloured asphalt surface of the runway. Their lateral spacing corresponded to the A319 main landing gear wheeltrack and their position (Figure 3) corresponded closely to the aircraft track estimated from FDR data. It was therefore concluded that G-DBCI's mainwheel tyres had made the marks during the takeoff ground run.

The track marks from the left main wheel tyres commenced approximately 1,035 m from the start of Runway 36L, adjacent to a turnoff (V2 turnoff) from the reciprocal Runway 18R, with the aircraft near to the centreline. The marks indicated a brief slight turn to the left, followed by a sustained right turn, during which track marks from the right mainwheel tyres became evident. After turning approximately 20° right of the runway heading, both the left and right track marks ceased, at points respectively 9 m and 6 m from the runway edge. No signs were found to indicate that any of the tyres had run on the runway shoulder or the grass surround.

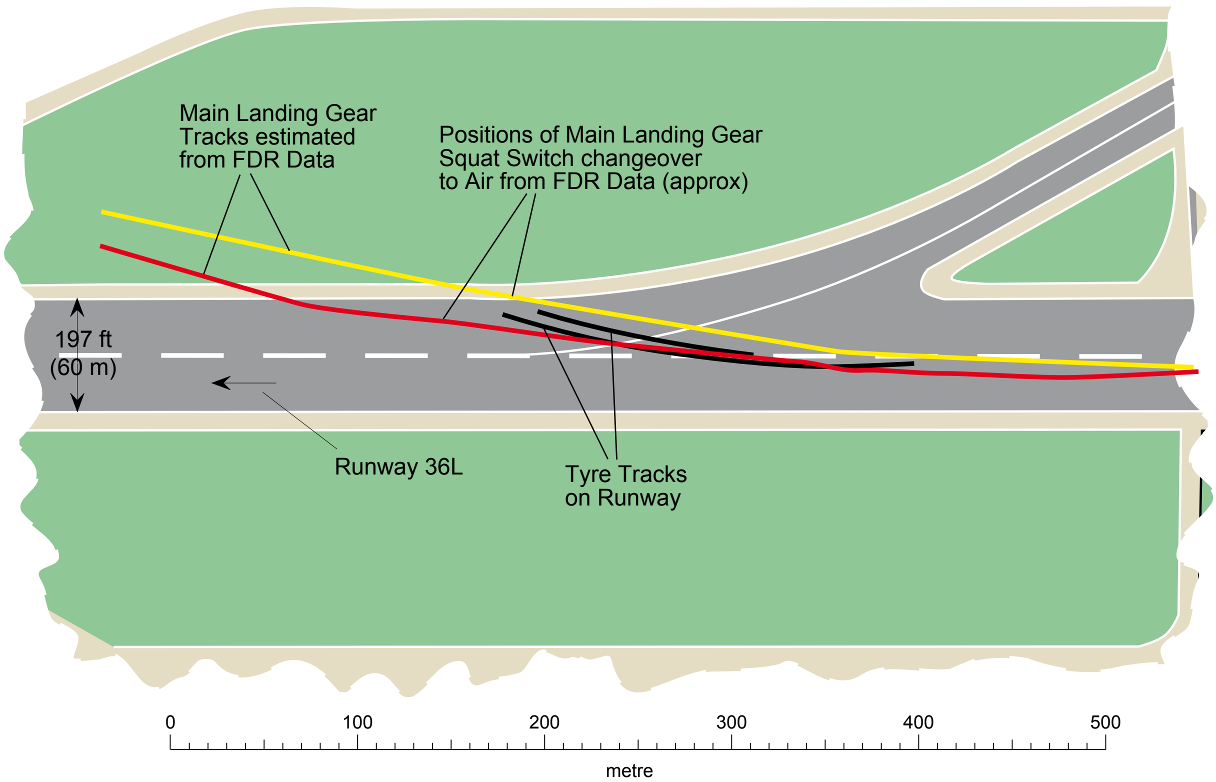



**Figure 3**

Plan view of runway tyre marks and main landing gear tracks estimated from FDR

**Recorded data**

The aircraft was fitted with a Cockpit Voice Recorder (CVR) and a Flight Data Recorder (FDR). By the time that the AAIB was notified, the CVR recordings had been overwritten, and therefore the CVR was not removed from the aircraft. The operator downloaded the FDR on the aircraft and supplied the downloaded data to the aircraft manufacturer and to the AAIB for further analysis.

The following description of events is based on the recorded data extracted from the FDR. All times are given in UTC.

The aircraft started taxiing from its stand at 0928 hrs and taxied a distance of 7.4 km to the runway. During the taxi, full and free flight control checks were carried out, first by the commander and then by the co-pilot. The recorded values of brake pedal positions and metered brake pressures were entirely consistent with normal aircraft taxiing. The runway was reached at 0942 hrs.

The aircraft was positioned on Runway 36L with a heading of 004ºM and configured with 10º of flap (equates to a flap lever position of 1+F). The autopilots were not engaged and both flight directors were on.

At 0944:13 hrs the thrust levers were advanced and the aircraft started to accelerate. With the exception of an initial left pedal/rudder input, the pedal/rudder inputs were minor and to the right; heading remained within 1.5º of runway heading (004ºM). Figure 4 shows salient recorded parameters from the point when the aircraft accelerated through an indicated airspeed of about 90 kt.

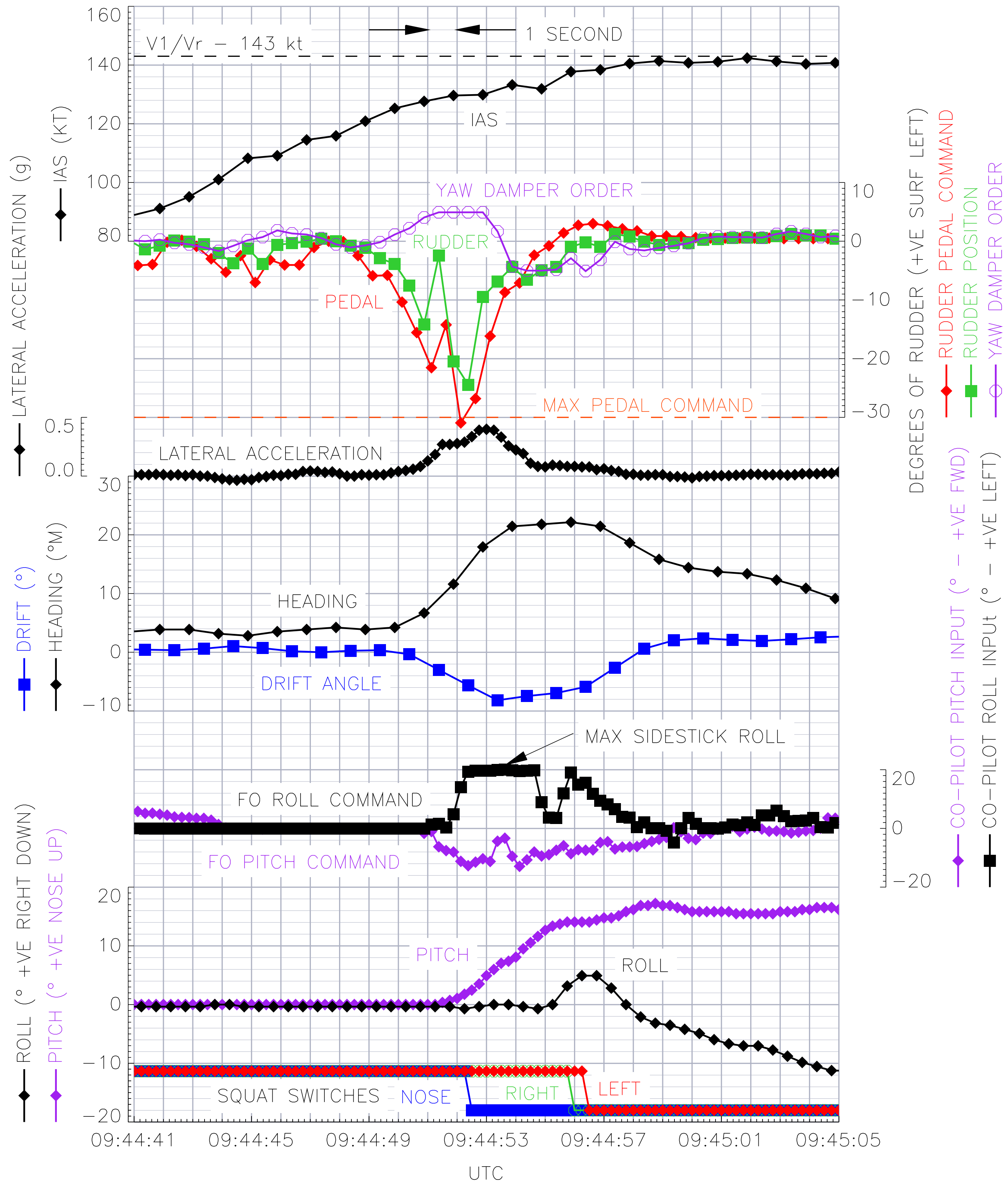



**Figure 4**

FDR Parameters showing control inputs and aircraft motion.
(Incident to G-DBCI on 18 April 2007)

At 0944:48 hrs, with an IAS of 116 kt, another right pedal input was initiated. Two seconds later, whereas previous inputs had started to return towards neutral, the right pedal input continued increasing and the heading increased through 005ºM. One second later the data shows a brief peak in pedal input at approximately 72% of full deflection. At this point the IAS was 128 kt and increasing, aircraft heading was passing through 007ºM and recorded drift angle was increasing through 3º.

The co-pilot's sidestick showed the start of a pitch-up command. Half a second later, the commander's sidestick registered a brief roll left input and the co-pilot's sidestick started to move towards a full left roll input. There was a one sample reduction in pedal input and rudder deflection. This was followed, half a second later, by a 31º yaw right command from the pedals (effectively a maximum 30º right rudder surface command) and an opposing 5º left rudder command from the yaw damper. This combination resulted in a recorded rudder surface deflection of 24º to the right.

At an IAS of 130 kt, with heading increasing through 015ºM and with full roll left command applied, the aircraft had started to rotate, increasing through a pitch attitude of 2º nose up. This airspeed equates to $V_R$ - 13kt.

The pedal and rudder deflection reduced over the next 3.5 seconds and the heading stabilised at approximately 022ºM. Drift angle peaked at 8º to the left of heading and started slowly reducing. During the rotation period, significant left roll was being commanded but this was opposed by the secondary roll effect of the yaw to the right and, with both main landing gear on the ground, main gear oleo compression. Hence no significant roll attitude was observed until the left roll command was brought to near neutral, resulting in a slight right roll. The co-pilot reapplied the left roll input using his sidestick but the aircraft continued rolling right. With a stable pitch attitude of 14º, an airspeed of 138 kt and a right roll of just over 3º, the aircraft left the ground.

Throughout the takeoff, the recorded lateral acceleration values were always to the right.

Figure 5 shows the aircraft speed and altitude compared to the noise abatement procedure requirements applicable to the departure from Schiphol Airport. The aircraft did not reach the $V_1/V_R$ speed of 143 kt until passing 460 ft amsl (about 470 ft aal) and did not reach $V_2$ until passing 740 ft amsl (about 750 ft aal). The target initial climb speed was achieved at a height of 1,100 ft aal.

The remainder of the flight appeared to be uneventful and the aircraft touched down at London Heathrow Airport at 1053 hrs.

Other parameters were examined over the period of the takeoff roll. The thrust lever angles and engine $N_1$ and $N_2$ values were symmetrical throughout. From initial brake release at the start of the takeoff roll until after the aircraft became airborne, no other brake pedal inputs or indications of brake pressure being applied were recorded. Additionally, no faults were recorded from the normal braking, antiskid or autobrake systems. The rudder trim position remained neutral.

The parameters that record system faults did not show any faults for the flight and normal pitch/roll laws were in effect throughout.

The rudder position parameter appears to be consistent with the rudder pedal position and yaw damper parameters. It was not possible to understand completely how these three parameters interacted because of the way that they were recorded, all being sampled at the same rate, four times a second, but not at the same time. An additional complication was the fact that the sample rates were not high enough to capture the full dynamics of the parameters. As a result it was not possible to establish from the recorded data whether the rudder was driving the pedal movement or whether pedal movements were driving the rudder. No pedal force parameters were recorded.

Following a recommendation made by the USA National Transportation Safety Board, proposals have been tabled to require higher recording rates for primary control surface positions, such as the rudder, on future build aircraft. However, it is considered impractical to increase these sample rates for in-service aircraft and therefore no corresponding Safety Recommendation is made in this report.

**Aircraft modelling and simulator testing**

The aircraft manufacturer used a computer model of the A319 to determine its expected behaviour in response to the control inputs indicated by G-DBCI's FDR data. The modelling was carried out using the wind velocity and other conditions as recorded during the incident. The results produced a close match with the FDR data for flight control surface deflections and aircraft manoeuvre parameters, such as heading, pitch angle and lateral load factor, indicating that G-DBCI had responded correctly to the recorded control surface deflections. Modelling scenarios including a wind gust, engine or brake problem did not yield a close correlation between the recorded data and predicted aircraft performance.

A number of takeoffs were performed in an A320 simulator to explore the differences between an engine failure before $V_1$ and a deflection of full right rudder pedal on the takeoff roll, as occurred during the incident takeoff. At the same speed of 120 kt, the rate of yaw experienced after a failure of the right engine was similar to that produced by full deflection of the right rudder pedal as recorded during the incident takeoff. It was also noted that introducing full left sidestick input (roll) on the ground, again as recorded during the incident, produced indiscernible aircraft roll while the aircraft remained on the ground.

**Wake turbulence**

Information on Wake Turbulence Spacing Minima for Departures is included in the CAA's Aeronautical Information Circular (AIC) 17/1999, entitled *Wake Turbulence*. This conforms to the International Civil Aviation Organisation (ICAO) requirements, with certain modifications which were not applicable in this case. It states that the minimum spacing at the time aircraft are airborne, departing from the same position, when a Medium aircraft (maximum takeoff weight between 40,000 kg and 136,000 kg) follows a Heavy aircraft (136,000 kg or greater) is two minutes.

It was calculated that G-DBCI became airborne exactly two minutes after the preceding A330.

**Takeoff performance**

The aircraft manufacturer advised that there was no performance penalty as a result of the aircraft becoming airborne 5 kt below the $V_R$ speed of 143 kt. The Joint Aviation Requirements (JAR) Certification Specifications (CS), applicable to large aeroplanes, state under CS25.107(e)(4):

> *'Reasonably expected variations in service from the established take-off procedures for the operation of the aeroplane (such as overrotation of the aeroplane and out-of-trim conditions) may not result in unsafe flight characteristics or in marked increases in the scheduled take-off distances…'*

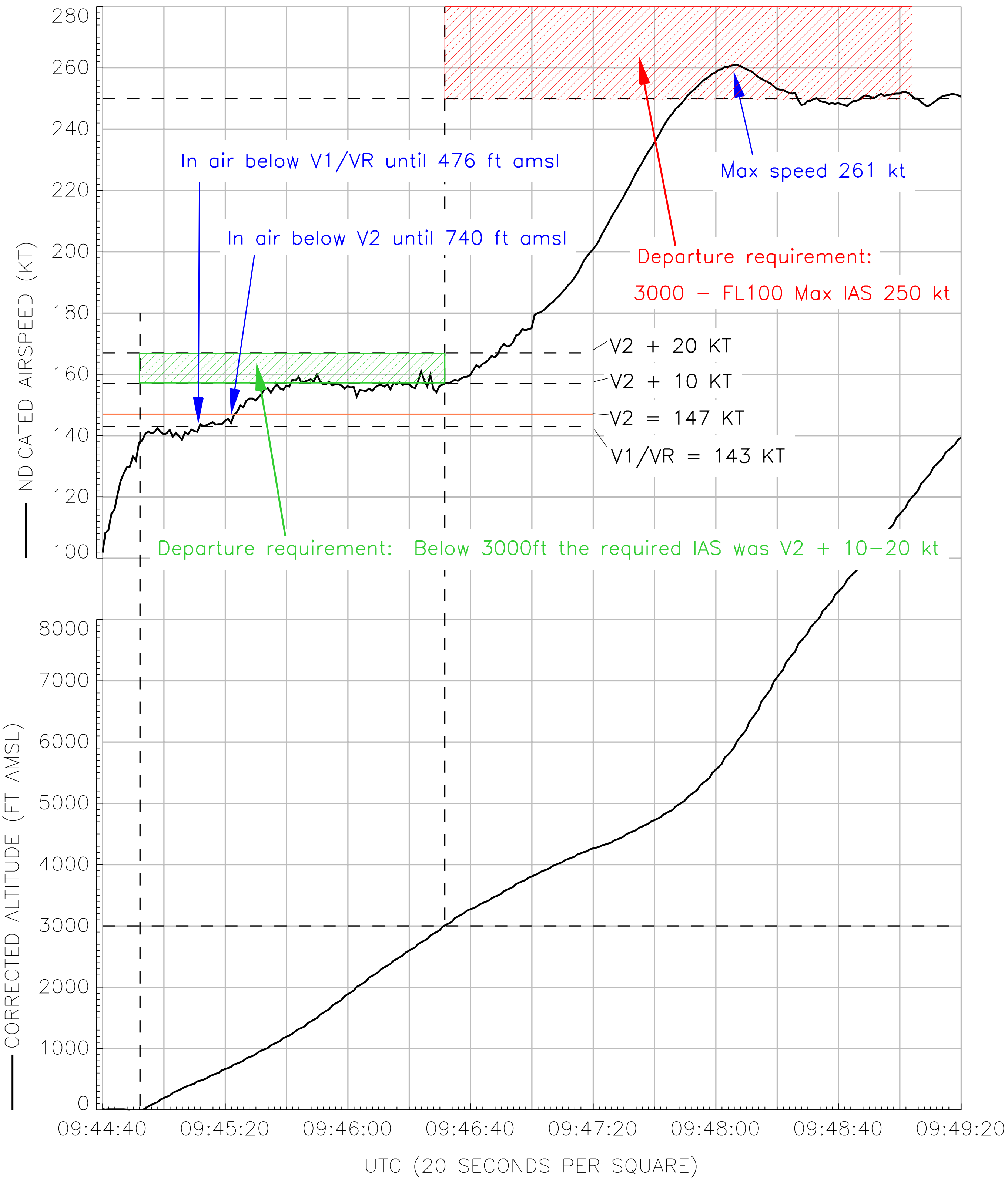



**Figure 5**

FDR parameters showing recorded airspeed relative to required airspeed after takeoff
(Incident to G-DBCI on 18 April 2007)

This is amplified in the relevant Acceptable Means of Compliance (AMC), AMC No. 2 to CS 25.107(e)(4), which states:

> *'For the early rotation abuse condition with all engines operating and at a weight as near as practicable to the maximum sea-level take-off weight, it should be shown by test that when the aeroplane is rotated rapidly at a speed which is 7% or 19 km/h (10 kt), whichever is lesser, below the scheduled $V_R$ speed, no 'marked increase' in the scheduled field length would result.'*

**Previous incidents of yaw disturbances during the takeoff roll**

Previous reports by crews of A320 series aircraft of unusual yaw disturbances during the takeoff roll had prompted an investigation by the aircraft manufacturer. These events were characterised in recorded data by a lateral acceleration and heading change, followed by a large counter rudder deflection and then the reversal of these parameters.

Following the investigation, the manufacturer published Flight Crew Operating Manual (FCOM) Bulletin No. 829/1, entitled '*Yaw Disturbances during the Takeoff Roll*', in September 2004. It advised operators that:

> *'tests confirmed that the lateral perturbations were not caused by an aircraft system malfunction, but were always due to external lateral gusts.'*

The Bulletin stated that A320 series aircraft had experienced approximately 30 cases:

> *'of "unusual" yaw movement during the take-off roll'*

sometimes referred to as a '*lateral jerk*'. It noted that the most significant of the events had included:

> *'an initial sharp lateral disturbance, associated with short, but substantial, lateral acceleration and heading variation'*

during the takeoff ground roll. Typical FDR traces of relevant parameters, including lateral load factor, rudder deflection and heading, were provided in this Bulletin, but without any indication of the magnitude of the excursions in these parameters.

The aircraft manufacturer had made a presentation on these yaw disturbances at an Operator's Flight Safety Conference in 2004. At that conference they presented quantitative data for one event which showed excursions of ±0.2g in lateral load factor and a heading change of 3º. This contrasts with the G-DBCI event where the commander reported a heading change of approximately 30º (later confirmed by the FDR to have been 18º).

The FCOM Bulletin also advised flight crews:

> *'that they may encounter such lateral disturbances, particularly in areas and in weather conditions where strong thermals have a tendency to develop. Pilots should, therefore, be prepared to react to such isolated disturbances by using the rudder normally, and avoiding excessive rudder input.'*

Evidence was found of other types of serviceable aircraft experiencing lateral deviations during the takeoff roll. In most of these cases a strong crosswind was the trigger for the event. This included an accident in 1997 involving an A320 aircraft in which the crosswind exceeded the handling pilot's limit as specified by that operator. One conclusion of the official investigation was that the cause of that accident was that :

> *'incorrect and excessive rudder was applied at high speed on take-off for indeterminable reasons, whilst the aircraft was under the control of the co-pilot.'*

Reports of lateral deviations during takeoff in serviceable aircraft where there has been either a light crosswind or none at all are rare. Investigation revealed three instances, which all involved A320 aircraft. Two of these takeoffs, in 1998 and 2001, were continued and another, in 2006, was aborted.

**Post-incident aircraft operation**

This investigation included assessment of the reasons for G-DBCI having continued in service after the incident, flying two further sectors before being removed from service by the operator for additional investigation. The relevant factors were as follows.

The crew of the aircraft waiting to takeoff behind G-DBCI had reported to Amsterdam Tower seeing the sudden turn and the runway tyre track marks left on the runway. However, it appeared that G-DBCI's flight crew had probably already made a specified radio frequency change after takeoff and did not hear the message. The report was passed to London ATC and thence to G-DBCI, but at some point the marks became referred to as 'tyre debris' on Runway 36L. At this point G-DBCI's crew suspected that the sudden turn had been caused by damage to the right main landing gear tyre(s), but did not have a tyre pressure indicating system to help verify or deny this. The Aircraft Technical Log for the incident flight contained a defect entry '*Suspect RH MLG tyre burst on T/Off. Emergency landing at LHR*'.

The operator's maintenance personnel, having found no anomalies with the tyres after inspecting the landing gear when the aircraft arrived at Heathrow, cleared the reported defect.

The operator's Duty Pilot Manager commenced an investigation immediately following the incident, using the operator's published '*Incident Procedure - Duty Pilot Manager Guidance*'. This listed a substantial number of responsibilities, actions and points to consider, the last of which was consideration of whether the aircraft recorders should be downloaded. He debriefed the flight crew and in light of their description of the event, which mentioned a substantial heading variation, referred to the manufacturer's FCOM Bulletin No 829/1. As previously noted, this did not give any indication of the typical order of magnitude of the yaw deviations due to gusts.

From the available information at that time, and in the absence of a flight recorder printout, the operator concluded that wake turbulence had caused G-DBCI to suffer a 'lateral jerk' and that further investigation of the aircraft was not required.

Later on the day of the incident the commander of G-DBCI learned that his aircraft had left tyre marks on the runway at Amsterdam. When he reported this information back to his base, G-DBCI was grounded for further examination and assessment of the FDR information.

**Procedures**

The procedure for takeoff is laid down in the company's Operations Manual. The guidance for a briefing for a Right Hand Seat (RHS) takeoff includes the advice that:

> *'If during the takeoff roll before V1 the call is STOP, the stop actions will be taken by the LHS (Left Hand Seat) pilot. The RHS pilot will revert to PNF duties.*
>
> *'... above 100 knots but before V1 the LHS pilot will only stop for an ECAM* (Electronic Aircraft Centralised Monitoring) *Warning, Engine Failure or a malfunction which renders the aircraft unflyable. In the event of a Warning or Caution during take-off, he will respond STOP or GO as applicable.'*

On the subject of the technique to use for the takeoff, the guidance given is:

> *'To counter the nose-up effect of setting engine takeoff thrust, apply half forward stick until the airspeed reaches 80 knots. Release the stick gradually to reach neutral at 100 knots.*
>
> *For crosswind takeoffs, routine use of the into wind aileron is not recommended…*
>
> *Once the thrust is set the captain keeps his hand on the thrust levers until V1 is reached.*
>
> *PNF will announce "ONE HUNDRED KNOTS"*
>
> *The PF crosschecks speed indicated on PFD and responds "CHECKED"*
>
> *Below 100 kt the decision to abort the take off may be taken, at the discretion of the captain, according to the circumstances.*
>
> *Above 100 kt, rejecting the take off is a more serious matter….*
>
> *After lift-off, follow the SRS* (Speed Reference System) *pitch command bar.'*

The SRS mode controls pitch to steer the aircraft along a path in the vertical plane at a speed defined by the SRS guidance law. In SRS mode, the aircraft maintains a speed target equal to V2 + 10 kt in normal engine configuration. When the Flight Management Guidance System detects an engine failure, the speed target becomes the highest of $V_2$ or current speed, limited by $V_2$ + 15 kt. The SRS pitch command bar is activated as part of the Takeoff mode, which combines the SRS vertical mode with the RWY (runway) lateral mode. Takeoff mode is available during the takeoff run and initial climb for flight director (FD) bars guidance.

The RWY lateral mode is represented by the green Ground Roll Guidance Command Bar on the PFD. This symbol is displayed when the aircraft is on the ground or below 30 feet radio altitude, provided a localizer signal is available. It shows the flight director yaw orders, to maintain the runway centreline. In this instance there was no localiser available on Runway 36L, so the RWY lateral mode was not activated and the green Ground Roll Guidance Command Bar was not displayed, leaving only the SRS pitch command bar displayed on the PFD.

The Operations Manual also gives advice on how PNF should guard the flying controls during the takeoff. It states:

> *'During take-off roll and initial rotation ..... PNF should "GUARD" the side stick and take-over push button, and be ready for an immediate take-over should this become necessary. When guarding the side stick, PNF must ensure that no inadvertent inputs are made.*
>
> *PNF should also "GUARD" the rudder pedals with heels on floor ready to take over if necessary. PNF should be careful not to exert any pressure or make any inadvertent input to the rudder.'*

**Personnel**

The co-pilot had accumulated 4,378 hrs in the A320 series of aircraft, of which the A319 is a common type, and had operated out of Amsterdam many times before. He commented that when he was PF during a takeoff it was his practice to glance at the sidestick order indication on the Primary Flight Display (PFD), colloquially referred to as the 'Maltese cross', to check the position of the sidestick control and that it was in the neutral position at 100 kt, as specified in the Standard Operating Procedures (SOPs).

During the co-pilot's last three assessments, a Licence Proficiency Check (LPC), an Operator's Proficiency Check (OPC) and a Line Check in the previous August, January and February, respectively, his 'manual flight' had been graded as 'standard' by the operator's flight operations training department. No concerns had been raised in the comments that had accompanied these assessments.

He had been PF in an A320 during a previous, aborted takeoff in March 2006. During that event the aircraft was taking off on a westerly runway in wind conditions which were described as being blustery from the south-west. It was reported that, at approximately 115 kt during the ground roll, the aircraft experienced a very strong gust of wind from the left and the co-pilot correctly applied control inputs to counter the yaw to the left. However, after a number of rudder pedal inputs, the aircraft started drifting to the right and the commander, who initially suspected but saw no sign on the instruments of an engine failure, took control and aborted the takeoff.

The data recorded during that event indicated that varying amounts of right pedal were used to maintain a relatively stable aircraft heading. Towards the end of the takeoff ground roll, a slight deviation to the left was recorded and corrected with right rudder. However, the aircraft heading then deviated right of the centreline and instead of correcting this with less right rudder or with left rudder, slightly less than half-full right rudder was applied, increasing the deviation. When the ensuing yaw rate exceeded 2 degrees per second, the takeoff was rejected.

It was concluded by the operator that the yaw to the right was a result of the wind variations and the co-pilot's rudder pedal inputs.

Following the event, the co-pilot was given refresher training in the simulator. This comprised two parts; a *Takeoff Safety Programme,* which was designed to assist pilots in reaching and maintaining proficiency in making '*GO/NO GO*' decisions and employing the correct techniques to stop the aircraft, and, secondly, improved use of rudder during takeoff in gusty crosswind conditions. Whilst the second part of this training was considered relevant, the first part was not consistent with the co-pilot's duties during a takeoff, as laid down in the company's Operations Manual.

The Takeoff Safety Programme involved engine failures mainly at $V_1$-5 kt, with one carried out at $V_1$-20 kt, a blown tyre and a cockpit alert, both at $V_1$-10 kt. The co-pilot completed the training to a satisfactory standard and displayed well-controlled handling in maximum crosswind conditions. Following this he was given further line flying training and his use of the rudder controls during takeoff was described as smooth and appropriate.

**Aviation psychology**

The events and circumstances of this incident were examined by an aviation psychologist who commented that:

*'it is unusual, but not unknown, for pilots to make large, inappropriate, apparently unconscious rudder inputs and sustain them for long periods.'*

The advice given was that:

*'for trained and experienced operators, closed loop control is generally a process that functions without much conscious thought about the details of command inputs.'*

It was also pointed out that:

*'memory of unexpected, confusing and alarming events is notoriously unreliable.'*

These factors often make the causes of erroneous control inputs difficult to determine.

The aviation psychologist further commented that:

*'the differences between the rudder control system and the manual elements of the primary flying controls are relevant to the directional error. In the elevator and aileron systems, the direction of control inputs is consistent with the resulting direction of rotation of the airframe. This is not the case with the rudder system, where the angular displacement of the rudder bar is opposite in sense to the resultant yaw command. Ab initio student pilots quickly adapt to this control law and generally are able to make appropriate rudder inputs without conscious difficulty. A possibility remains that, in exceptional circumstances, for example when alarmed or startled, a pilot might operate the rudder in the wrong sense.'*

Consideration was given to why an inappropriate response might remain undetected and uncorrected for several seconds. In his report, the psychologist stated that:

*'A key factor is the liberation of closed loop control from conscious attention that results from training and practice. In a tight control loop, where attention is closely focussed on feedback from the system, errors in control input will be corrected relatively rapidly. The commands required to achieve this close control do not demand much, if any, conscious thought in routine circumstances. When attention is intermittent or feedback is delayed, detection of an error could take seconds or even longer. For example, an inappropriate, discrete switch selection could easily pass unnoticed; the physical action is not closely monitored once the decision is made and evidence that the selection is wrong may take some time to arrive or command attention.*

*In addition, in aviation, primary control is generally effected manually. Where foot inputs are required, they tend to be discrete commands executed less frequently and potentially with less continuous monitoring of the feedback than manual commands. Where a task requires both manual and pedal inputs and there is acute competition for attention, it is likely that manual control will dominate and pedal control will receive less attention.'*

Comparison was drawn to a similar phenomenon to inappropriate rudder activation which is better documented in road safety.

*'Unintended acceleration occurs when a driver depresses the accelerator instead of the brake. Cases have been recorded of continuing and*

*increasing acceleration. Obvious differences here are that only one limb is involved and the characteristic error is to select the wrong pedal rather than the wrong direction of application. In other respects, there are important similarities. The error remains undetected. The operator persists and even increases the force applied. Effective corrective action is not taken for some time. The operator may remain unaware of the error even after the situation has been resolved. The underlying mechanisms are probably similar to those involved in inappropriate rudder commands. In particular it is noteworthy that the effect of the initial feedback, i.e. the unexpected acceleration, is to increase arousal level and with it the strength of the erroneous movement. Conscious attention is captured by the visual scene and the demands of manual control; lower limb activity is effectively unmonitored.*

*Factors which might, in principle, contribute to an extended period of unmonitored control movement include distraction, high workload, over-arousal and under-arousal. Collateral evidence for any of these is lacking. In the absence of specific causes for any of the others, under-arousal is the most likely.'*

The rest periods that the crew had received prior to the incident were examined and it was not considered likely that their performance was compromised by fatigue. However, it was thought conceivable that, in this instance, taxiing for a long period in benign conditions, before commencing the takeoff, could have led to a degree of relaxation and under-arousal.

**Discussion**

The takeoff roll continued normally until the aircraft reached a speed of 124 KIAS. A rudder pedal movement to the right then occurred, coincident with a proportionate movement of the rudder in the same direction, alleviated by a yaw damper input to the left, and the aircraft's heading increased to the right. The FDR data and the runway tyre track marks showed that G-DBCI started turning right off the centre of the runway approximately 1,035 m after the start of Runway 36L, at an airspeed of around 128 kt. The rudder pedal and rudder movement continued for 1.5 seconds before the FDR indicated that the rudder pedals and rudder were moved to the left for 0.5 seconds. The rudder pedals and rudder then continued moving to the right for another 0.5 seconds, reaching their maximum positions as the aircraft speed was passing 130 KIAS, although, again, the yaw damper reduced the magnitude of the rudder deflection.

During the last second of this sequence, the co-pilot's sidestick, which had been in the neutral position from the time the aircraft had reached 100 KIAS, was moved to give left roll and pitch-up control orders. Thereafter, the rudder pedals were returned to the neutral position over a period of 3 seconds, during which a full left roll control order was maintained on the co-pilot's sidestick for 2.5 seconds and the commander's sidestick also registered a left roll order for one second. The aircraft had not rolled, so it is considered that the sidestick commands for a roll to the left were made in response to the yaw to the right, either because of the effect of the lateral acceleration on the flight crew or as instinctive inputs to stop the turn, or both.

A number of FDR parameters showed that asymmetric thrust or wheelbrake activity had not occurred during the takeoff ground run and were not responsible for the rapid yaw. The computer modelling showed that the control surface deflections recorded on the FDR had been fully consistent with the recorded movement of the flight deck controls, that G-DBCI had responded correctly, and confirmed that the right yaw had resulted from the rudder deflection.

The investigation consequently examined in detail the possible reasons for the rudder deflection. FDR data indicated normal behaviour of the rudder trim system and the yaw damper. Additionally, the trim system could deflect the rudder only at a rate that was much lower than that recorded and the yaw damper authority was much lower than the maximum recorded deflection angle; thus neither system was capable of producing the rudder deflection recorded.

It was therefore evident that either the rudder deflection had been commanded by displacement of the rudder pedals or a malfunction had caused an uncommanded rudder deflection that had back-driven the pedals. Determination as to whether the pedals or the rudder was leading the deflection was not possible from the FDR data alone because the parameter sampling rates were insufficient, pedal force was not recorded and the data transport delays could not be determined with adequate precision. However, information from the aircraft manufacturer indicated that, in the absence of a failure in the rudder control mechanical system, hydraulic pressure in the PFCUs would prevent the rudder from being back-driven by external forces. Additionally, in the event of depressurisation of all three hydraulic systems, even full-scale rudder deflection would cause only part-scale movement of the rudder pedals. No defect with the rudder system was found, and no anomalies with the system were found during service following the incident. Thus it was concluded that the rudder deflection had been caused by displacement of the pedals.

The initial right rudder pedal input and aircraft turn to the right seems to have been undetected, until the movement of the rudder pedals was reversed, briefly. The rapid reversal of the rudder pedals was probably a result of recognition of the situation that had developed. However, continuation of the rudder pedals to full right travel may have been as a result of a startled response to another factor. Exactly when the commander called 'engine failure' is not known, but it might have been that announcement which caused sufficient alarm for the application of full right rudder. From that point on, the rudder pedals were returned to the neutral position. G-DBCI lifted off before reaching the edge of the runway surface and the co-pilot manoeuvred the aircraft back towards the runway centreline, before it continued to follow the SID, accelerating slowly to the SRS target speed of $V_2$+10kt by 1,100 feet amsl. The time taken for the aircraft to accelerate to $V_2$, the takeoff safety speed, was undesirable, bearing in mind that it is the speed that should be achieved by the screen height (35 feet agl) if an engine failure occurs at $V_1$.

The responsibility for aborting or continuing a takeoff lay with the commander. Although he diagnosed an engine failure, it is not clear at what speed he made that decision. The tests in a simulator suggested that the aircraft's rate of turn to the right, as a result of the right rudder pedal application, was similar to that which would be experienced during a failure of the right engine at the same speed. The speed of the aircraft at which the turn started was about 20 kt below $V_1$. The operator's SOPs indicate that it would have been appropriate to abort the takeoff, albeit at a late stage in the takeoff roll.

The commander did not call *'STOP'* or *'GO'*, so the co-pilot continued as PF and continued the takeoff, in accordance with the SOPs. The aircraft lifted off on a heading which was 18º to the right of the runway centreline, at an airspeed 5 kt below $V_1$. The recorded data shows that the aircraft had stopped turning before the main landing gear had extended, as indicated by the squat switches. Had the takeoff been aborted, when the turn to the right was well established, the aircraft would probably have departed the runway surface, with potentially severe consequences. Once airborne, there was no indication of any turbulence and the aircraft continued to respond correctly to the inputs made on the co-pilot's flying controls. It is possible that vestiges of the wake turbulence behind the A330 remained, but there were no signs that it was significant enough to disturb G-DBCI during the takeoff.

The circumstances of this incident differed from the previous event involving the co-pilot, in March 2006, in that on that occasion that aircraft was disturbed by a strong gust of wind. Initially, the rudder moved in the correct sense to counter the yaw to the left. However, the aircraft drifted to the right as more right rudder was applied and the commander took control, aborting the takeoff. The refresher training following that event gave the co-pilot practice in maintaining directional control of the aircraft during takeoffs in strong crosswinds. His aircraft handling was assessed as smooth and appropriate. The element of that training which required the co-pilot to abort the takeoff was not relevant because the SOPs require the LHS pilot to take control of the aircraft and perform that function when he has made the decision to STOP. The co-pilot's three most recent assessments raised no concerns about his 'manual flight', which was rated as 'standard'.

It was a matter of some concern that the aircraft had continued in service for two flights following the incident, before a comprehensive investigation to ascertain whether there might have been an aircraft malfunction. The evidence indicated that communication difficulties had been responsible.

The initial report of '*tyre debris*', describing what were more specifically tyre rubber marks, led the crew to suspect a tyre burst. A TPIS could have provided an indication that this was not the case but was not fitted. The diagnosis of a tyre burst was then entered as a defect in the aircraft's Technical Log, rather than a description of what had happened. After having found no tyre anomalies, the operator's engineers cleared the defect and no outstanding report that might have suggested a possible aircraft malfunction then remained in the Technical Log to prompt further maintenance action.

Once it had been established that the tyres were undamaged, the operator's operational investigation considered that the yaw deviation described by the crew had probably resulted from wake turbulence from the aircraft that had taken off shortly before G-DBCI. This appeared to be generally consistent with the events described in the FCOM Bulletin No 829/1, which described 'lateral jerks' resulting in 'substantial' heading variation. It is unlikely that this conclusion would have been reached had the bulletin provided an indication of the typical order of magnitude of yaw deviations observed due to gusts. On this basis the aircraft continued in service until the operator became aware of the presence of tyre marks on the runway.

On examination, the FDR data showed that the characteristics of this event differed from those described in the Bulletin, in which typical FDR traces showed that rudder activity occurred after the yaw deviation. However, the FDR data was not available when the operator initially assessed the incident, based solely on the contents of the crew report. Following the event, the operator has stated the intention to revise its Incident Procedure guidance, including specifying early involvement of its Flight Safety Department and earlier readout of the FDR.

**Conclusions**

The aircraft deviated to the right during the takeoff roll as the result of a full right rudder pedal input, which was initiated at 124 KIAS. The speed of the aircraft was between 100 kt and $V_1$ and the rate of turn was such that the commander considered that there had been an engine failure. The appropriate SOP in such circumstances was to abort the takeoff, which required the commander to announce '*STOP*' and take control, albeit in the late stages of the takeoff roll. No '*STOP*' call was made and the co-pilot continued with the takeoff, as trained.

At some point the commander called 'engine failure', but when is not clear. The aircraft stopped turning after deviating 18° from the centreline heading and rotated, becoming airborne before the main wheels had reached the edge of the runway surface. Its speed was 5 kt below $V_R$ but there was no performance penalty resulting from this underspeed rotation and the aircraft was manoeuvred back over the runway centreline.

There was no indication of any wake turbulence from an Airbus A330, which had rotated 2 minutes before G-DBCI, having had an effect on the A319, although vestiges of that wake turbulence may have remained. G-DBCI slowly accelerated to the SRS target speed of $V_2$+10 kt and continued on its assigned SID. The emergency landing at the aircraft's planned destination, which the flight crew elected to carry out in case of damage to the right main tyres, was uneventful and a subsequent engineering check revealed no fault with the tyres.

G-DBCI continued to operate two further sectors before being grounded, pending further investigation. As a result, the recording of the crew discussions on the flight deck during the takeoff from Amsterdam was overwritten. This deprived the investigation of valuable information relevant to this serious incident, bearing in mind that memory of unexpected, confusing and alarming events is unreliable.

The reason for the initial rudder pedal input and deviation of the aircraft from the centreline during the takeoff roll could not be determined. However, it was considered that distraction and under-arousal of the flight crew in benign conditions were possible factors. The application of full right rudder pedal may have been an alarmed response during the sequence of events, before the aircraft lifted off.

Part of the refresher training which the co-pilot received following a previous aborted takeoff in March 2006 did not reflect the operator's SOPs for situations in which a takeoff should be aborted. Therefore, the following Safety Recommendation is made:

**Safety Recommendation 2008-027**

It is recommended that British Midland Airways Limited review their flight crew simulator training to ensure that it reflects their current Standard Operating Procedures.

The operator had initially believed that the yaw deviation had been consistent with the type of event described in FCOM Bulletin No 829/1. It was unlikely that this conclusion would have been reached had the Bulletin provided an indication of the typical order of magnitude of the yaw deviations due to gusts, thereby making it apparent that the excursion in G-DBCI's case had been very much greater. Therefore, the following Safety Recommendation is made:

**Safety Recommendation 2008-028**

It is recommended that Airbus revise Flight Crew Operating Manual Bulletin No 829/1 to include a quantitative indication of the typical range of aircraft heading and lateral acceleration deviations which may be observed due to gusts occurring during the takeoff ground roll.

**INCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | ATR42-300, EI-SLD |
| **No & Type of Engines:** | 2 Pratt and Whitney PW120 turboprop engines |
| **Year of Manufacture:** | 1985 |
| **Date & Time (UTC):** | 18 January 2007 at 2225 hrs |
| **Location:** | London Stansted Airport |
| **Type of Flight:** | Commercial Air Transport (Cargo) |
| **Persons on Board:** | Crew - 2 Passengers - None |
| **Injuries:** | Crew - None Passengers N/A |
| **Nature of Damage:** | None |
| **Commander's Licence:** | Airline Transport Pilot's Licence |
| **Commander's Age:** | 41 years |
| **Commander's Flying Experience:** | 2,732 hours (of which 2,144 were on type)<br>Last 90 days - 147 hours<br>Last 28 days - 35 hours |
| **Information Source:** | AAIB Field Investigation |

**Synopsis**

Soon after takeoff from London Stansted Airport the aircraft developed a yawing motion which persisted as a yawing/rolling motion of varying severity. The yaw damper could not be engaged. An emergency was declared and the aircraft returned to Stansted. No mechanical fault was found which would have caused the motion, although an undetected and intermittent fault affecting components within the rudder control system could have degraded the aircraft's handling characteristics with the yaw damper not engaged, as could a takeoff with the rudder control system incorrectly configured. The nature of the motion and observed control deflections were such that an inadvertent and inappropriate rudder input by a pilot would have been required for the oscillations to persist. Four Safety Recommendations were made, concerning operational advice to flight crews and ongoing serviceability checks for Flight Data Recorders (FDRs).

**History of the flight**

On the evening of the incident, the aircraft was to operate a series of freight flights, originating and ending at Glasgow Airport. The flight crew of two had been operating the aircraft continuously for some days and had flown it to Glasgow the previous night, arriving at 0145 hrs. Both pilots were adequately rested when they reported at 1600 hrs for their night duty.

Glasgow had been affected by snow and strong winds during the day, and the crew arranged for the aircraft to be de-iced prior to departure in order to clear snow from the aircraft's surfaces. However, there was no ice detected on the aircraft prior to departure, and the surface temperature was reported to be 3ºC. The first flight of the evening, to Stansted, was uneventful apart from an occasional, intermittent and very brief illumination of an amber caution light on the Central Crew Alerting System (CCAS). This situation had reportedly persisted for a few weeks, but the caution was illuminating randomly and only very briefly, so had not been identified. The aircraft landed at Stansted at 2055 hrs.

Forecast strong crosswinds had prompted the crew to load sufficient fuel for a diversion back to Glasgow, so there was no need to refuel for the onward flight to Dublin. With the commander as handling pilot, the aircraft departed from stand at 2211 hrs. On board were the two pilots, 2,800 kg of freight and 300 kg of ballast. The calculated takeoff mass was 15,459 kg, with a maximum takeoff mass of 16,700 kg. The Centre of Gravity (CG) was calculated at 28% Mean Aerodynamic Chord (MAC), slightly aft of neutral.

The aircraft took off from Stansted's Runway 23, with a reported wind from 240º at 14 kt. Almost immediately after becoming airborne, the crew experienced a yawing motion, which developed into a motion described later by them as being similar to a Dutch roll. In accordance with standard flight procedures, the co-pilot attempted to engage the yaw damper after takeoff but it would not engage. The commander told the co-pilot she was having difficulty controlling the aircraft. The aircraft climbed to 3,000 ft above mean sea level (amsl) and maintained approximately the runway heading. When the aircraft was seen by Air Traffic Control (ATC) to be deviating from the cleared 'BUZAD 6R' Standard Instrument Departure (SID), the controller instructed the crew to turn right. The co-pilot informed the controller of the control difficulties and requested radar vectors for an immediate return to the airport. Figure 1 shows the aircraft's ground track, based on recorded radar data.

The aircraft was vectored around a right-hand radar pattern for an ILS approach to Runway 23. The crew

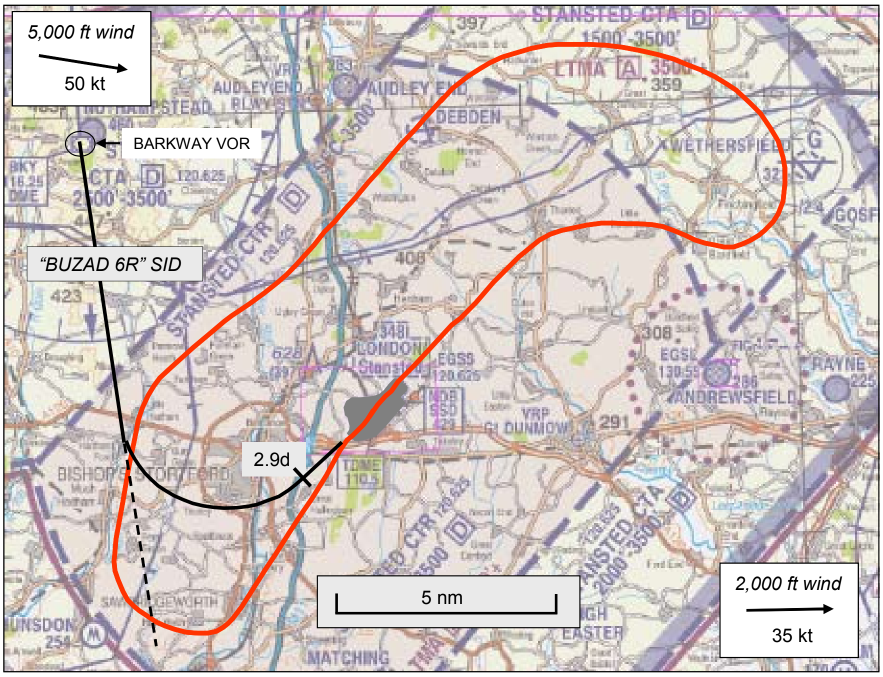



**Figure 1**

Aircraft ground track, SID and wind data elected not to declare an emergency initially, but did so after reviewing the situation. The commander experienced difficulty in turning right onto final approach and the aircraft flew through the runway centreline. Following further vectoring, the aircraft established on the Runway 23 localiser, but in the process descended inadvertently below the glidepath. This situation persisted until late in the approach, when the crew received configuration warnings related to landing gear and flaps, which were not correctly set for landing. The aircraft continued and landed from a reduced-flap approach at 2241 hrs, after a flight of 15 minutes 24 seconds. The crew did not experience any control difficulties during the rollout phase and were able to taxi normally to the stand.

**Flight crew reports**

The commander had been flying the ATR 42 and ATR 72 for six years before the incident. She had been with the operator for four years, during which time she had been promoted from co-pilot to captain. Of her 2,144 hours on type, 525 hours had been in command. The co-pilot had also been flying the ATR 42 and ATR 72 for six years. Of a total of 2,700 hours, he had 800 hours on the ATR 42.

The aircraft motion was reportedly confined to a gentle yawing motion initially, producing heading changes of just a few degrees. The co-pilot tried to engage the yaw damper several times but it would not engage, and the commander at first attributed the motion to this fact. As the aircraft drifted to the left of the climb out track, she attempted to turn to the right, but said that only a shallow angle of bank could be achieved with full control wheel deflection to the right. The predominant motion remained one of yaw, which increased markedly during turns. The co-pilot described the motion as if the rudder was being displaced across its full range of travel within a one to one and a half second period, though he did not handle the flying controls at any stage of the flight. The motion varied in severity and, at its worst, was extremely uncomfortable and adversely affected the crew's ability to manage the flight. The crew also reported turbulence associated with relatively strong winds at low levels.

Both pilots reported that turns to the right were difficult. The commander perceived there to be limited, though acceptable, roll control authority to the left, but very restricted authority to the right. She said she was reluctant to use the rudder pedals, as both pilots perceived the problem to be with the rudder, although she stated that her feet remained on the rudder pedals throughout. Neither pilot recalled much, if any, movement of the rudder pedals.

According to the co-pilot, the aircraft motion did improve somewhat with flap 15 extended for landing, which was deliberately selected late on the approach. However, the commander was still having difficulty controlling the aircraft, and instructed the co-pilot to handle the engine and propeller controls for landing, which he did. The final touchdown was controlled and described as smooth, with no control problems on the ground.

**Description of the rudder system**

The ATR 42 is equipped with a manually operated primary flight control system, which is augmented in the roll axis by hydraulically operated spoilers. The pilots' rudder pedals are connected, via cables, to a spring-loaded servo tab on the rudder trailing edge. The principle of operation is shown in Figure 2. The rudder itself is connected to a Releasable Centring Unit (RCU, also referred to as the 'rudder cam'), the internal springs of which maintain a centring force (approximately 10 kg force at the rudder pedals) towards the trimmed

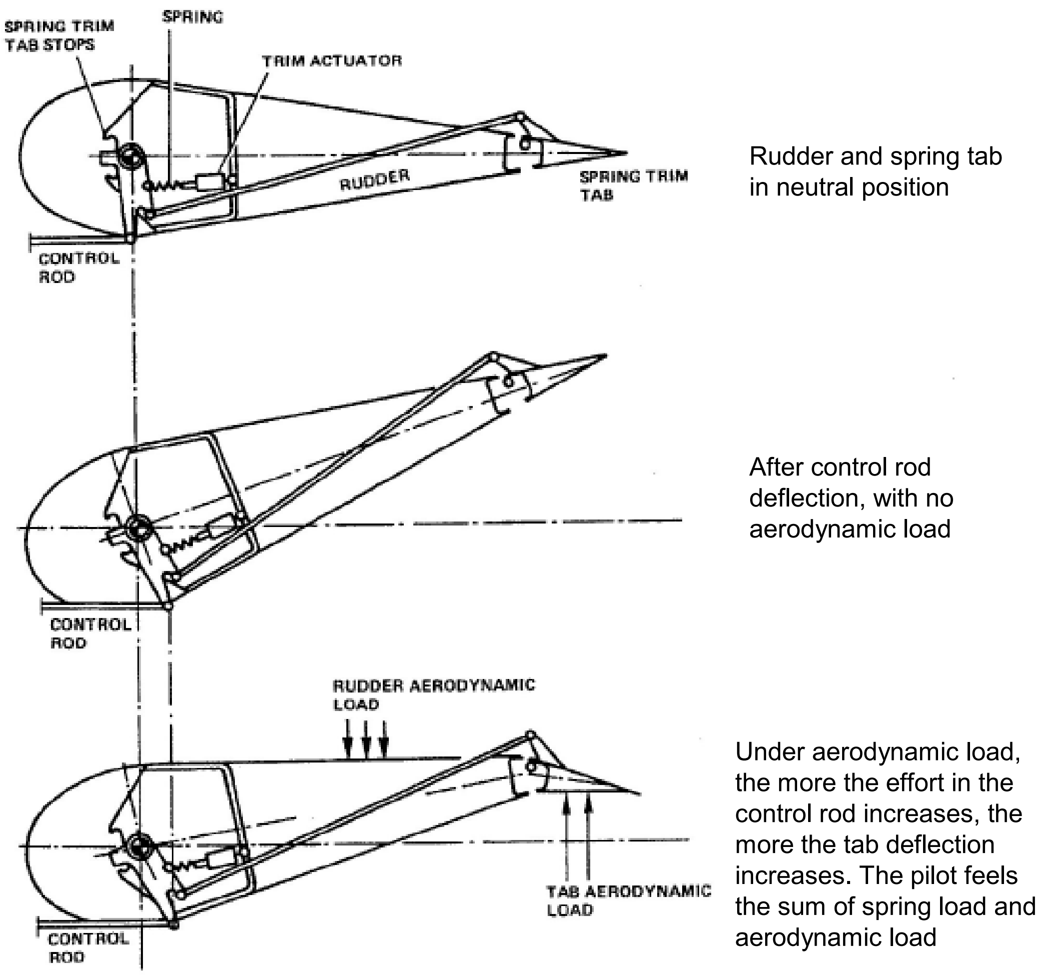



**Figure 2**

Schematic representation of rudder and spring tab operation

position. The purpose of this device is to improve the aircraft's directional stability, and hence stabilise the Dutch roll tendency, by constraining the movement of the control linkage. The yaw axis control system has no related cautions on the CCAS panel.

An electrically operated trim actuator acts on the same linkage and is controlled from the flight deck pedestal (Figure 3). The design of the rudder trim switch in the flight deck is such that a left or right trim demand also makes an electrical connection to an electromagnetic clutch within the RCU, causing it to release the rudder linkage, thus allowing it to centre on the new trimmed position. The clutch also releases the RCU whenever the yaw damper is engaged. Figure 4 shows a schematic diagram of the system, where it can be seen that both the trim and yaw damper electric inputs to the RCU clutch are routed via a relay (designated Relay 31CG on the diagram). The yaw damper is a function of the Automatic Flight Control System (AFCS), which also controls the autopilot, and is normally engaged shortly after takeoff to provide yaw damping and turn co-ordination. The AFCS computer sends electrical signals to a yaw servo, which acts on a cable drum that is connected to the rudder servo tab control linkage.

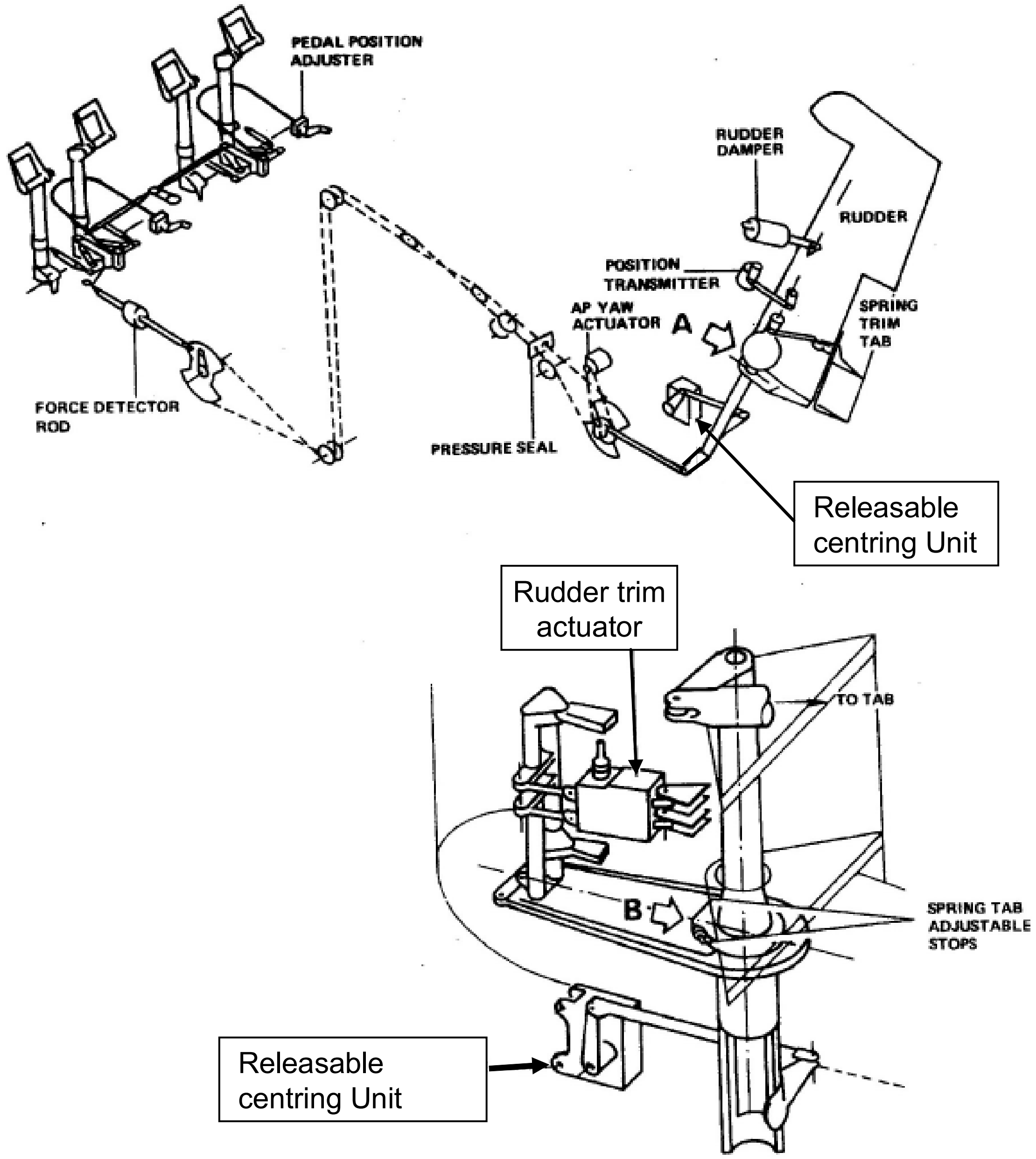



**Figure 3**

Rudder system layout

A self-contained gust damper is fitted between the rudder and the fin; this is a hydraulic fluid-filled dash-pot that provides a rate-sensitive opposing force to rudder movement. Thus, with the aircraft on the ground (ie with no tab aerodynamic load) a pilot's rudder pedal input would be opposed by the combined forces from the tab spring, the RCU internal springs and the gust damper.

Finally, a force detector rod is provided in the rudder control system below the flight deck floor. This disconnects the autopilot/yaw damper if a load in excess of approximately 30 kg is applied to either rudder pedal.

Prior to takeoff, the RCU must be confirmed as being centred on the trimmed, rudder-centred position. To

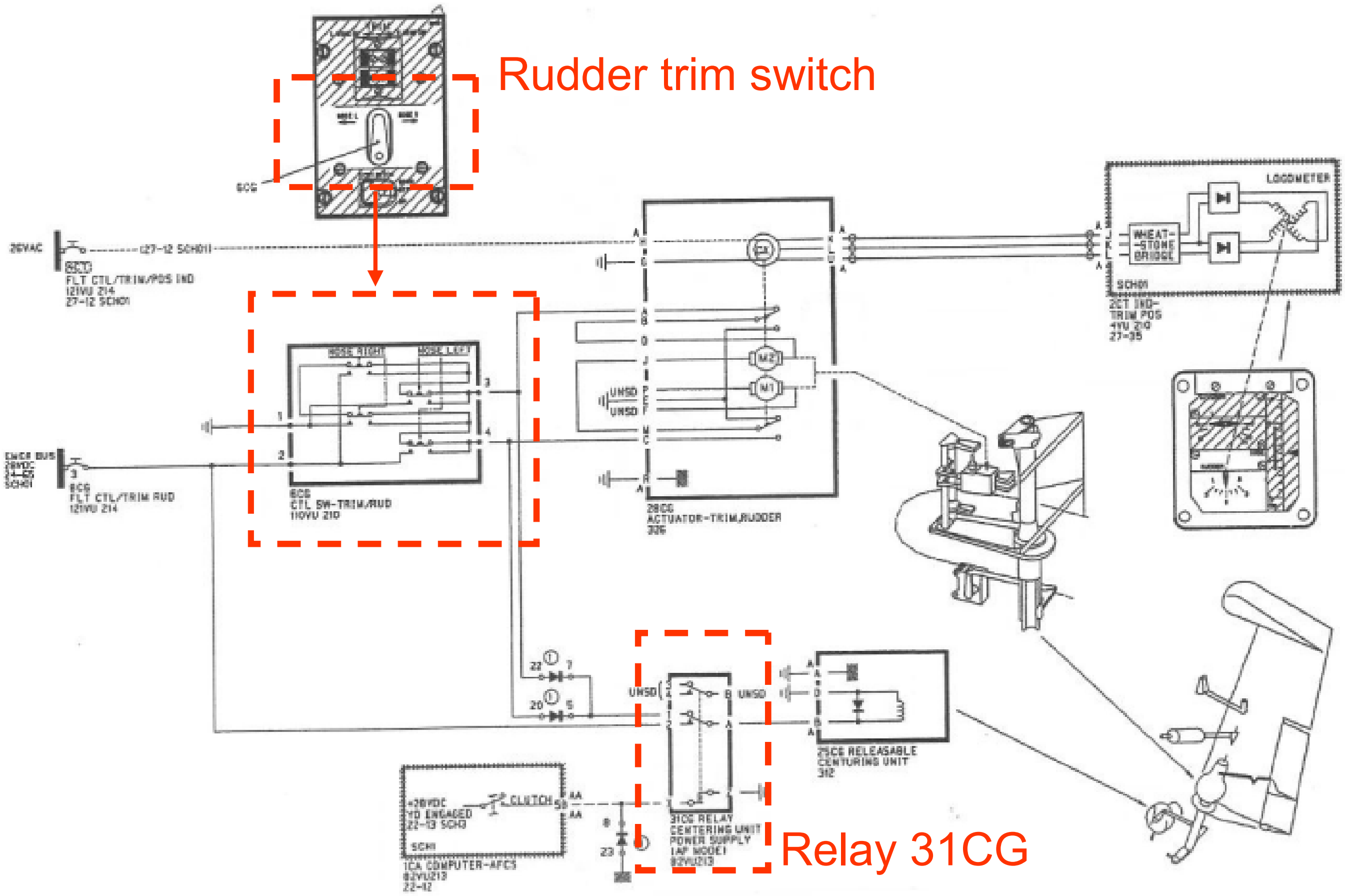



**Figure 4**

Yaw control schematic

achieve this, the rudder pedals must be centred by the pilot and then the rudder trim switch should be moved momentarily. This ensures that the RCU is centred about the neutral, trimmed rudder position.

### Examination of the aircraft

Whilst the crew reports suggested a problem with the rudder system, the opportunity was taken to conduct a function test of the aileron system together with the hydraulically operated roll spoilers. No problems were found. Sufficient panels were removed from the aircraft interior to be able to inspect the rudder control system. With the cables so exposed, the rudder travel, trim operation and cable tensions were checked and found to be satisfactory.

The tail cone was removed, which exposed the base of the rudder and tab, together with the rudder input lever and RCU. All the components were secure and undamaged. It was also noted that the desiccant cartridge on the RCU was showing its normal blue colour (moisture ingress would cause it to turn pink). The gust damper was examined, with no evidence of loss of hydraulic fluid being found. The only untoward feature was a small amount of play in the tab bearing, but the operator's engineering staff noted that other aircraft in their ATR 42 fleet had exhibited similarly worn bearings without any detrimental effect on rudder operation.

Following communications between the operator and the manufacturer, the latter prepared a list of airframe checks to be conducted before the aircraft was returned to service; this involved a structural inspection of the fin attachment area. In addition, a number of components were changed, with the removed items being retained for subsequent testing. These were the AFCS computer, yaw servo, trim switch, RCU and the 31CG relay. Following the inspection of the airframe and installation of the replacement components, the aircraft returned to service, with no further problems being reported.

**Examination of components**

The AFCS computer and yaw servo were tested, under AAIB supervision, at the manufacturer's UK overhaul facility. The computer was manufactured in 1988 and was not equipped with a fault register. The unit was opened and no evidence of damage or contamination was evident. It was then subjected to a pre-flight software check, during which it was noted that there was a marked 'ripple' on a 5v dc supply that was used throughout the unit. However, it remained within the specification and was attributed to being typical of the power supply board that was used at the time of manufacture. The computer was then subjected to an automated production test, paying particular attention to the yaw damper servo sections of the procedure; no problems were encountered.

The yaw servo was also subjected to a production test; this was successful apart from the motor speed being marginally faster than the specification requirement. This was not considered to have any relevance to the subject incident.

The trim switch, RCU and relay were sent to the overhaul facilities of their respective manufacturers in France. The strip-examinations were supervised, on behalf of the AAIB, by a representative from the Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile. The trim switch functioned satisfactorily on test and no significant defects were found during disassembly.

The RCU was manufactured in 1986 and had been modified by the manufacturer in 1988. The use of non-standard screws on the casing suggested that the unit had been overhauled subsequently by an organisation other than the manufacturer. Internally, it was found that the brake pads within the clutch assembly were worn, with some resultant polishing on the friction plates. This in turn had resulted in the override torque being outside the specification when tested. The manufacturer stated that this would have had no effect on normal operation of the RCU. It was additionally noted that some oxidation had occurred within the electrical connector, with the resultant white powder having coated one of the pins. Whilst this was not excessive, there was the possibility of a high resistance which, in extremis, could cause a failure of the RCU clutch to release.

The 31CG relay was tested and found to be satisfactory. It can be seen in Figure 4 that three of the contact pins are unused. The active ones were noted to be blackened as a result of electrical arcing in service but this was stated to be a normal phenomenon and had not resulted in erosion of the contacts.

In conclusion, the examination of these components did not reveal any significant defects that could realistically have resulted in a permanently released RCU. The presence of oxide on one of the RCU connector pins was not considered severe enough to cause problems, but had it done so, the result would have been a failure of the RCU to release when rudder trim was applied or when the yaw damper was engaged.

**Radar and radiotelephony (R/T) information**

The Stansted radar head provided position, track, groundspeed and Mode C altitude information. Magnetic headings and Indicated Air Speed (IAS) values were derived using wind data for the surface, 2,000 ft and 5,000 ft. The ground track of the aircraft is shown at Figure 1, together with wind and SID data.

Takeoff speed appeared normal, and consistent with a calculated $V_2$ of 104 kt. The aircraft started to drift to the left immediately after lift-off, but began to correct back towards the runway centreline before the upwind threshold was passed. However, at about 630 m past the upwind end of the runway (2.0 nm from the 'ISX' Distance Measuring Equipment (DME), which was zero ranged to the runway threshold), the aircraft started to drift left again, and from that point flew an almost steady track of 215º. The aircraft levelled at 3,000 ft at 2.4 DME, after which groundspeed began to increase. At the 2.9 DME turn point, the aircraft was heading 225º, tracking 10º left of the centreline and displaced from it by 0.25 nm to the left (south of the centreline).

The IAS increased to between 220 and 230 kt. When the Stansted controller noticed the aircraft was not flying in accordance with the SID, he instructed the crew to turn right to a heading of 360º. The co-pilot acknowledged the instruction, adding "WE'VE GOT A SYSTEMS PROBLEM, WE'RE JUST TRYING TO RESOLVE IT". The turn commenced at 6.4 DME, during which IAS reduced to about 195 kt. When the turn was complete, the aircraft maintained a steady track consistent with a heading of 360º and IAS continued to reduce to about 180 kt. The measured turn rate was 1.824º/sec, equivalent to a rate 0.61 turn. The bank angle required to achieve this turn performance under steady state conditions would have been 17.9º.

The co-pilot transmitted "WE DO SEEM TO HAVE A MAJOR PROBLEM HERE WITH THE FLIGHT CONTROLS, WE WOULD LIKE RADAR VECTORS TO RETURN TO THE FIELD PLEASE". The controller asked if the crew would be able to make a normal approach and the co-pilot said "AFFIRM…NOT A PROBLEM AT THE MOMENT…" When the controller then requested the nature of the problem, the co-pilot replied "…SEEM TO HAVE REDUCED CONTROL IN BOTH AILERON AND RUDDER AT MOMENT BUT WE CAN'T IDENTIFY THE PROBLEM". The controller asked if the crew were declaring an emergency to which the co-pilot declared "NEGATIVE AT THIS TIME". However, after further discussion between the crew about the advisability of declaring an emergency, the co-pilot transmitted "…OUR PROBLEMS SEEM TO BE INCREASING, WE ARE NOW DECLARING AN EMERGENCY".

The crew were instructed to turn right onto 040º. After rolling out of the turn, the aircraft achieved a steady track of 050°, consistent with the heading. A rate of 2º/sec (rate 0.67) was achieved during the turn, which would have required an average bank angle of 19.5º. Following further ATC instructions to turn left to 030º, the aircraft stabilised on a track of 043º. At this point the aircraft had 9º right drift and the IAS had reduced to about 175 kt.

Initially, the turn rate towards finals was noticeably lower and the aircraft flew through the runway centreline. About 40 seconds after starting the turn, the aircraft started a descent to 2,000 ft on ATC instruction. IAS during the initial turn and descent showed an increase, and averaged about 205 kt, with groundspeed reaching between 220 and 230 kt. Between the point that the aircraft turned right from the downwind track and when it levelled at 2,000 ft, the achieved turn rate was only about 1.1º/sec, or rate 0.37, equivalent to about 12º angle of bank in steady conditions.

Accurate IAS values for the remainder of the turn onto finals were difficult to establish. Aircraft IAS appears to have stabilised about 190 kt, with a reduction starting as the aircraft turned through a south-westerly heading (the groundspeed fell more rapidly than the change of relative wind alone would account for). During this period the turn rate increased significantly. Assuming an IAS range of 160 kt to 190 kt, the required bank angle would have been between 19º and 23º. The aircraft stabilised on a heading 35º right of the runway QDM, with an IAS of about 160 kt.

At about 7 nm from touchdown the crew received landing clearance. The radar-derived approach profile is shown at Figure 5. At 5.5 nm from touchdown, ATC instructed the crew to turn left onto 250º, to descend to 1,700 ft altitude and either report established on the localiser or call "visual". The co-pilot reported established and the controller cleared the crew to descend on the ILS. However, the aircraft descended below 1,700 ft before reaching the glideslope and was about 300 ft to 400 ft below it at 4 nm. At about 3.5 nm from touchdown the aircraft started to deviate further below the glideslope until it levelled at about 500 ft above airfield level (aal). It then descended further to about 300 ft aal which it maintained until intercepting the normal approach path at about 1 nm from touchdown.

At about 2 nm from touchdown there was a significant speed reduction below about 160 kt which, from the pilots' reports, would be coincident with the selection of flap 15. Wind reports from ATC showed a fairly steady surface wind from 240º at 16 to 18 kt. After landing, ATC asked if the crew were able to vacate the runway normally. The co-pilot replied "AFFIRM, FULL CONTROL ON THE GROUND".

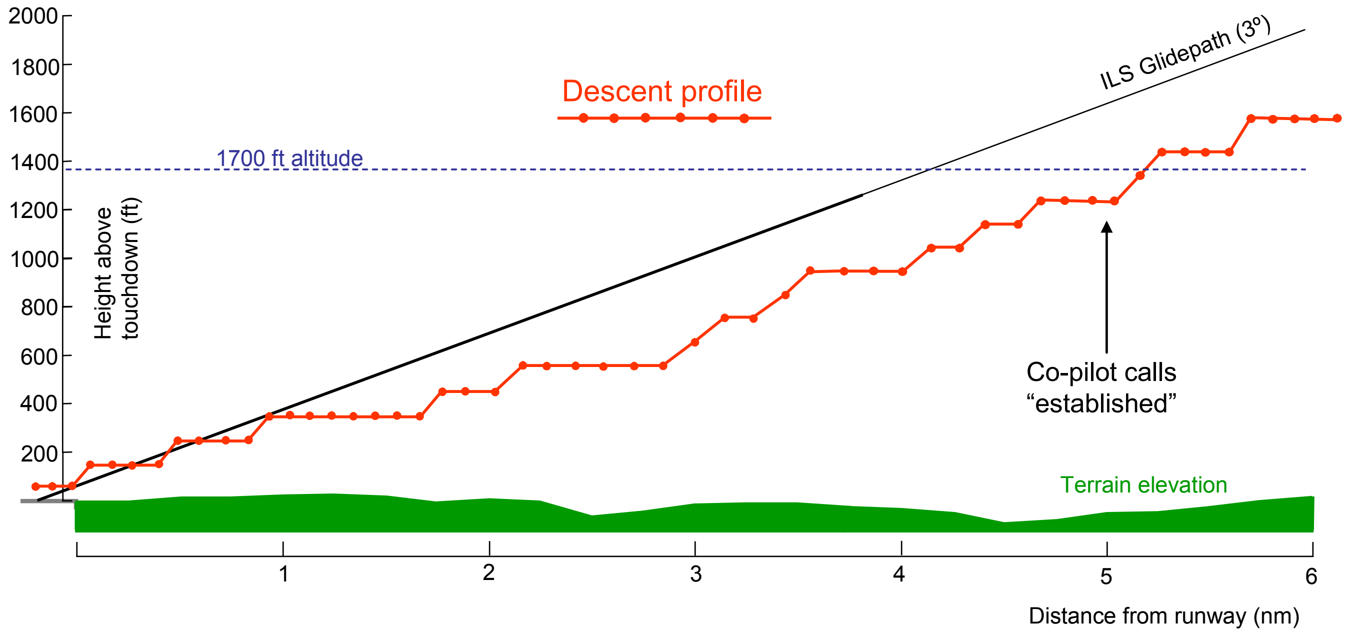



**Figure 5**

Final approach

## Flight recorders

*General*

The aircraft was equipped with a Flight Data Recorder (FDR) and a Cockpit Voice Recorder (CVR), capable of recording a minimum duration of 25 hours of data and 30 minutes of audio respectively. In addition, the aircraft was equipped with a Quick Access Recorder (QAR), which would record the same data as that recorded by the FDR. The FDR system recorded a total of 58 parameters which included the position of the rudder, lateral acceleration and the left aileron position. Sampling rates for both the rudder and left aileron position were four per second. The rudder pedal and control wheel positions were not recorded. A plot of the salient FDR parameters is at Figure 6.

The FDR and CVR were removed from the aircraft and replayed at the AAIB. The incident flight, from 'before takeoff' checks to final aircraft shutdown, was available from the CVR. When the FDR was replayed, it was found that only two minutes of the flight had been recorded. Further analysis identified that the 25 hours of data consisted of only partial sections of flight. The operator subsequently replayed the QAR media, but it was found to contain no data. A mechanical fault was later identified with the QAR unit, preventing the media from being correctly inserted.

*FDR information*

Reliable FDR data became available about 40 seconds after takeoff, as the aircraft was climbing through 1,500 ft, configured with 15° flap, landing gear retracted and the autopilot not engaged. Engine torques and propeller speeds on both engines were stable and power was set at the climb setting. Indicated airspeed was 115 kt. Lateral and vertical accelerations confirmed the turbulent conditions reported by the crew.

During the two minutes of FDR data, significant rudder travel and lateral control inputs were recorded. Soon after the data began, the rudder (which had been displaced to the left) moved right through 11.6º of travel (about 20% of its range), to 6.8º right deflection (Figure 6, Point A), the maximum recorded. Simultaneously, a left roll input was made, and the aircraft reached 6º right bank, also the maximum achieved during the recorded period (Figure 6, Point A). The greatest recorded aileron deflection during the period was 4.5º. The maximum possible surface deflections for the rudder and aileron were +/-30º and +/-14º respectively. At aileron deflections greater than 2.5º the wing spoilers would begin to deploy on the down-going wing.

The next three oscillations shared similar characteristics of rudder motion and lateral control input. On each occasion the rudder moved rapidly from its right deflected position to the left (maximum travel was nearly 13º), in one second or less, accompanied by an opposite roll control input over the same duration. The rudder then returned to the right at a slightly lower rate, with a similarly slower roll input. The period of these oscillations was between 4.3 and 5 seconds.

The applied lateral control input did not always appear to be in response to aircraft rolling motion, particularly during the most significant recorded oscillations. From Point A, the rapid reversal of roll input to the right was initiated when the aircraft was both banked slightly to the right and rolling to the right, a situation repeated during the next oscillation. The initial right bank coincided with the correction back to the runway centreline, after the aircraft drifted left just after lift off. The subsequent left bank resulted in the aircraft stabilising about a mean heading of 225º, which was also the runway heading, and consistent with the ground track seen on radar.

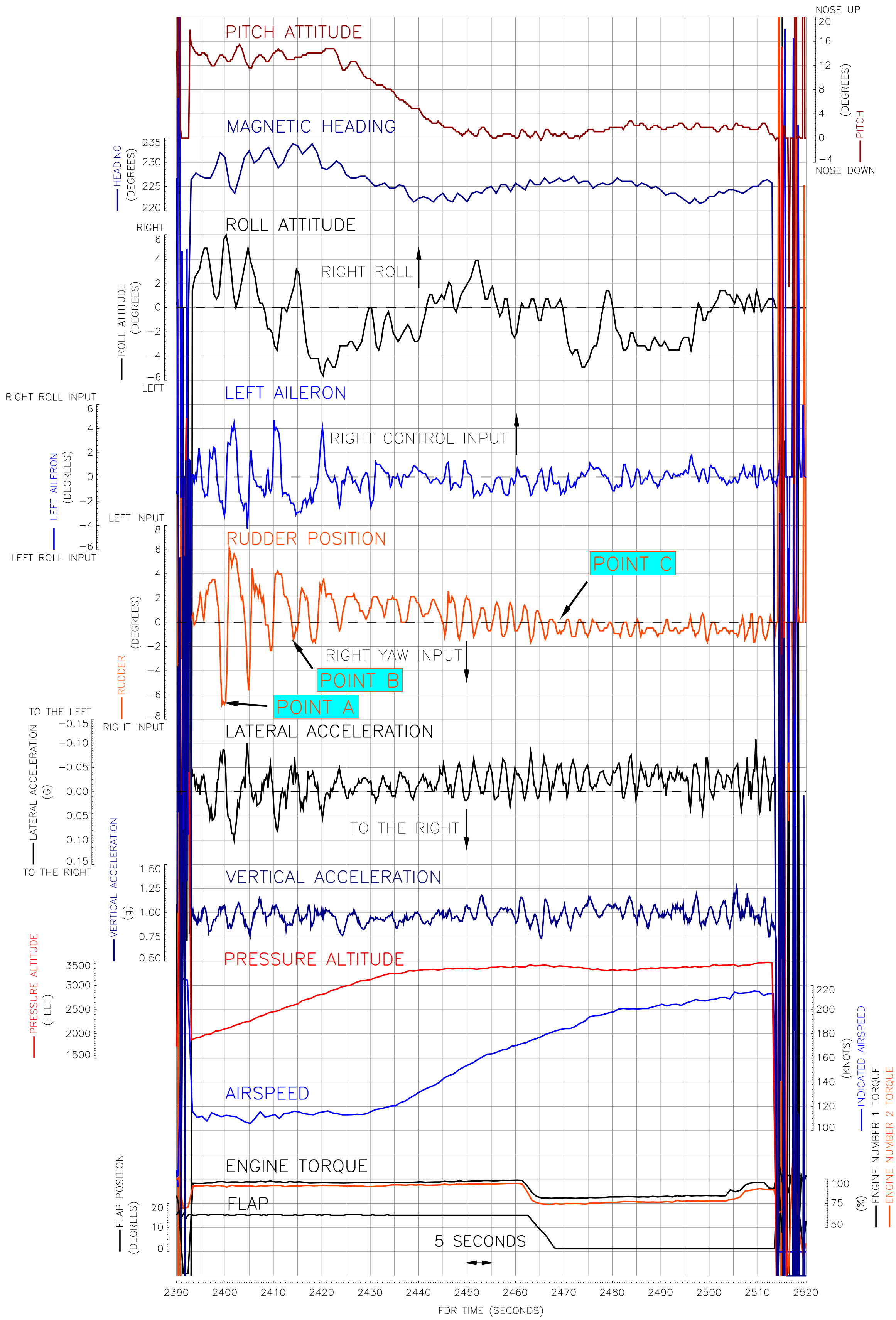



**Figure 6**

Salient FDR parameters

The oscillation starting at Point B differed from the previous three in that the left roll input was maintained whilst the rudder moved through a similar motion, though with reduced amplitude. On the next oscillation a roll input similar to the earlier oscillations was made, and the rudder travel increased slightly again. A further series of oscillations, with much reduced rudder travel and lateral input, was seen as speed increased with flaps still extended, just before engine power was reduced and flaps retracted (Point C). At this point there was an almost coincident reduction in the magnitude of the rudder oscillations. For most of the remainder of the recording, rudder position movement was small and appeared related to the background turbulence.

*CVR information*

The CVR recorded the 'before takeoff' checklist and responses, during which the commander confirmed that the flying controls had been checked and the rudder cam was centred. The takeoff phase sounded normal until just after the landing gear was raised, when the commander noted that the heading reference bug was incorrectly set and asked the co-pilot to reset it. Nineteen seconds after the co-pilot's "ROTATE" call, the commander said "WHY IS THE AIRCRAFT GOING LIKE THAT?" Three seconds later, a caution chime was heard and the co-pilot said "YAW DAMPER'S DISENGAGED FOR SOME REASON". The commander replied "YEAH AND THE AIRCRAFT IS GOING FROM SIDE TO SIDE". Ten seconds later, just before the FDR data starts, the co-pilot said "AFCS INVALID". Just after Point A at Figure 6, the commander said "THE AIRCRAFT IS TURNING FROM SIDE TO SIDE". Before the aircraft levelled at 3,000 ft, the co-pilot attempted to engage the yaw damper again. A further audio chime was heard and the co-pilot said "NO IT JUST SAYS AFCS INVALID". When the motion had subsided, 23 seconds before the end of available FDR data, the commander said "ITS ROCKING BUT THAT'S PROBABLY BECAUSE OF THE YAW DAMPER ISN'T IT?" and the co-pilot agreed.

During initial radar vectoring, the commander said "I MEAN WE JUST HAD NO CONTROL WHATSOEVER." The co-pilot said "IT'S JUST THE YAW DAMPER" to which the commander replied "BUT IT'S JUST - THE AIRCRAFT IS IMPOSSIBLE TO CONTROL". Five minutes after takeoff, as the aircraft was flying downwind, the commander commented "IT'S CALMING DOWN A BIT … BUT IT WAS COMPLETELY OUT OF CONTROL". Although the co-pilot indicated on the R/T that the problem was worsening when he formally declared an emergency, the CVR suggested this was not the case. It was done after the crew discussed it and agreed that it was the correct course of action.

During the right turn towards final approach, the commander seemed unsure if the aircraft was actually turning. She asked the co-pilot "AM I TURNING NOW?". He replied "SLOWLY" then "YEAH, YOU'RE NOT TURNING", then a short while later "OK YOU'RE IN THE BANK NOW THAT'S FINE". Later, as the aircraft was being vectored for the approach the commander initiated a discussion about whether the problem could be due to abnormal propeller pitch. Although the co-pilot observed that there had been no unusual engine or propeller indications, the commander became convinced that a propeller pitch problem existed, and continued to refer to it until after landing.

The co-pilot became visual with the runway about 6 nm from touchdown, but the commander did not see it until later when the co-pilot was able to 'talk' her eyes on to it. The co-pilot warned her about the aircraft's height and speed when it began to deviate, and the commander asked him to assist by controlling the power levers as she was again finding it increasingly hard to control the aircraft. After a brief discussion, it was decided to land with a reduced flap setting.

During the approach the Enhanced Ground Proximity Warning System (EGPWS) Mode 5 "GLIDEPATH" alert sounded. In the latter stages of the approach the co-pilot warned "WATCH YOUR HEIGHT", just before the EGPWS 500 ft height call-out occurred, followed immediately by the 'landing gear not down' aural warning and the EGPWS Mode 4 "TOO LOW FLAPS" alert call-out. Co-incident with this, the co-pilot announced that he was lowering the landing gear, and also selected Flap 15. He again warned the commander "KEEP YOUR HEIGHT" (Figure 5 shows that the aircraft levelled at about 500 ft for a time). The co-pilot announced that the landing checklist had not been completed, but confirmed to the commander that the landing gear and flaps were correctly set. The EGPWS "TOO LOW FLAPS" and "GLIDEPATH" alerts continued until touchdown.

Only a single CCAS audio chime was heard which could not be related to a known event. This occurred when the aircraft was nearing final approach, but neither pilot was heard to comment on it.

*CVR – Crew Resource Management (CRM) aspects*

The event had a significant adverse impact on standard flight procedures and CRM. Although each pilot referred at different times to the problem being associated with the yaw damper's failure to engage, there was no formal troubleshooting or review process, so the Quick Reference Handbook (QRH) was not consulted. There was no briefing for the approach, and no descent, approach or landing checklists were carried out. Although the approach culminated in a reduced flap landing, because this was a late decision the implications were not fully considered beforehand, resulting in the EGPWS flap warning. However, despite the obvious distraction, the crew collectively identified the flight path excursions on final approach (although the actual correction was quite late) and were able to work together in the latter stages when the commander asked for assistance with the engine controls.

## Dutch roll

When an aircraft is yawed, it also rolls. This is because of the different airspeeds experienced by each wing, and the consequential imbalance in generated lift. A Dutch roll is a combination of yaw and roll in which the aircraft experiences a continually reversing yawing/rolling motion. The relationship between an aircraft's lateral and directional qualities determine how susceptible it will be to Dutch roll. An aircraft with dominant directional stability will tend to be spirally unstable, while an aircraft with excessive lateral stability will have a greater tendency to Dutch roll. Dutch roll is normally associated with swept wing aircraft (whose tendency to roll with yaw is greater than for comparable straight wing aircraft) and high altitude flight, where aerodynamic damping is reduced.

Whilst a stable or even neutral Dutch rolling tendency need not present a significant challenge to a pilot, assistance is normally required to prevent the task of piloting such an aircraft from becoming too demanding or tiresome with time. A Dutch rolling tendency usually results from a lack of effective fin and rudder area. If the rudder is allowed to trail downwind in a sideslip, the effectiveness of the fin is reduced and hence the aircraft will be more likely to Dutch roll. In the case of a hydraulically powered rudder, the rudder does not trail downwind in a sideslip, thus increasing the fin's effectiveness. Alternatively, or additionally, a yaw damper can be used to sense developing yaw and apply a corrective rudder input.

The ATR 42 is equipped with a yaw damper. However, as the rudder is not hydraulically powered, it would be prone to trail downwind to some degree if the aircraft were to experience side-slip (thus reducing directional stability) when the yaw damper was not engaged. The RCU is intended to increase the aircraft's resistance to Dutch roll, in this case by keeping the rudder centred about the trimmed position until a threshold force is applied by the pilot to move the rudder. If the RCU fails, or its centred position differs significantly from the aerodynamically trimmed position, the benefits provided by the RCU in terms of directional stability will be lost. In this case, the situation can only be restored if the pilot exercises positive and continuous control through the rudder pedals to ensure that the rudder does not move from its desired, trimmed position.

**Certification flight tests**

During certification flight tests of the ATR 42, the aircraft's Dutch roll characteristics following simulated RCU failures were demonstrated at altitudes between 7,000 ft and 10,000 ft. The failures considered were a) yaw threshold loss (ie permanent failure of the RCU clutch to engage), and b) rudder threshold centring loss about the trimmed position (ie RCU centred about a position other than the trimmed one).

In both cases the test report noted that Dutch roll could easily be stopped by *'locking the (rudder) pedals with the feet or engaging the yaw damper'*. Both failure cases were classified as 'minor'. Figure 7 depicts, in simplified form, a Dutch roll-induced during flight test with both the yaw damper and RCU disengaged. This is overlaid with the data from the incident flight to allow a direct comparison.

At a meeting between the AAIB and the manufacturer, a flight test department representative described the aircraft's handling qualities in respect of its natural Dutch roll tendency and behaviour in RCU failure cases. It was stated that the ATR 42 will not naturally enter a Dutch roll, which had to be induced and aggravated during test

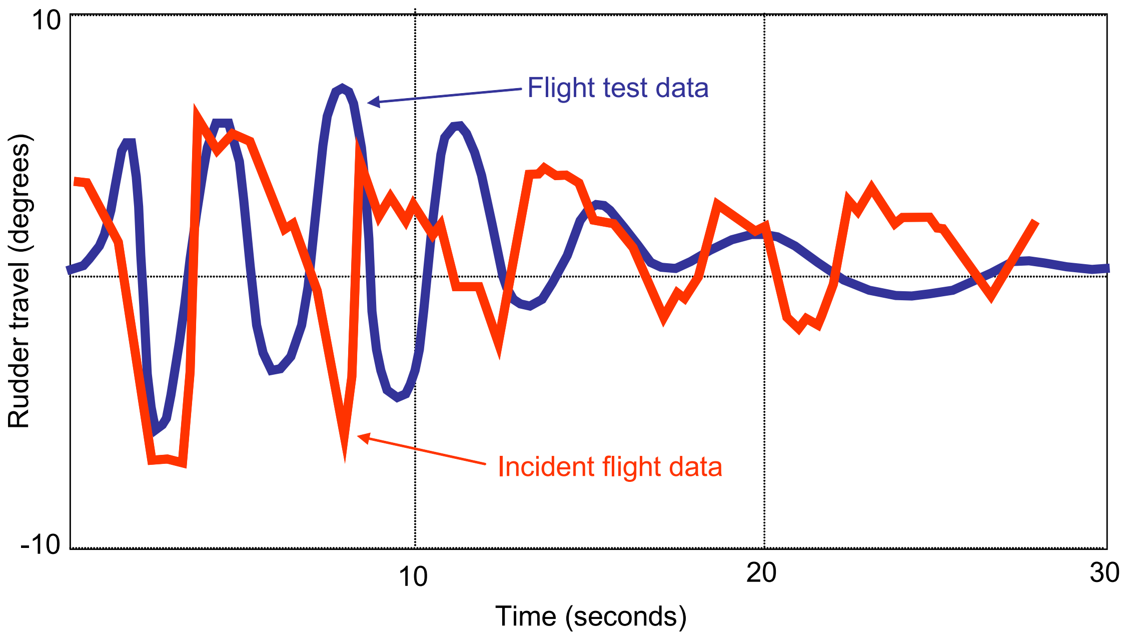



**Figure 7**

Incident FDR plot overlaid on flight test Dutch roll data flights by positive application of rudder. The Dutch roll motion was more pronounced at aft centres of gravity and with full flap selected, particularly approaching the flap limiting airspeed. However, takeoff flap was not considered to have a significant effect.

The RCU was described as being required only to stop minor yaw oscillations involving small rudder deflections. If the RCU was not correctly centred about the rudder trimmed position for takeoff, it would not significantly affect the aircraft's handling; the test certification paperwork stated that many takeoffs had been made in this condition without a problem, and that Dutch roll, when it appeared, was easily stopped by the actions described above.

Although the observed motion bore some similarities to a Dutch roll, it was not the same. In particular, the uneven and high rates of rudder travel were not natural motions, and the frequency was different. Although coarse use of roll control (involving activation of wing spoilers) would induce yaw, it was considered that the only way in which the rudder could move in the way it did was though the direct assistance of the spring tab, ie by pilot application. It was stressed that the rudder damper also operates during flight, so always acts to limit the rate of rudder travel.

**Information to flight crews**

A Flight Crew Operating Manual (FCOM) was produced by the aircraft manufacturer and contained information, guidance and procedures for flight crews. Concerning the yaw control system, the FCOM contained four relevant sections: a technical description of the system, a *'procedures and techniques'* section, a *'normal procedures'* section (which included pre-flight system checks), and procedures to be followed in the event of system failures.

The *'procedures and techniques'* section described the purpose and normal use of system features. Concerning the RCU it stated:

> *'The threshold cam automatically synchronises to actual rudder pedal position each time the rudder trim switch is activated. Therefore, before take-off, the rudder trim setting must be made with rudder pedals in neutral position'*

and:

> *'As far as Dutch roll is concerned, yaw damper action (if selected) or RCU are sufficient to adequately dampen Dutch roll oscillations. The rudder should not be used to complement yaw damper action'*

The operator produced its own Standard Operating Procedures (SOPs), based upon those contained within manufacturer's FCOM. They described the before-takeoff check of the rudder and RCU thus:

> *'**CM1**[1] checks full and free rudder movement, left spoiler if visible, and with rudder neutral, centres the rudder cam'*

The FCOM *'Procedures following failure'* section detailed the crew action for an RCU failure in the format shown in Figure 8.

The FCOM also contained a procedure with the title *'AILERON MISTRIM MESSAGE, or EXCESSIVE LATERAL TRIM REQUIRED or ABNORMAL FLIGHT CHARACTERISTICS OF THE AIRPLANE'*. Although one of the conditions for initiating the drill was

**Footnote**

[1] CM1 – left seat pilot and normally the commander, as in this case.

**<u>RUD RELEASABLE CENT UNIT FAIL</u>**

**ALERT**

There is no indication of a rudder releasable centering unit failure other than a dutch roll oscillation tendency

**PROCEDURE**

| RUD RELEASABLE CENT UNIT FAIL | |
|---|---|
| ■ If YD is available | |
| YD ---------------------------------------- | ENGAGE |
| ■ If YD is not available | |
| KEEP THE FEET ON THE PEDALS | |

**Figure 8**

FCOM Procedure for RCU failure

'abnormal flight characteristics of the aircraft', the procedure addressed only lateral control problems. The associated actions were to disconnect the autopilot and fly the aircraft manually prior to adjusting lateral trim. There was no information concerning problems with yaw axis control.

Both of the above procedures were also contained within a Quick Reference Handbook (QRH), immediately available on the flight deck. However, the RCU failure drill in the QRH did *not* contain the alert statement:

> *'There is no indication of a rudder releasable centering unit failure other than a Dutch roll oscillation tendency.'*

The manufacturer's Master Minimum Equipment List (MMEL) allowed for aircraft dispatch with the RCU inoperative, provided that the yaw damper was operative and used or, if it was not, for a maximum of two flight legs. The related operational note for the latter case stated:

> *'If the yaw damper is inoperative, PF [pilot flying] will keep his feet on the pedals to be ready to control rudder.'*

**Previous occurrence**

The manufacturer was aware of only one other similar incident. This 1990 event occurred whilst the aircraft was making an approach to land when the yaw damper disengaged and could not be re-engaged until the AFCS computer had been re-set. During this period, the aircraft rolled ± 15°. The subsequent investigation revealed that a link attaching one of the springs within the RCU had failed.

**FDR system fault**

*System description*

The FDR system consists of three primary components; the FDR, a Flight Data Acquisition Unit (FDAU) and a Flight Data Entry panel (FDEP). The purpose of the FDAU is to acquire and process information from the various aircraft systems and sensors before transmitting data to the FDR to be recorded. On the ATR 42, the

FDAU also computes the engine target torque, which is displayed on the engine torque indicators on the flight deck. The FDEP is located in the flight deck, towards the rear of the centre instrument pedestal. Its primary purpose is to indicate the status of the FDR system. This is accomplished by illuminating two integral indicators if the FDR, FDAU or FDEP fail. As is common in most FDR installations, there is no associated aural warning or indication on the CCAS panel should the FDR system fail. A test of the system can be readily accomplished by activating a switch in the flight deck.

As well as each component part of the FDR system having a Built In Test (BIT) function, the system also incorporates a 'loop back' check of the aircraft wiring between the FDAU and FDR. In the event that data is sent to the FDR but not recorded, a fault will be indicated on the FDEP. Failure of the FDR to record may be due to electrical power loss, loss of the incoming data signal from the FDAU or an internal fault in the FDR itself. The FDEP fault indicators will remain illuminated for the period that a fault is detected, but will extinguish if the fault subsequently clears. The system does not provide a historical log of failures.

In normal operation, the FDR system is electrically powered prior to flight. The FDAU and FDEP are powered from a separate source through one relay. If, during normal operation, the FDAU/FDEP relay failed such that power was removed from the FDAU and FDEP, both units would stop functioning, rendering the FDR system inoperative. In this case, the FDEP fault indicators would not illuminate, as the status function would also be inoperative. However, the fault would result in the loss of the target torque parameter (provided by the FDAU). Both the aircraft manufacturer and operator advised that the loss of the parameter would be readily identifiable during normal operation of the aircraft.

*FDR system defect*

The FDEP fault indicators were confirmed as being serviceable and both the FDR and FDAU were replaced. The replacement FDR was a different model from the one installed at the time of the incident, recording data into a solid state memory rather than a magnetic tape. Shortly after the aircraft had returned to service, the operator performed a readout of the FDR which revealed that the defect was still present. The FDR was replaced again and the FDAU/FDEP electrical relay was also replaced; subsequent readouts of the FDR and QAR indicated that the fault was no longer present.

Although the fault cleared after the FDR was replaced a second time, it is unlikely that both the incident and first replacement FDRs were defective. The first replacement unit was of a different type from the FDR installed during the incident, making it unlikely to have developed a similar fault. As the replacement FDAU had not been further disturbed when the fault eventually cleared, it is probable that the FDAU installed at the time of the incident was also serviceable. If the FDAU/FDEP relay had failed, the loss of the target torque indication for a considerable period of time would probably have been detected by flight crews. No such loss of indication was reported. It was therefore unlikely that the system fault was due to a defective FDR, FDAU or FDAU/FDEP electrical relay.

The fault was most likely to have been a result of an intermittent electrical connection, which was resolved during the second FDR replacement. A loss of the data signal from the FDAU to the FDR, or FDR electrical power would have resulted in the FDR stopping. As it was unlikely that the FDAU/FDEP relay had been the cause of the defect, it can be assumed that a system fault indication on the FDEP would have been present. Based on the FDR data, a fault would have been indicated for prolonged periods of time during at least the previous 25 hours of aircraft operation, both on the ground and in flight. The operator advised there had been no associated reports of a FDR system defect prior to the incident. The last readout of the FDR had been performed in July 2005 and no defects were found.

*Regulatory requirements*

The readout requirement for EI-SLD had been set by the Irish Aviation Authority (IAA) at once every two years. However, some of the operator's other ATR 42 aircraft had readouts conducted at intervals of 12 months. The operator advised that the difference arose because the previous operator of these aircraft modified the recording systems and specified 12 month readouts for some of them. The operator has now aligned the fleet readout period at 12 months.

The Standards and Recommended Practices (SARPS) contained in ICAO Annex 6 Part I stated that an annual readout of the FDR should be performed and that a complete flight from the FDR should be examined in engineering units to evaluate the validity of all recorded parameters. JAR-OPS 1[2] provided for the preservation of FDR recordings but it did not include a requirement to perform a routine readout of the FDR. This differed from JAR-OPS 3 (applicable to helicopters) which did include a requirement to readout the FDR within the last 12 months.

On 1 October 2007, the AAIB issued the following Safety Recommendation in response to FDR deficiencies identified during the investigation of a runway overrun accident involving a Fairchild SA277 AC Metro III, registration EC-JCU:

**Safety Recommendation 2007-60**

It is recommended that the European Aviation Safety Agency require operators to conduct an annual operational check and evaluation of recordings from FDRs to ensure the continued serviceability of the system. The annual check should require, as a minimum, a readout of the FDR and an evaluation of the data, in engineering units, in order to establish compliance with recording duration, error rates and validity of all recorded parameters.

The European Aviation Safety Agency (EASA) responded on 14 November 2007 stating that:

*'Consideration is given as to making these provisions part of the relevant European regulations.'*

The status was identified as 'open' by EASA, and remains so at the time of writing.

In addition to the annual readout, ICAO Annex 6 Part I addressed the requirement for a routine check of the FDR system Built-in-Test (BIT) thus:

*'Prior to the first flight of the day, the built-in test features on the flight deck for the CVR, FDR and Flight Data Acquisition Unit (FDAU), when installed, should be monitored.'*

JAR-OPS 1 partially addressed this requirement, referring operators to EUROCAE document ED55 for the FDR check, but the applicability was only for aircraft first issued with a Certificate of Airworthiness (C of A) after 1 April 1998. The C of A for EI-SLD was first issued in 1985. It should be noted that JAR-OPS 1 was compliant with ICAO with regards to a requirement for a daily check of the CVR when one is fitted.

**Footnote**

[2] JAR-OPS contains the operational requirements for European Joint Aviation Authorities operators engaged in Commercial Air Transport operations.

The operator carried out a Flight Data Monitoring (FDM) programme on its ATR 42 fleet, supported by data from the QAR. The FDM programme was performed on a voluntary basis as the aircraft was less than the 27,000 kg mass limit specified by JAR-OPS 1. The last available QAR data was from 11 October 2006. Data from between 2004 and 2006 was analysed, with no evidence of a recording defect.

**Analysis**

*General*

The limited FDR data supported the crew's reports that the aircraft was subject to an unusual motion which combined yaw and roll, and which varied in severity throughout the flight. However, the recorded data as a whole suggested that there was more flight path control available than the crew perceived or recalled. It is not certain that the recorded oscillations were representative of the motion at its most severe, but the crew's remarks on the CVR during the FDR data period suggest that it was.

The motion was clearly such that it interfered with the crew's ability to manage the flight and to troubleshoot the problem. It ultimately resulted in an unstable final approach which generated EGPWS warnings. Although the aircraft's behaviour caused the crew the most concern, its contribution to the unstable final approach must be seen as the most significant aspect of the incident.

*Crew recollections*

Some of the co-pilot's responses to ATC and the delay in declaring an emergency were at variance with the commander's comments about the aircraft being out of control, although both pilots were in agreement that the motion was very uncomfortable. The commander recalled that the aircraft could only just be made to turn right with full right lateral control, but this was not supported by the recorded data. The FDR data showed that the aircraft was capable of responding to lateral control input, but that the input itself was reversing relatively quickly from one direction to another, apparently in direct opposition to the yawing motion. The aircraft's heading during the recording period stabilised on the runway heading, which was maintained without significant lateral inputs. The aircraft therefore drifted left of the departure track not because of restricted control authority, but because the heading did not take into account the effect of the wind.

The turn rates seen on radar (which were nearly all to the right), were generally equivalent to moderate angles of bank. The notable exception was the initial turn towards finals, but the CVR data suggested that the angle of bank increased in response to the co-pilot's remarks, so it is more likely that this was due to pilot input rather than reduced control authority. This was at the same time as a descent was starting which, given the degree of control difficulties the commander reported, could have lead to an inadvertent reduction in turn rate as she concentrated on the vertical flightpath. The aircraft was flying at a relatively high groundspeed at this stage which, combined with the effect of the wind, meant that any prolonged reduction in applied bank would have caused the aircraft to fly through the runway centreline, as occurred.

After the flight, both pilots said that they had assumed they were dealing with a rudder problem but, apart from brief references to the yaw damper soon after takeoff, neither voiced this during the flight. In the case of unusual control problems it may be desirable to hand over control of the aircraft for a while when safe to do so, to gain the second pilot's view of the problem which could assist with troubleshooting. This action has the added advantage that, if the handling pilot is inadvertently influencing the situation, this may be detected. As the co-pilot did not handle the controls in this case, his perception of the problem must have been influenced by the commander's description.

*Aircraft oscillations*

The co-pilot recalled that the yaw damper would not engage after takeoff, and on the CVR stated that the yaw damper had "…DISENGAGED FOR SOME REASON", a remark accompanied by an audio chime. This was after the commander had made her initial comments about the aircraft's motion, so it is uncertain whether the yaw damper engaged for a short while only or not at all. Initial selection of the yaw damper may have been delayed whilst the co-pilot reset the heading reference bug at the commander's request. If this had been the case, and the yawing motion had become established before the yaw damper selection was made, there could have been erroneous or inconsistent air data inputs to the AFCS computer, which would account for the AFCS INVALID message and failure of the yaw damper to engage. Rudder movement alone would not have inhibited yaw damper engagement, unless it was associated with high pedal forces.

An RCU fault could have contributed to the motion, although no significant defects were found with the unit and there had been no similar events involving this aircraft reported beforehand. Although thought unlikely by the manufacturer, the oxidation that had occurred within the RCU electrical connector could possibly have caused a failure of the RCU clutch to release when commanded by a trim or yaw damper command. However, as the RCU clutch would normally be engaged during initial climb out anyway, it is unlikely that this was a contributory factor, provided the RCU was centred correctly.

Had the RCU *not* been correctly centred prior to takeoff, the benefits in terms of Dutch roll stabilisation afforded by it would have been lost or reduced, depending on how far the actual RCU datum was from the aerodynamically trimmed position. The commander correctly replied to the before-takeoff checklist item so it must be assumed the check was carried out correctly. However, if the RCU clutch had failed in a permanently engaged state sometime before this, the checklist actions would not have been effective and the RCU would have remained at whatever datum it had adopted beforehand, which may not have been appropriate for takeoff.

If this was the case, it would have introduced a continuous centring force towards a non-trimmed position as well as reducing the aircraft's resistance to Dutch roll. The fact that positive rudder inputs would have been required during the slightly crosswind takeoff roll may have masked this until the aircraft was airborne. A failure of the clutch to disengage when commanded would also account for the failure of the yaw damper to engage.

At the altitudes, configurations and airspeeds concerned in this incident, the aircraft would not have had a significant natural Dutch roll tendency. Certification flight tests had been conducted at higher altitudes where Dutch roll was more likely and had shown that the aircraft would readily recover once appropriate action was taken by the pilot. Any failure of the RCU would not have caused the motion if the commander had taken the action of preventing rudder pedal movement by firmly placing her feet on the rudder pedals, although this was not adequately described in the flight manuals. Had she left the pedals free, and a Dutch roll had developed, it would not have generated the rudder movement seen on the FDR data, although coarse lateral control inputs would have produced a secondary yaw effect.

If the aircraft had become airborne in a slight slip (as it would for a crosswind takeoff), with the RCU not centred and in turbulent conditions, it is conceivable that these conditions would have initiated yaw oscillations before the co-pilot was able to engage the yaw damper (which he may not have attempted immediately due to the commander's instruction to reset the heading bug). However, the subsequent rate and amount of rudder movement (which were not natural and were unlike that seen during certification flight tests) could only have been generated by the servo tab. Given that the rudder control system was examined and found serviceable after landing, the driving force could only have been supplied by one of the pilots. It is therefore likely that the motion was due, at least in part, to a pilot-induced oscillation (PIO).

*Prevention and recovery actions*

With the widespread use of reliable and sophisticated yaw dampers on modern aircraft, Dutch roll has become a phenomenon which is possibly less well understood by today's flight crews than those of earlier generation transport aircraft. Thus, it is important that correct information is available to crews and that they be aware of the correct recovery actions should the protection afforded by modern aids be lost. Although the purpose of the yaw damper is likely to be well understood by flight crews, that of the RCU may not. RCU failure cases were regarded by the manufacturer as 'minor', and so not the subject of detailed training.

Although the flight test report stated that Dutch roll could be easily stopped by *'locking the pedals with the feet',* this advice did not appear in any of the normal flight operations or training documentation. The RCU failure actions merely stated 'KEEP FEET ON THE PEDALS', which did not adequately describe the full corrective action. In flight, crews would normally refer to the QRH in abnormal or failure situations. An average crew, dealing with an unusual aircraft motion would be most likely to consult the lengthily titled QRH item *'AILERON MISTRIM MESSAGE, or EXCESSIVE LATERAL TRIM REQUIRED or ABNORMAL FLIGHT CHARACTERISTICS OF THE AIRPLANE'.*

It was therefore recommended that:

**Safety Recommendation 2008-017**

ATR should amend the ATR 42 Quick Reference Handbook (QRH) and Flight Crew Operating Manual (and those of other ATR types if similarly affected), to include in the Releasable Centring Unit failure actions the requirement that pilots must lock the rudder pedals by the feet to prevent unwanted rudder pedal movement. The revised RCU failure actions should be incorporated (or referred to) in the QRH actions concerned with abnormal flight characteristics of the aircraft.

Aircraft dispatch with both the RCU and yaw damper inoperative was allowed under the provisions of the manufacturer's MMEL, although such operations were limited to two flight legs. This would be to enable an aircraft to be flown to a maintenance base for rectification. However, the operational note that the pilot keep his feet on the rudder pedals 'to be ready to control the rudder' did not reflect the actual requirement that the pilot should keep his feet firmly on the pedals and prevent unwanted rudder pedal movement. It was therefore recommended that:

**Safety Recommendation 2008-018**

ATR should amend the ATR 42 Master Minimum Equipment List (and that of other ATR types if similarly affected), for dispatch with both RCU and yaw damper inoperative, to more accurately describe the pilot action required to positively prevent unwanted rudder pedal movement.

*Final approach*

The crew made an early decision to return to Stansted, so there was not a great deal of time to diagnose the problem and prepare for the approach. Each pilot had made brief reference to the yaw damper (or lack of it) causing the motion, but there was no further discussion about the likely cause until on approach, and so the QRH was not referred to. The CVR showed that little preparation was carried out prior to the approach, although the co-pilot was heard to confirm that the navigation aids were correctly set. Although there had also been no discussion or briefing about the approach or landing configuration, it was agreed late in the flight that a reduced flap setting would be used.

The aircraft's vertical profile was satisfactory until just prior to the final approach, when the aircraft descended below 1,700 ft and below the glide slope. It is therefore likely that it was the commander's high workload at that point which affected her ability to accurately control the flightpath, despite the co-pilot prompting her to correct the deviation. She would have been aware that the aircraft and crew were not ideally prepared for the approach, and the uncertainty that still existed about the problem would have added to the stress of the situation. This was further compounded by the problems getting established on the localiser, and a perceived need to establish visual contact with the runway much sooner than was actually required.

As the aircraft descended though 1,000 ft aal, its flight path began to deviate further below the glideslope, until the co-pilot and EGPWS together warned of the low height. By this stage the commander had become convinced that the problem was due to a propeller pitch malfunction, which she continued to refer to until after landing, and which presented a further distraction at a critical phase of flight.

It is likely that the fatiguing and confusing nature of the motion, the short time available and the attempt to gain an early visual sighting of the runway contributed to the unstabilised approach. Although the crew had eventually decided to extend flaps at a relatively late stage, late selection of gear and the possibility of aggravating the motion so close to the ground was not discussed. It also left inadequate time to complete the landing checklist.

*Flight data recorder defect*

The absence of reliable FDR data for the whole flight hampered the investigation process. The IAA required the operator to carry out a readout of the FDR every two years. The ICAO Annex 6 requirement was for an annual readout, but there was no associated JAR-OPS 1 requirement. This deficiency was addressed by AAIB Safety Recommendation 2007-60. In reply, EASA agreed to give consideration to incorporating the provisions of the EUROCAE document (which met the ICAO requirements) into European regulations. At the time of writing, the EASA response was classed as 'open'.

It was therefore recommended that:

**Safety Recommendation 2008-019**

The European Aviation Safety Agency should, when considering AAIB Safety Recommendation 2007-60, include in its deliberations the FDR deficiency identified in this investigation and the adverse effect this had on the investigation process, with a view to expediting any remedial actions.

It is probable that the FDR system fault was present for some time, yet there was no requirement to monitor the FDR system BIT. Contrary to the SARPs contained in ICAO Annex 6, Part 1, no daily check of the CVR, FDR or Flight Data Acquisition Unit (FDAU) is required by JAR-OPS 1.

It was therefore recommended that:

**Safety Recommendation 2008-020**

The European Aviation Safety Agency should require that, prior to the first flight of the day, the built-in test features on the flight deck for the Cockpit Voice Recorder, Flight Data Recorder and Flight Data Acquisition Unit, when installed, should be monitored to ensure correct operation.

**Conclusion**

The cause of the aircraft's motion could not be positively identified, but it was not a natural motion and so must have been due, in part at least, to inappropriate control inputs by one of the pilots. It is possible that the RCU was not correctly centred on the trimmed, rudder-centred position before takeoff. An intermittent failure of the RCU clutch to disengage may have led to the aircraft taking off with the RCU incorrectly centred, which would have prevented yaw damper engagement as well as making the aircraft more prone to a Dutch roll-type oscillation.

At its worst, the motion was severe enough to significantly impair the crew's ability to operate and manage the aircraft. The crew considered an immediate landing to be the preferred option, though this reduced the time available to troubleshoot the problem and to prepare themselves and the aircraft for the approach. Ultimately this contributed to an unstable approach which generated unsafe configuration warnings.

**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)<br>Last 90 days - 118 hours<br>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.

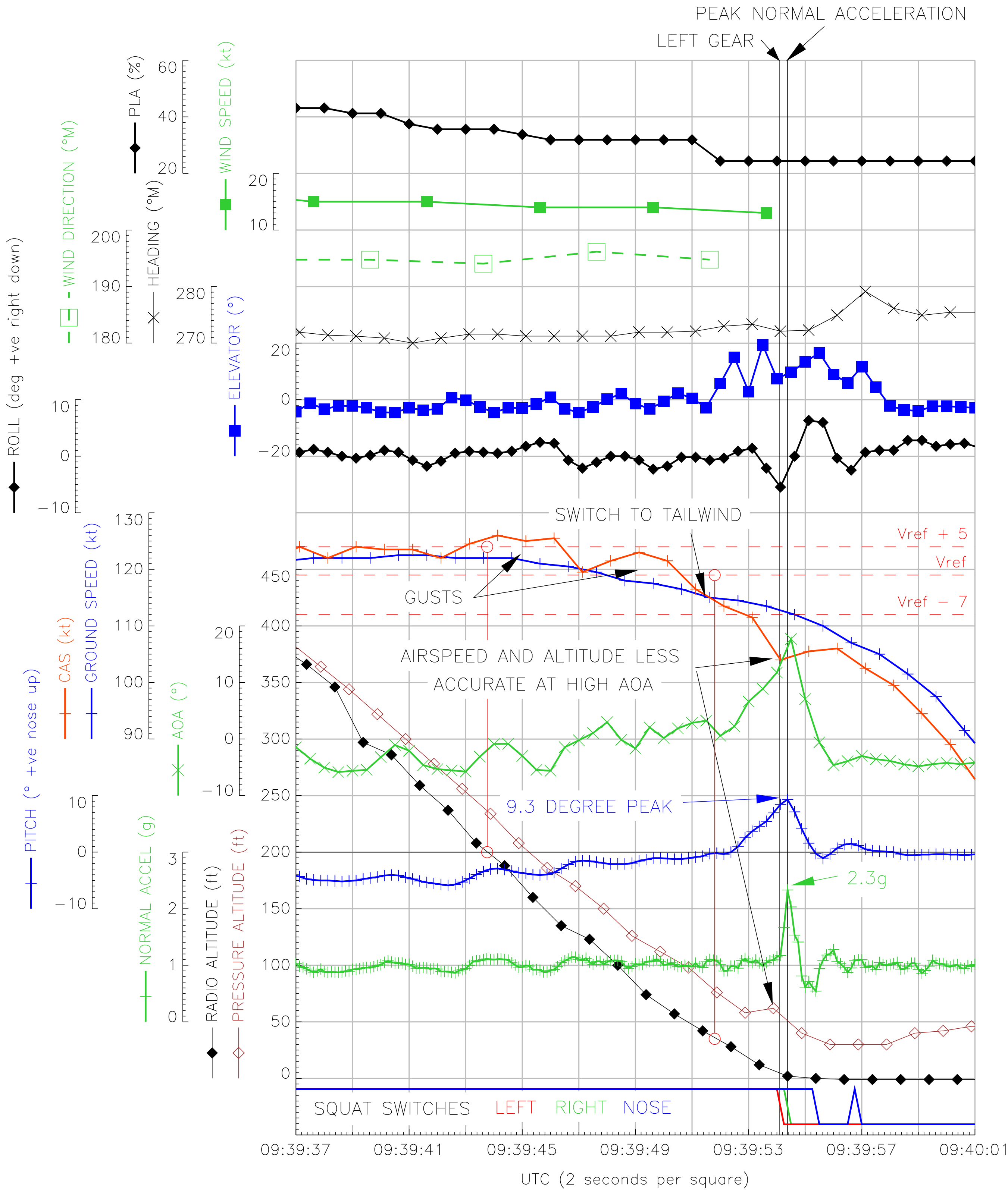



**Figure 1**

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.

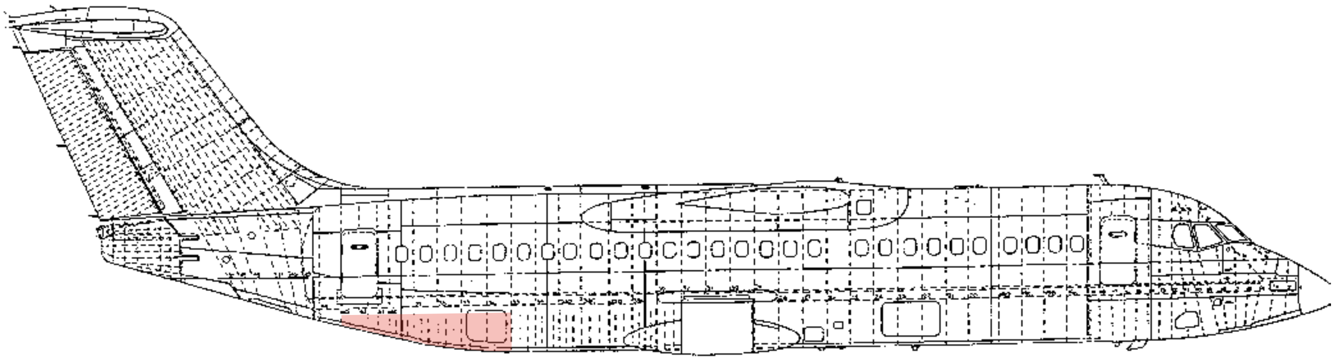


**Figure 2**
Area of damage to the lower fuselage

**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.

**INCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Boeing 747-4Q8, G-VHOT |
| **No & Type of Engines:** | 4 General Electric CF6-80C2B1F turbofan engines |
| **Year of Manufacture:** | 1994 |
| **Date & Time (UTC):** | 7 December 2006 at 1445 hrs |
| **Location:** | London Heathrow Airport |
| **Type of Flight:** | Commercial Air Transport (Passenger) |
| **Persons on Board:** | Crew - 20 Passengers - 386 |
| **Injuries:** | Crew - None Passengers - None |
| **Nature of Damage:** | None |
| **Commander's Licence:** | Airline Transport Pilot's Licence |
| **Commander's Age:** | 50 years |
| **Commander's Flying Experience:** | 11,750 hours (of which 750 were on type)<br>Last 90 days - 133 hours<br>Last 28 days - 49 hours |
| **Information Source:** | AAIB Field Investigation |

**Synopsis**

Taking off from London Heathrow, both stick shakers began to operate continuously shortly before $V_1$. The commander elected to continue the takeoff and, after a period of troubleshooting in the air, dumped fuel and returned to land at Heathrow. Maintenance engineers consulted the aircraft BITE (Built-In Test Equipment) and replaced the right-hand ADC (Air Data Computer). The subsequent takeoff proceeded normally until approximately 5 kt before $V_1$, when the stick shakers again began to operate. The commander immediately rejected the takeoff and the aircraft was stopped safely approximately two-thirds of the way along the runway. There was no damage or injury.

This report includes a number of Safety Actions implemented by the operator and the aircraft manufacturer.

**History of the flight**

The flight crew reported for duty at 1230 hrs for a flight to New York, and made normal pre-flight preparations. The co-pilot was to be Pilot Flying for the sector. Prior to departure, the flight crew received the Heathrow departure ATIS[1] which reported that the surface wind was from 240° at 21 kt gusting to 31 kt, visibility was

**Footnote**

[1] Automatic Terminal Information Service, a recorded broadcast of pertinent information including weather conditions, runway in use, etc.

in excess of 10 km, there were one or two octas of cloud at 3,400 ft above the aerodrome, and three or four octas at 4,500 ft. The temperature was 11°C and the dewpoint 6°C, and the QNH was 986 mb.

The flight boarded normally and the pushback, startup, and taxi towards Runway 27R were uneventful. The aircraft was loaded with 386 passengers and their bags, 2 flight crew and 18 cabin crew, and 88,200 kg of fuel, making the takeoff mass 325,623 kg. The takeoff speeds were calculated as $V_1$ 146 kt; $V_R$ 156 kt; $V_2$ 165 kt.

The aircraft lined up on the runway and was cleared for takeoff. The commander then assumed responsibility for the thrust levers, in accordance with the company's SOPs (Standard Operating Procedures), and advanced the levers for takeoff. At 80 kt, the flight crew compared the airspeed indications on the PFDs (Primary Flight Displays) and the Standby Airspeed Indicator, which were in agreement.

Shortly before $V_1$, both stick shakers began to operate continuously. The commander later described this as "extremely distracting" but stated that the warning appeared to be spurious. He elected to continue the takeoff, with the intention of dealing with the problem in the air. Throughout the initial climb, the commander verified that the aircraft's speed, attitude and thrust were correct, and he concluded that he had been correct in his initial analysis: the warning was not a genuine indication of the aircraft's approaching an unacceptably high angle of attack.

The co-pilot continued to fly the aircraft and in due course engaged the autopilot in the normal way. The co-pilot then accepted responsibility for radio communications with ATC, in order to enable the commander to devote his full attention to analysing the situation. The commander looked for the stick shaker circuit breakers on the overhead circuit breaker panel, without success. He then attempted to contact the company's engineers on the appropriate VHF radio frequency, again without success, before contacting the company's operations control on their frequency, and requesting that engineers should call the aircraft. The engineers then contacted the aircraft by radio and spoke with the commander, who described the problem. The engineers described where the stick shaker circuit breakers were located, and the commander found them without difficulty. He pulled both circuit breakers, which caused the stick shakers to stop. The co-pilot levelled the aircraft at FL170, and the pilots then considered whether to continue the flight to New York.

From this time onwards, until the aircraft's descent and approach, the flight crew were occupied not only with resolving their technical difficulties, but also avoiding flight in areas of developed cumulus cloud, which were present over southern England at the time of the incident[2].

The flight crew noticed an ALT DISAGREE message on their EICAS (Engine Indication and Crew Alerting System) displays, and that the altitude indication on the co-pilot's PFD was FL170, whilst the commander's display read FL167. The commander recalled that the standby altimeter indicated FL166 or 167. Soon after the ALT DISAGREE message was noted, the flight crew saw an IAS DISAGREE message - from this time, until landing, the flight crew continually cross-checked their altitude and airspeed indications, to guard against further difficulty. The crew consulted their company operational control and decided to return to land at Heathrow; they advised ATC of this and that they needed to dump fuel

**Footnote**

[2] Developed cumulus cloud is associated with icing and turbulence.

in order to return. Controllers at the London Terminal Control Centre opened a new console and the aircraft was asked to make contact with a controller at that console on a discrete frequency. Thereafter, the aircraft was provided with a dedicated ATC service. On making initial contact with the controller, the flight crew were instructed to turn to avoid entering an active Danger Area (their navigation displays were incapable of displaying airspace such as Danger Areas). The controller advised the flight crew that their indicated altitude was varying slightly (this seemed to occur as the flight crew selected alternative air data sources which were fed to the ATC transponder).

The commander referred to the QRH (Quick Reference Handbook) and located the 'IAS DISAGREE' checklist

BACK

BOEING 10.5

747 Flight Crew Operations Manual

**IAS DISAGREE**
**(AIRSPEED/MACH UNRELIABLE)**

Condition: **Captain and First Officer airspeed indications differ by 5 knots or more, or airspeed/Mach indication suspected to be unreliable.**

**One or more of the following may be evidence of unreliable airspeed/Mach indication:**
- **Speed/altitude information not consistent with pitch attitude and thrust setting.**
- **Airspeed/Mach failure flags.**
- **PFD current airspeed box amber.**
- **Blank or fluctuating airspeed displays.**
- **Variation between Captain and First Officer airspeed displays.**
- **Amber line through one or more PFD flight mode annunciations.**
- **Overspeed indications.**
- **Radome damage or loss.**
- **Simultaneous overspeed and stall warnings.**
- **Display of one or more of the following EICAS messages:**

| | | |
|---|---|---|
| >ADC LEFT | >AIRSPEED LOW | >OVERSPEED |
| >ADC CENTER | HEAT P/S CAPT, | RUD RATIO DUEL |
| >ADC RIGHT | HEAT P/S F/O | RUD RATIO SNGL |
| AILERON LOCKOUT | HEAT P/S L, R, AUX | |

Continued on next page



April 1, 2005 D6-30151-438 10.5
VS Revision 30/01.10.05

**Figure 1**

'IAS DISAGREE' checklist

(Figure 1). He read through the first part of the checklist, and concluded that, whilst the checklist was describing the circumstances correctly, it did not offer any immediate resolution of the condition. The flight crew then determined, from their knowledge of the aircraft's systems, that the problem was rooted in one of the two Air Data Computers (ADCs) fitted to the aircraft. They decided to select the functioning (left) ADC as the source for both sets of flight displays. Having made this selection, both sets of displays showed the same air data[3].

The flight crew then began preparing the aircraft for a return to Heathrow; this involved dumping a quantity of fuel, reprogramming the FMC, and briefing for the arrival and approach. Staff at the LATCC took measures to ensure that the aircraft's arrival would be handled efficiently, and elected to be suspicious of the altitude data from the aircraft. Given this suspicion, and to ensure that the flight crew would be able to vary their track to avoid weather, the Ockham holding stack was cleared of traffic, selected outbound aircraft from Heathrow and Gatwick airports were instructed to remain on the ground, and all movements at London City were stopped. Thus the incident aircraft was afforded 'sterile airspace' for its arrival and approach.

The aircraft landed without incident at 1556 hrs, and taxied to a parking position. Maintenance engineers then consulted the aircraft BITE and replaced the right-hand ADC.

Whilst the engineers worked on the aircraft, the operator's crewing staff discussed duty times with both pilots. No standby flight crew were available, and both pilots agreed that they were fit to extend their duty times using 'commander's discretion', to enable the aircraft to depart. In anticipation of the technical problem's resolution, the aircraft was refuelled and the flight crew were provided with the necessary paperwork for a further departure.

In due course, the aircraft taxied for departure again, and the takeoff roll commenced on Runway 27R at 1744 hrs, with the co-pilot handling. The aircraft was now loaded with 89,300 kg of fuel, making the takeoff mass 327,423 kg. The takeoff speeds were calculated as $V_1$ 147 kt; $V_R$ 157 kt; $V_2$ 165 kt. At this time, the departure ATIS stated that the wind was from 240° at 21 kt, visibility was in excess of 10 km, and there were one or two octas of towering cumulus cloud at 3,500 ft above the aerodrome. The temperature was 9°C and the dewpoint 4°C, and the QNH was 988 mb. Windshear was forecast.

The takeoff proceeded normally until approximately 5 kt before $V_1$, when the stick shakers began to operate. The commander immediately rejected the takeoff, the flight crew executed the appropriate drills, and the aircraft was stopped without incident approximately two-thirds of the way along the runway. Following a brief discussion of the relative merits of parking the aircraft close to the runway to enable the brakes to cool, and taxiing to a parking position, the flight crew elected to follow the latter course, monitoring the brake temperatures as they did so. The brake temperatures remained acceptable during the slow taxi to the parking position.

The passengers were accommodated overnight near the airport, and the flight and cabin crew carried out appropriate post-flight actions before going off duty.

**Footnote**

[3] Altitude, airspeed, etc.

**Recorded data**

The aircraft carried a half-hour Cockpit Voice Recorder (CVR), a 25-hour Flight Data Recorder (FDR) and a Quick Access Recorder (QAR). The flight during which the stick shaker problem was first reported and the subsequent Rejected Take Off (RTO) were recorded on both the FDR and the QAR. The CVR ran on after the event, overwriting any useful recordings.

Where this aircraft type uses multiple systems for redundancy, these are generally split into 'left/right' or 'No1/No2' systems. The parameters recorded by the FDR and QAR mostly originate from 'left' or 'No1' systems. In this incident, the recorded angle of attack and stick shaker parameters would have been based on the left angle of attack (AOA) sensor, including the QAR 'AOA1' and 'AOA2' parameters which reported the two resolver angles from the same left AOA sensor.

Data replayed from the FDR and QAR showed that Flight VIR45 departed Heathrow on the first flight at 1426 hrs. The aircraft headed west and climbed to FL170; the right autopilot engaged as the aircraft approached FL50. After reaching FL170 the aircraft started a number of holding manoeuvres. At 1449 hrs the right autopilot disengaged and the left autopilot was engaged. Shortly after, at 1450 hrs, the ADC source for the co-pilot's instruments was switched from the normal right-hand source to the left-hand source. A descent was initiated at 1540 hrs. All three autopilots were engaged when the aircraft was descending through FL50 and then disengaged at approximately 700 ft agl. The aircraft landed back at Heathrow at 1556 hrs.

Only two brief warnings were recorded and these were associated with autopilot disconnects. The 'stick shake' parameter did not show any recorded activation and no ADC faults were recorded. The AOA parameters recorded on the FDR and QAR did not show any anomalies. An anomaly with landing gear status was recorded; other recorded parameters indicate this was a recording or sensing problem rather than an issue with the landing gear. The QAR also recorded a discrepancy between the status of AOA heat on the left and right systems; a review of other aircraft showed this to be a systematic recording problem, later addressed by the operator.

The next takeoff run started at 1744 hrs. The CAS did not build smoothly but the weather was reported as gusty. The data recorded a peak CAS of 155 kt, at which time the longitudinal acceleration started to register a reduction in acceleration, indicative of the first effects of an RTO. At no time during the RTO was there any indication of pitch rotation of the aircraft.

The data from the RTO showed similar anomalies as the previous flight regarding the AOA heat and landing gear. No stick shake warnings or AOA discrepancies were recorded. The co-pilot's instrument source selections were set to their default selections, ie aligned to right-hand sources. The autobrake was armed in RTO mode.

For both the RTO and the previous flight, the recorded data did not give any indication of AOA sensing or stall warning problems. The only indication of an anomaly with the instrument or warning systems during the first flight was that the co-pilot's source of ADC was switched from the right-hand system.

**CVR preservation**

The 'ICAO Annex 6' (Annex 6 to the Convention on International Civil Aviation), Part I, 11.6 states:

> *'An operator shall ensure, to the extent possible, in the event the aeroplane becomes involved in an accident or incident, the preservation of all related flight recorder records and, if necessary, the associated flight recorders, and their retention in safe custody pending their disposition as determined in accordance with Annex 13.'*

During the investigation into why the CVR was left to overrun following the RTO, it was established that the operator's procedures did not, at that time, fully support the above requirement. The operator undertook to revise its procedures to comply with the requirement and this has been completed.

**Quick Reference handbook (QRH)**

The aircraft manufacturer published QRHs for the aircraft. The QRH Non-Normal Checklist Introduction includes the following information and guidance:

> *'The Non-Normal Checklists chapter contains checklists used by the flight crew to cope with non-normal situations... Most checklists correspond to an EICAS alert message. An EICAS alert message annunciates a failure condition and is the cue to select and do the checklist...*
>
> *'A condition statement is given for all alert messages. The condition statement briefly describes the condition which caused the message to show.*
>
> *'Checklists can have both recall and reference items. Recall items are critical steps that must be done from memory. Recall items are printed in a box. Reference items are actions to be done while reading the checklist. In the Table of Contents for each non–normal checklist section, the titles of checklists containing recall items are printed in bold type.'*

The 'IAS DISAGREE' checklist (Figure 1), appeared on the right-hand page when the QRH was held open. The checklist began with a statement summarising the non-normal condition to which the checklist relates. Below this statement, the phrase:

> *'One or more of the following may be evidence of unreliable airspeed/Mach indication'*

introduced a list of ten conditions, one of which listed eleven EICAS messages which might be present. Below this list, and tabulated below the second column of messages, was the statement:

> *'Continued on next page.'*

On the following page (overleaf), a boxed checklist consisting of five recall actions (to be completed from memory) was presented. This checklist continued onto the next page, with a series of reference items (to be completed from the checklist).

**Rejected takeoff decision**

The Boeing 747 Flight Crew Operations manual contains the following statement in relation to rejected takeoffs:

> *'After 80 knots and before V1, the takeoff should be rejected only for engine fire/failure, an unsafe configuration, predictive windshear warning (as installed) or other conditions severely affecting the safety of flight.'*

**System description**

This aircraft was one of two in the operator's Boeing 747-400 fleet equipped with only two air data computers (ADCs), the rest each having three.

Each ADC takes inputs from the pitot-static system, the total air temperature (TAT) probes and the angle of attack (AOA) sensors, where they are converted into digital signals. Barometric-corrected altitude and computed airspeed are displayed on the commander's and co-pilot's primary flight displays (PFD). 'Source select' switches allow each pilot to determine which ADC input is used to supply the displays. ADC output is also supplied to other aircraft systems, including the flight management system and the stall warning computers.

Angle of attack (AOA) information is supplied to the ADCs from two sensors, one mounted on either side of the nose of the aircraft. A sensor comprises an external vane connected, via a gear train, to a pair of resolvers.[4] The vane adopts an angle according to the direction of the airflow passing over it, which is converted to an electrical output to the ADC. One of the resolvers is connected to an alternate power supply and provides a degree of redundancy. The left and right AOA sensors supply respectively the left and right ADCs. A schematic diagram of the left ADC system, together with some of the peripherals, including the AOA sensor, is shown at Figure 2.

The ADC self-test can be initiated using the Central Maintenance Computer System (CMCS), when the aircraft is on the ground. The CMCS also interfaces with all major avionic, electrical and electromechanical systems on the aircraft, and monitors their integrity. Information on failed components is stored in a fault register, which can be accessed via the multifunction control and display units on the flight deck. A 'Present Leg Faults' (PLF) message lists the time of the fault, together with an associated fault code. A hard copy can be obtained in the form of a Post Flight Report (PFR) via a printer mounted on the pedestal. Maintenance staff can subsequently look up the code in the Fault Isolation Manual (FIM), which instructs on rectification action. A Fault Reporting section of this manual can be used as a route to fault isolation when the fault is reported verbally or written up in the Technical Log, ie in the absence of CMCS-generated messages.

It is the IDS (Integrated Display System) comparator function that sets the 'ALT DISAGREE' and 'IAS DISAGREE messages when the commander's and co-pilot's instrument displays differ by more than 200 ft and 5 kt respectively for more than 5 seconds.

As noted earlier, the ADCs also supply other systems, including the Stall Warning Management Computers (SWMCs). There are two of these, left and right, supplied respectively by the left and right ADCs. The SWMCs are part of the Modularised Avionic Warning Electronics Assembly (MAWEA) and also take data from other aircraft systems. Master Monitor cards A and B (also within the MAWEA) take leading and trailing edge flap position information, landing gear position and flight management computer data, with each card supplying both SWMCs. From this data, each SWMC calculates the maximum angle of attack permissible before the aircraft approaches a stall condition. In the event that this value is exceeded, two solid-state switches in the SWMC operate to activate the stick shaker motors. The stall warning system is enabled, on the ground, at speeds above 140 kts or when pitch angle exceeds 5°.

**Footnote**

4 A resolver is a type of rotary electrical transformer that functions as a transducer. The primary winding, which is connected to an AC supply, is attached to the rotor and induces currents in three 'star-connected' secondary windings on the stator. The magnitude of the currents are a function of the angle of the rotor relative to the stator, which thus provides a way of measuring angular displacement.

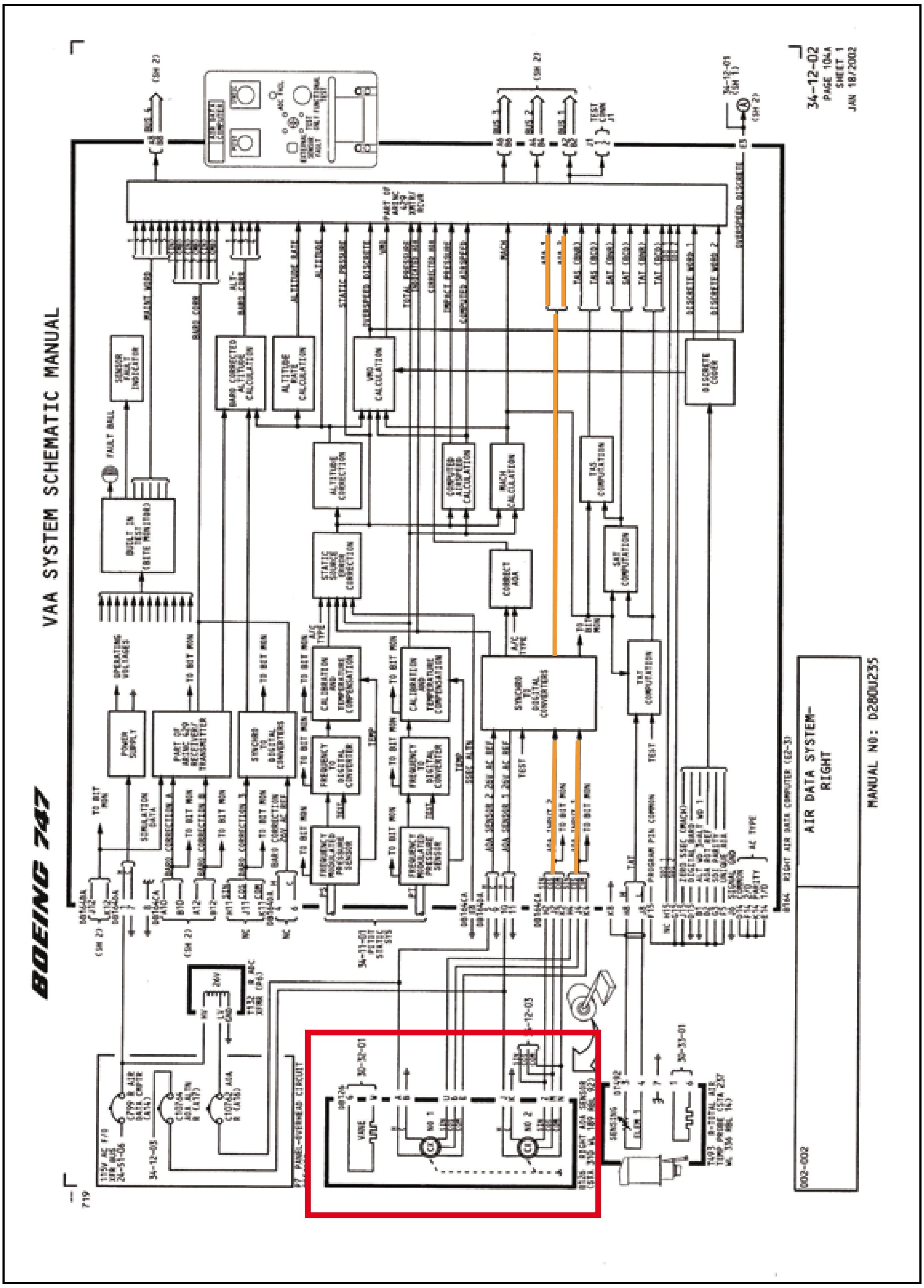



**Figure 2**

Schematic of RH Air Data Computer

**Examination of the aircraft**

The BITE test, after the aircraft returned to Heathrow, was conducted on the right-hand ADC; this resulted in a CMCS Ground Test Message Report, 'adc-r overspeed signal > mm-b interface fail' (mm-b is 'Master Monitor B'), together with the Fault Message Code 34675. The maintenance crew looked up this code in the FIM, with the procedure indicating the right-hand ADC be replaced. The Technical Log was annotated with the words 'ADC 'R' FAILS BITE TEST…ADC 'R' REPLACED…'

The first PLF messages, timed at 1427, related to the left and right stick shaker motor 'power off/fail', and were generated when the flight deck crew pulled the stick shaker motor circuit breakers. Two additional PLF messages, at 1436 and 1437, were respectively the 'IAS' and 'Altimeter Disagree' events. The accompanying Fault Message codes were 34649 and 34640 (the first two digits, 34, refer to the aircraft system by ATA Chapter number, 'Navigation' in this case). The fault isolation procedures for both of them called for replacement of the commander's (ie left) ADC. No mention was made of the AOA sensors. There were no messages relating directly to the stick shaker activation.

Although the maintenance personnel were aware of the stick shaker event, their actions were primarily directed by the ADC BITE report: thus the right-hand ADC was the only component that was changed prior to the next departure, which resulted in the rejected takeoff following the recurrence of the stick shaker activation. The Technical Log report of the stick shaker event could have been used to access the FIM via the Fault Reporting section, but even had this been done, there was no instruction to check the AOA sensors.

On the following day, 8 December, the operator's maintenance engineers subjected the aircraft to a simulated flight; this involved deploying the flaps to the takeoff position and connecting a pitot test set to, in turn, the left and right pitot heads. A pressure equating to approximately 140 kt was applied, representative of the airspeed at which the incident occurred,. It was found that when the right-hand pitot system was being tested, the stick shaker was activated even when the AOA vane was in the approximate horizontal position. No faults were apparent in the left system. Accordingly, the right AOA sensor was changed and the system re-tested, with satisfactory results. The opportunity was also taken to check the T232 transformer (Figure 2), since it supplies a reference voltage to both the AOA sensor and the ADC, with an attendant possibility of causing a malfunction of both components.

The aircraft was returned to service, with no further problems being reported by the flight crews. However, during the period 13-17 December 2006, PLF messages started to appear, indicating an intermittent 'aoa vane r fail'. On 18 December this component was changed once again, after which the aircraft performed without recurrence of similar faults.

**Examination of components**

*1. Air data computer*

The right-hand ADC was taken to the manufacturer's UK overhaul facility, where it was found that no hard faults were logged in the internal memory. Whilst this might be considered surprising in view of the BITE test performed on the aircraft, the aircraft manufacturer indicated that a BITE failure could include 'external or interface faults', a category that is not logged in the ADC fault memory as the ADC cannot detect them. These could include, for example, a blockage in the pitot system or a bent AOA vane. The aircraft manufacturer explained that the fault message 34675 ('ADC-R OVERSPEED SIGNAL > MM-B INTERFACE FAIL') was the result of doing the ADC ground test when the maintenance engineer responded '*No'* when asked (by the CMCS) if the Overspeed Warning was heard on the flight deck: conducting the ADC ground test should trigger the Overspeed Warning. Fault message 34675 was not related to spurious Overspeed Warnings or AOA sensor faults.

A simulated AOA signal was applied to the ADC, with no faults being apparent. The unit was then subjected to an automated production test, again with no faults found.

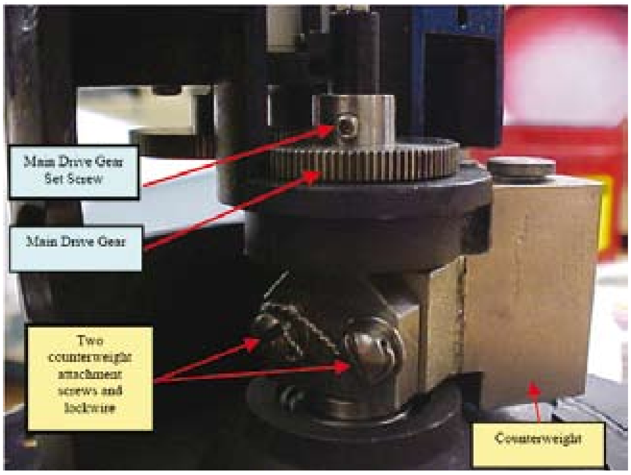
*2. Angle of attack (AOA) sensors*

The operator stated that the first AOA sensor, removed from the aircraft on 7 December 2006, was part of the spares 'pool' and was most recently repaired in March 2003 by their usual repair organisation. It had been installed in the right-hand position on G-VHOT on 9 February 2005 when a fault developed in the previously installed unit (see below).

Following the incident of 7 December 2006 the sensor was sent to its manufacturer's facility in Seattle, USA, where it was examined in the company of representatives of Boeing and the National Transportation Safety Board. When the unit was placed on test, it failed the part of the test schedule where the vane, positioned at discrete points throughout its operating range, should result in specified electrical outputs supplied to the ADCs. These were somewhat random in nature and subsequent disassembly revealed the main drive gear to be loose, being able to rotate freely 360° around the main shaft. The counter-weight was also found to be loose and had a free play of about +/- 2 ° rotation. Examination of the main gear revealed that the set screw that secured it to the shaft was not fully tightened: the overhaul manual specifies an assembly torque of 4.0 - 4.5 inch-pounds for this item. This was established as the reason for the random readings of the resolver outputs with respect to vane displacement, which thus resulted in the right ADC receiving erroneous angle of attack data. An exploded view of an AOA sensor, together with photographs of an intact unit and the internal gear train, is shown at Figure 3.

The second AOA sensor, which was from a different manufacturer, was removed from the aircraft on 18 December 2006 and was examined at a UK facility in January 2007 under AAIB supervision. The documentation associated with this component indicated that it had been installed on G-VHOT in October 1994, at the aircraft's entry into service. It had been removed on 9 February 2005 due to recurrent PLF messages of 'aoa vane r fail' and returned to the same repair organisation that overhauled the first unit. It was declared serviceable in December of that year and was installed on G-VHOT on 8 December 2006 following the stick shaker incident. As noted above, it was removed from the aircraft ten days later, following similar PLF messages.

The workshop report from 2005 contained no detail as to the nature of the repair; however, during the AAIB supervised examination, it was apparent, from its pristine condition, that the vane had been renewed. An internal examination revealed that a slight seepage had occurred from an oil-filled damper. When the unit was placed on test, with the resolver outputs being displayed on an oscilloscope and a digital voltmeter, a small calibration error was noted. The vane was rotated over its full range of movement and although the test initially appeared satisfactory, it was found that a slow rate of vane rotation revealed an 'open spot' for resolver No 2 at the approximate 29° position, possibly as a result of a contaminant particle in the brush-type resolver pick-off. In the opinion of the overhaul agent, this feature almost certainly accounted for the intermittent failure




**Schematic of AOA sensor**

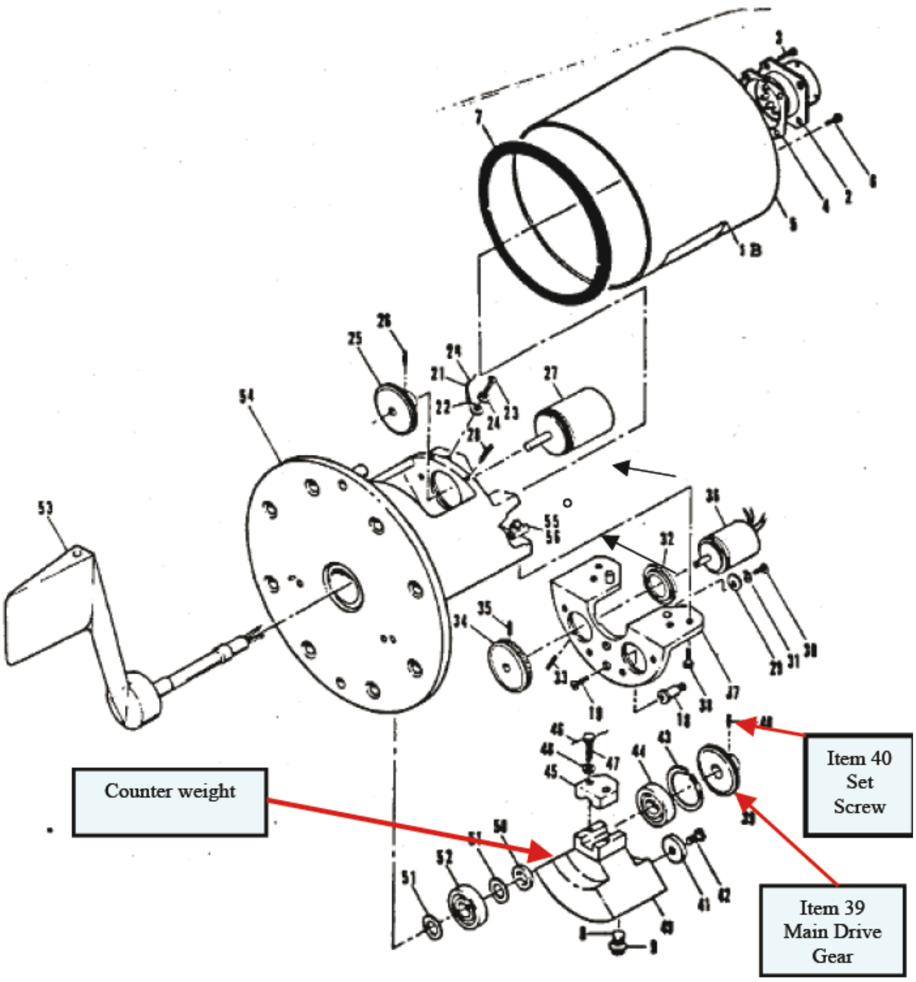



**Figure 3**

AOA sensor

messages. The almost immediate reappearance of the fault messages following its reinstallation on the aircraft on 8 December, suggested that the original defect had not been rectified following its shop visit in 2005.

**Reliability information**

The AOA sensors are maintained 'on condition' with typically one or two being removed per year on the operator's Boeing 747 fleet, which in 2006 achieved more than 67,000 flying hours. Since 2002, the mean time between unscheduled removals for this component is in excess of 93,000 hours.

**Analysis - Engineering**

*1. The stick shaker event*

The investigation revealed that the incident was caused by a defective AOA sensor in which an internal gear train became unsecured, resulting in both resolvers generating potentially highly inaccurate outputs to the right hand ADC. There was no way in which the ADC could 'know' that these values were false, which thus led to the stall warning system being activated for what it registered as excessively high angles of attack. In addition, high angles of attack in any aircraft alter the airflow around the static ports and pitot probes, introducing inaccuracies in the IAS and altimeter readings. In this aircraft, the ADC applied the appropriate corrections, thus leading to the discrepancies between the right and (correct) left instrument readings.

The replacement AOA sensor, which, by coincidence, had been installed on the same aircraft when it first entered service, also had a fault. This produced no flight deck effects but led to recurrent failure messages via the CMCS. Both AOA sensors had been through the same repair organisation.

The fact that G-VHOT was one of two aircraft in the operator's fleet equipped with only two ADCs prompted the question of whether the incident would have occurred in the same way on an aircraft with three ADCs. The manufacturer indicated that the centre ADC receives inputs from the left and right AOA sensors, with the left sensor being the primary. Unlike the left and right ADCs, the centre ADC could be switched to the alternate source in the event of a fault being detected. If the subject aircraft had been equipped with a centre ADC, and if the right AOA sensor failed, then selecting the centre ADC from the F/O source-select panel would have cleared the associated 'ALT/IAS DISAGREE' messages and stick shaker activation. The centre ADC, using the functional left AOA sensor, would have acted act as the 'hot spare' for the right-hand air data system. However, if the left AOA sensor failed, then the left ADC and centre ADC would be similarly affected and centre ADC source selecting by the commander would have had no effect.

The second stick shake event, which resulted in the rejected takeoff, is likely to have been the result of a high angle of attack signal from the defective sensor, coupled with the stall warning system becoming enabled at 140 kt.

*2. The troubleshooting*

The initial rectification action relied entirely on the PLF and BITE result messages, together with the fault codes, although none of the latter was associated with the stick shake event. In particular, the right ADC BITE report, together with the FIM instructions, convinced the maintenance personnel that changing the right ADC would solve the problem. The BITE report implicated Master Monitor 'B', which feeds the right-hand SWMC. The 'Interface Fail' part of the message was ambiguous in that it could have indicated an internal ADC fault, or possibly a communication fault between the ADC and the Master Monitor card.

The fact there were no messages pointing to an AOA sensor failure raises questions on the way the ADC determines the validity of sensor data and on the overall troubleshooting process. In the event of, say, the loss of a reference voltage, or, a problem with the resolver pick-off, as happened with the replacement AOA sensor, then the data is identified as invalid and a failure message posted. However, inaccurate (as opposed to invalid) AOA information caused by the slipping gear train within the AOA sensor was processed as normal, resulting in a stick shake activation that the system did not identify as a failure.

The ADC is part of a complex system, which, combined with the CMCS and the FIM, is endowed with a considerable diagnostic capability. However the level of technology, although sophisticated, is such that it would be unrealistic to expect a 100% success rate, and this incident provides an illustration of its shortcomings. Indeed, in this instance the problem was finally resolved only when the maintenance engineers conducted a simulated takeoff, It is surprising that the FIM directed attention to the equipment that processed data rather than the components, such as the AOA sensors, that generated it. Furthermore, in response to the IAS/ALT disagree messages, the FIM instructed the *left* ADC to be changed; the logic behind this was not apparent, and the engineers ignored it anyway.

**Safety actions - FIM**

The FIM is a 'living document' that is periodically revised as a result of in-service experience. Following these incidents, the manufacturer reviewed the FIM to include a check on the AOA sensors as part of the troubleshooting for the stick shaker, which is part of ATA Chapter 27 but there was, at that time, no similar proposal for Chapter 34 (Navigation). Had the revision existed at the time of the G-VHOT incidents, however, it would not have affected the particular outcome, since the maintenance personnel did not pursue the stick shake troubleshooting route.

The operator reviewed the contract details covering pooled component repairs. Whilst the same overhaul organisation was retained, a quality audit was performed on the repair and overhaul of the AOA sensors.

It is apparent that the maintenance crew, following the initial stick shake/instrument event, were guided primarily by the ADC BITE report and the associated FIM instructions. An automated diagnostic process is always going to be a preferred option to the time-consuming alternative of consulting technical manuals, especially when maintenance crews are under pressure to deliver the aircraft for an already delayed flight. In the event, the problem was not successfully rectified, resulting in an aborted takeoff close to $V_1$. Whilst FIM amendments may be viewed as a 'sticking plaster' approach, a more comprehensive suite of checks in the Air Data fault section of the FIM, including some or all of the primary sensors, may have prevented the aircraft from being despatched with the defect unresolved.

In the time since the incident to G-VHOT, the aircraft manufacturer, Boeing, has revised the Boeing 747-400 series FIM tasks for '*Capt IAS/Alt Disagree*' to include additional checks of the AOA sensor.

**Analysis - Operations**

*Initial response to the stick shaker activation*

The first departure proceeded uneventfully until the stick shakers activated slightly before $V_1$. Faced with a sudden and unexpected problem at high speed during takeoff, the commander made an accurate assessment that the activation was erroneous, that the aircraft was not in genuine difficulty, and that continuing the takeoff was an appropriate course of action. Analysis of the FDR data indicated that the takeoff was normal, and that the co-pilot handled the aircraft without difficulty, despite the distraction of the stick shakers. Although CVR information was not available, the flight crew accounts of events on board the aircraft, and analysis of ATC recordings, indicated that this potentially awkward problem was dealt with effectively and a normal departure profile was flown.

There was no checklist to assist the commander in dealing with the malfunctioning stick-shakers, nor had he encountered the problem previously. Having identified that eliminating the distraction and nuisance caused by the continuous operation of the stick shakers was a priority, the commander took the logical course of action to attempt to identify the relevant circuit breakers, first by inspection of the circuit breaker panels, and then with the assistance of the company's engineers. The absence of a ready means of locating the circuit breakers caused a slight delay, and the operator took safety action after the event as a consequence:

**Safety action - stick shaker circuit breakers**

In light of this event, the operator reported that the stick shaker circuit breakers on all of their aircraft have now been fitted with collars, to aid speedy identification.

**Action in response to the EICAS messages**

The flight crew were presented with two EICAS messages: ALT DISAGREE and then, soon after, IAS DISAGREE. Each message appeared in similar text and in the same position on the display; nothing differentiated between the two messages.

In the event, the flight crew did not carry out the recall actions of the IAS DISAGREE checklist, but rather, the commander consulted the QRH itself and was presented with the page shown in Figure 1. He identified that the condition statement, and other information on the first page of the checklist, did concur with the indications in the flight deck, but he did not proceed to the following page where the checklist, consisting of both recall and reference items, was located.

It is appropriate to examine reasons why the commander may not have proceeded to the appropriate checklist. Two matters require analysis: why did the commander not identify that action by recall was appropriate, and, when examining the QRH, why did he not proceed to the second page of the checklist where the recall and reference items were detailed?

First, although the ALT DISAGREE message directed the flight crew to carry out a QRH procedure by reference to the QRH, whilst the IAS DISAGREE procedure required the flight crew to carry out actions by recall, no characteristic of the latter EICAS message identified it as requiring recall action. Some recall actions (such as engine fire) are rehearsed regularly in simulators, and are prompted by distinct indications (red lights in engine controls, warning lights, and a bell). Others must be remembered as recall actions solely from knowledge of the relevant checklist, and where this knowledge is not routinely rehearsed, it may be expected to become somewhat dormant. The operator's Boeing 747 QRH contains few recall checklists, and the operator reported that simulator training, since this event, has focussed on effective and accurate use of the QRH and, in particular, the ALT DISAGREE and IAS DISAGREE checklists. The operator also devised a specific simulator detail based on this event for recurrent training.

The first page of the IAS DISAGREE checklist is densely packed in its upper two thirds with descriptive text, and blank beneath, suggesting that the content under that title is complete. The direction to the next page is not highlighted in any way, but appears tabulated below the list of EICAS messages which may relate to the condition, and is to some degree 'camouflaged' by the list above it.

The QRH design was discussed with the operator and the aircraft manufacturer. These discussions centred on whether the checklist was optimised for ease of use, and in particular, whether the design directed the reader to the recall actions with urgency. As a result of these discussions, the operator and manufacturer took safety action as detailed below.

**Safety action - QRH labelling**

As a short-term solution, the operator amended all of the QRHs on its aircraft with adhesive labels directing flight crew to recall actions shown on the second page of the IAS DISAGREE procedure, and other Boeing 747 checklists longer than one page.

**Safety action - QRHs**

The aircraft manufacturer has been redesigning the QRHs for all models of its aircraft. One goal is to ensure that, where a checklist includes recall items, such items appear on the first page of the checklist. The manufacturer estimates that all models will receive their initial release of this redesign by the end of 2008.

**Aircraft navigation in unusual circumstances**

The assistance provided to the aircraft by the dedicated ATC controller was valuable, as it enabled the controller to devote time exclusively to communicating with and controlling G-VHOT, as well as co-ordinating with colleagues responsible for airspace in which G-VHOT was operating.

Large commercial aircraft operate almost exclusively within the boundaries of controlled airspace, and there is no need, in normal operations, for flight crew to have information such as the dimensions of dangers areas on their navigation displays[5]. Paper charts, showing such airspace, are carried on board, and could be consulted if the need arose. However, whilst the flight crew were resolving their technical difficulties, attempting to track the aircraft's position on a paper chart by traditional methods would have added greatly to the flight crew workload.

**Safety action - the decision to return aircraft to service**

The operator of G-VHOT reported that in light of this event, changes had been made to the manner in which the company reacts to unusual events. If an aircraft returns to its point of departure, or a rejected takeoff is carried out, the decision to 're-launch' the flight will be made at corporate level (by senior managers rather than staff exclusively involved in day-to-day operations). The decisions will involve the duty pilot (one of a team of management pilots who share a duty to be contactable), and there will also be a 'Quality Assurance Hold', while all aspects of the return or rejected takeoff are assessed, before a decision is taken, involving the Quality Management, to return the aircraft and crew to service.

**The rejected takeoff**

The commander's decision to reject the (second) takeoff in response to the stick shaker was not in accordance with normal practice. The Boeing 747 Flight Crew Operations manual stated that:

**Footnote**

[5] GPS navigation displays on general aviation aircraft often have the ability to display such information.

> *'After 80 knots and before V1, the takeoff should be rejected only for engine fire/failure, an unsafe configuration, predictive windshear warning (as installed) or other conditions severely affecting the safety of flight.'*

As the commander had correctly diagnosed on the previous departure, a malfunctioning stick shaker, by itself, would not *'severely affect the safety of flight.'*

However, having already conducted a flight in the course of which the crew dealt with several malfunctions, and given that it appeared that the rectification action had not resolved at least one of those malfunctions, the commander's decision to reject the takeoff is understandable and reflects a recognition that to be airborne again with, perhaps, complex and multiple problems, was undesirable.

The FDR data indicated that the rejected takeoff manoeuvre was accomplished correctly, and the flight crew experienced no difficulty in stopping the aircraft approximately two-thirds of the way along the runway.

**Summary of safety actions**

The Safety Actions noted above were implemented by the operator during the prolonged technical investigation, consulting the manufacturer and the AAIB.

**INCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Cessna 208 Caravan I (floatplane), G-MDJE |
| **No & Type of Engines:** | 1 Pratt & Whitney Canada PT6A-114A turboprop engine |
| **Year of Manufacture:** | 2001 |
| **Date & Time (UTC):** | 24 May 2008 at 1930 hrs |
| **Location:** | Overhead Partick, Glasgow |
| **Type of Flight:** | Commercial Air Transport (Non-Revenue) |
| **Persons on Board:** | Crew - 2 Passengers - None |
| **Injuries:** | Crew - None Passengers - N/A |
| **Nature of Damage:** | Water rudder detached in flight |
| **Commander's Licence:** | Commercial Pilot's Licence |
| **Commander's Age:** | 34 years |
| **Commander's Flying Experience:** | 4,615 hours (of which 6.5 were on type)<br>Last 90 days - 32 hours<br>Last 28 days - 6.5 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot |

**Synopsis**

Whilst flying over Glasgow at 1,200 ft, the left float water rudder fell from the aircraft due to a failure of its attachment post. The damage to the attachment post was consistent with the rudder having struck a submerged object.

**History of the flight**

The aircraft had taken off from the river Clyde on a positioning flight to Loch Lomond. Shortly after reaching its cruising altitude of 1,200 ft, a vibration was felt through the aircraft which lasted for approximately 10 seconds. The pilot carried out a visual inspection of the airframe from the cockpit and saw that the left float water rudder was missing. The aircraft diverted to Glasgow Airport where an uneventful landing was made. The water rudder was later recovered from a garden; no one on the ground was injured.

Examination of the aircraft revealed that the water rudder attachment post at the rear of the left float had been distorted, and a weld on the rudder pivot tube had failed, allowing the separation of the rudder. The damage was consistent with the water rudder having struck a submerged object. The aircraft had operated for 85 hours since its last scheduled water rudder inspection (required at 100 hour intervals). To prevent corrosion, a liberal coating of grease is applied to the rudder mechanism during the inspection, and this is likely to have obscured the presence of the damage during any subsequent pre-flight inspection.

**INCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Cessna 550 Citation Bravo, G-IKOS |
| **No & Type of Engines:** | 2 Pratt & Whitney Canada PW530A turbofan engines |
| **Year of Manufacture:** | 2001 |
| **Date & Time (UTC):** | 5 February 2008 at 1815 hrs |
| **Location:** | Biggin Hill Airport, Kent |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 2 Passengers - 2 |
| **Injuries:** | Crew - None Passengers - None |
| **Nature of Damage:** | None |
| **Commander's Licence:** | Airline Transport Pilot's Licence |
| **Commander's Age:** | Not provided |
| **Commander's Flying Experience:** | 8,422 hours (of which 117 were on type)<br>Last 90 days - 61 hours<br>Last 28 days - 4 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the commander, Mandatory Occurrence Report form submitted by the first officer. |

**Synopsis**

A windshear encounter at two miles on an approach to Biggin Hill Airport resulted in an apparent wing drop. The approach was continued and the aircraft bounced on the subsequent landing. A go-around was called by the PNF but the PF (commander) decided to continue and landed successfully.

**History of the flight**

The aircraft was being flown from Nice to Biggin Hill Airport with the commander as the PF. At 2,000 ft amsl on the approach into Biggin Hill, the crew reported that the wind vector displayed on the Electronic Flight Instrumentation System (EFIS) showed 54 kt and the reported surface wind was 230°/15 kt. After capturing the glideslope for a fully coupled approach to a manual night landing on Runway 21, the PF reduced speed to "minimum approach" (approximately 115 kt). At two miles from the runway threshold G-IKOS encountered severe windshear and the EFIS speed tape showed the speed trending to below 100 kt. The autopilot pitched up to maintain the glideslope and the aircraft appeared to stall with a right-wing drop. The PF recovered from the stall by lowering the nose and increasing power and decided to continue the approach. On landing the initial touchdown was flat and G-IKOS entered a series of porpoising bounces. During the second bounce the first officer (F/O) called for a go-around, but the commander decided to continue the landing. G-IKOS was stopped within the runway length and taxied normally to its parking position.

**Commander's report**

The commander submitted an aircraft accident report form to the AAIB. He considered that the windshear was an isolated weather phenomenon and consequently decided to continue the approach. He acknowledged that the aircraft bounced on landing but stated that at all times he had control of the aircraft and maintained the runway centreline.

The commander assessed the cause of the landing incident as a combination of the "wind, touchdown speed and bad light conditions at the moment of landing."

**First officer's report**

The first officer completed a CAA Mandatory Occurrence Report (MOR) form. In his report he noted that the minimum approach speed of Vref + 10 kt was being flown and at least 15 kt was lost in the windshear event. He stated that, on landing, the initial touchdown was very flat and a series of 's' porpoises occurred reaching heights of 10 to 15 ft. On the second bounce he called for a go-around but the commander replied that there was no need.

**CVR**

Before the event was reported to the AAIB, the operator removed and downloaded both the CVR and FDR. During the windshear encounter the F/O can be heard stating "SPEED SPEED SPEED SPEED." The commander replies "WOW, WE HAVE TO REPORT THAT, SEVERE WINDSHEAR." The crew have a brief discussion about flying at minimum approach speed.

During the approach there is a GPWS call out "GLIDESLOPE GLIDESLOPE" immediately followed by an automated "MINIMUMS" and the commander responds "LANDING". A few seconds later the F/O comments "YOU CAN'T FLY MINIMUM APPROACH IN THIS WEATHER" and the commander responds "NO-NO WAY ARE YOU CRAZY WITH THE WINDSHEAR."

Five seconds after touchdown the F/O calls for a go around, the commander responds "WHY".

During the rollout the commander asks the F/O if the surface of the runway is bumpy and the F/O responds "NO THERE WAS NO FLARE."

**FDR**

The FDR recorded both the windshear event and the subsequent landing.

The FDR fitted to G-IKOS recorded IAS once per second. Initially G-IKOS was stable on the approach at 117 kt but one second later the speed was recorded at 105 kt. The pitch attitude decreased over the next four seconds to 7° nose down and the IAS increased to 133 kt. During this event the minimum vertical acceleration was recorded as 0.498g. As the aircraft pitched up during the recovery a transient acceleration of 1.74g was recorded. The roll attitude is recorded twice per second and the maximum roll attitude recorded during the event was 6.1° right-wing down. During the remainder of the approach, the IAS remained unstable, varying between 111 kt and 139 kt.

The bounced landing had an initial vertical acceleration of 1.6g reducing over the next second to 0.53g before increasing over one quarter of a second to 2.1g.

**Analysis**

Although the reported surface weather was benign, the change in wind velocity of some 40 kt in the final 1,500 ft of the approach gave warning that a rapid shear area may exist. The selection of a speed greater than minimum approach speed may have provided a greater margin for windshear. The PF carried out the correct immediate actions of lowering the nose and increasing thrust to regain energy but the airspeed remained unstable for the remainder of the approach. A go-around executed at this point may have prevented the subsequent bounced landing.

**Safety action by the operator**

Since this incident the operator has introduced stabilised approach criteria whereby crews must go-around if not stable by 500 ft agl or if the approach becomes destabilised below 500 ft agl.

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Nomad N22B, N6302W |
| **No & Type of Engines:** | 2 Allison 250-B17E turboprop engines |
| **Year of Manufacture:** | 1983 |
| **Date & Time (UTC):** | 12 August 2007 at 1530 hrs |
| **Location:** | Chatteris Airfield, Cambridgeshire |
| **Type of Flight:** | Aerial Work |
| **Persons on Board:** | Crew - 1 Passengers - 13 |
| **Injuries:** | Crew - None Passengers - None |
| **Nature of Damage:** | Nosewheel collapse |
| **Commander's Licence:** | Private Pilot's Licence (CAA and FAA) |
| **Commander's Age:** | 44 years |
| **Commander's Flying Experience:** | 1,000 hours (of which 150 were on type)<br>Last 90 days - 24 hours<br>Last 28 days - 8 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB |

**Synopsis**

The aircraft, with 13 parachutists on board, inadvertently entered cloud as it climbed through about 8,500 ft. The pilot descended the aircraft and regained VMC at about 4,000 ft; however one of the engines ran down due to icing before the engine anti ice system was selected on. The pilot was unable to restart the engine and returned to his departure airfield, where he flew a faster than normal approach in accordance with training he had received for single-engine landings. The aircraft landed long and the pilot was unable to stop it before the end of the runway. During the subsequent overrun, the nosewheel entered a ditch causing the nose leg to collapse.

The pilot did not hold a type rating for the aircraft, as required under CAA and JAR's, however he was operating under his FAA licence, (based on his CAA licence) and he incorrectly believed he did not require a specific type rating.

**History of the flight**

The flight was intended to drop 13 parachutists, forming six tandem pairs and a single jumper, at a height of 10,000 ft over Chatteris Airfield. During the climb, the pilot saw a large cumulonimbus cloud ahead, the top of which was above the aircraft. He believed the aircraft would be able to climb over it but at about 8,500 ft, the aircraft unexpectedly entered cloud.

The pilot transferred his attention to the instruments and selected the engine anti-ice on but not in sufficient time to prevent the left engine running down due to icing. He commenced a descent and turned back towards the airfield to try and regain VMC, using a GPS unit for navigation. His attempts to restart the left engine were unsuccessful and he therefore prepared for a single-engine landing. The aircraft regained VMC as it descended through 4,000 ft in the descent.

The pilot stated he increased the approach speed from the normal speed of 70 kt to the blue line speed of 80 kt and landed further into the runway than normal to compensate for the reduced power available. This, combined with the damp grass runway surface and reduced reverse thrust available, caused the aircraft to overrun the end of the runway. The nosewheel subsequently entered a ditch, causing the nose leg to collapse.

Neither the pilot nor the parachutists, who had remained on board throughout, were injured and they were all able to vacate the aircraft unassisted.

**Weather**

An aftercast obtained from the Met Office showed that an area of unstable air was affecting the area, with showers, some heavy, in the vicinity. Cloud cover was estimated as FEW at about 2,000 ft agl, FEW, SCT or BKN at about 4,000 ft and layers at about 7,000 ft. The cloud type most likely to be encountered was cumulus surmounted by stratocumulus, with some cumulonimbus also reported in the area. The temperature at 8,500 ft was reported as about minus 0.6ºC.

**Pilot qualifications**

The pilot was employed by the parachuting club as a parachuting instructor but was also their Chief Pilot, flying in an unpaid capacity. This allowed him to conduct parachute dropping flights under the privileges of a private pilot's licence.

The pilot held a private pilot's licence issued by the CAA and another issued by the FAA. He did not hold an instrument rating but did hold an IMC rating, valid when flying under the privileges of his CAA licence. He also held a twin rating for both his CAA and FAA licences and a CAA night rating.

The pilot had conducted all his training for the FAA licences and ratings in the UK. This included a 'high performance' endorsement, a generic qualification allowing pilots to fly more complex types of aircraft, such as the Nomad. However under JAR regulations such a generic qualification is not deemed sufficient for the Nomad and pilots are required to undertake specific training in order to gain a type rating.

The FAA requires pilots to be checked by an instructor every two years, termed a biannual check; the pilot's last biannual check was conducted on 11February 2006 on the Nomad. His last CAA check was a multi-engine renewal carried out on a Beech Baron on 6 January 2007.

**FAA licence restrictions**

Pilots holding certain CAA and JAR licences can apply to have an equivalent FAA licence issued without the need to undergo any additional training or qualification. Such 'piggyback' FAA licences are subject to FAA pilot certification rule 61.75 (e)(3) which states:

> *'Is subject to the limitations and restrictions on the person's US certificate and foreign pilot licence when exercising the privilege of that US pilot certificate in an aircraft of US registry operating within or outside the United States.'*

As a result of enquiries, the FAA has stated that this limitation includes type ratings.

The FAA's answer to an enquiry by another pilot seeking confirmation that the aircraft could be flown on such a 'piggyback' style licence, without a specific rating, was that this was acceptable where the aircraft is not recognised by 'other CAAs'. Whilst there are currently no Nomads on the UK register, a JAR type rating does exist for the aircraft and it would therefore be possible to operate the type on the UK register and for pilots to gain the relevant JAR type rating.

Had the pilot held an original issue FAA licence, not reliant on any other licence, then the requirement to have a type rating on his CAA licence would be negated.

**Comment**

The accident occurred because the aircraft landed too far into the runway at a higher than normal speed following a single engine failure. The engine failure occurred because ice was encountered before engine anti-icing was selected and the pilot was then unable to re-start the engine. The pilot was quite candid in stating that he should have diverted to a more suitable airfield but his mindset at the time, being in an asymmetric condition near Maximum All Up Weight (MAUW), was to land as soon as he could.

The investigation revealed that the pilot was operating to a level of qualification that would not be accepted under CAA or JAR standards. Had the pilot completed the JAR type rating it is possible that the correct single engine approach profile would have been flown which makes the issue of FAA licence restrictions more significant. A meeting was held on 1/2 April 2008 between the EASA, the FAA and TCCA in an attempt to improve the harmonisation of licensing rules. Also, oversight by the British Parachute Association (BPA) of member organisations is complicated where foreign registered aircraft and foreign licensed pilots are used; these operations must also comply with the regulations in force in another state. There are obviously areas of confusion that exist concerning foreign licensing and therefore the following recommendation is made:

**Safety Recommendation 2008-031**

It is recommended that the Federal Aviation Administration (FAA) clarify the implications of FAA pilot certification rule 61.75 (e)(3) to those in possession of FAA licences that are based on foreign state licences.

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Beech 76 Duchess, G-OADY |
| **No & Type of Engines:** | 2 Lycoming O-360-A1G6D piston engines |
| **Year of Manufacture:** | 1978 |
| **Date & Time (UTC):** | 30 April 2008 at 0858 hrs |
| **Location:** | Runway 20, Doncaster Sheffield Airport |
| **Type of Flight:** | Training |
| **Persons on Board:** | Crew - 2 Passengers - None |
| **Injuries** | Crew - None Passengers - N/A |
| **Nature of Damage:** | Both propellers damaged and engines shock-loaded, damage to nose landing gear doors, forward bulkhead and nose cone |
| **Commander's Licence:** | Commercial Pilot's Licence |
| **Commander's Age:** | 40 years |
| **Commander's Flying Experience:** | 3,664 hours (of which 1,521 were on type)<br>Last 90 days -100 hours<br>Last 28 days - 41 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot |

**Synopsis**

The student pilot was practising touch-and-go circuits under the supervision of an instructor. He touched down on completion of the second circuit, but during the ground roll selected UP on the landing gear selector switch. The nose gear of the aircraft retracted, causing the propeller blades and aircraft nose to contact the ground. The aircraft then slid to a stop on the runway.

**History of the flight**

The student, an experienced military pilot with 2,230 hours PIC and 31 hours flown in the preceding 90 days, was undergoing tuition to gain a civilian multi-engine rating. However, he was new to this aircraft and had only three hours on type. The student pilot and instructor departed from Leeds Bradford Airport at 0825 hrs, flew the short distance to Sheffield Doncaster Airport and began flying a routine visual circuit training detail, performing touch-and-go landings. The weather was fine, the runway was dry and visibility was good. The student had been briefed prior to commencement of the training detail to follow the standard company procedure, that the instructor would 'clean up' the aircraft (retract flaps and reset switches as required) during the ground roll then call 'flaps up', allowing the student to commence the takeoff. The student had been briefed to keep his hands on the control column and throttles during this procedure.

The student pilot completed the first circuit successfully and progressed round the circuit again, touching down and continuing the ground roll. The instructor then called "I'll tidy up the aircraft" at which point the student removed his hand from the throttles and moved the gear selector switch to the UP position. Both the instructor and student recognised this immediately and returned the gear selector switch to the DOWN position. The main gear remained down and locked, however the nose gear retracted. The front of the aircraft dropped, bringing the propeller blade tips into contact with the ground. The aircraft then landed on its nose, damaging the nose gear doors and nose cone. It continued to slide down the runway veering slightly to the left before coming to rest to the left of the runway centreline. The air traffic controller in the tower observed the nose gear retraction and mobilised the airport emergency services using the crash alarm. He then directed a landing helicopter to execute a 'missed approach' and closed the runway, by which time the instructor had also reported the accident on the radio.

**Safety protection system**

The Beech 76 aircraft has a safety retraction switch which is designed to prevent inadvertent retraction of the landing gear on the ground. The system is triggered by a pressure switch installed in the pitot system, which deactivates the hydraulic pressure pump circuit when the 'impact air'(pitot) pressure is below that generated by an aircraft airspeed of 59 to 63 kt. During the ground roll phase of the touch-and-go in this accident the aircraft remained above this speed range.

**Comment**

The selection of the landing gear to the UP position by the student pilot was described as a "reflex" reaction. This is a well-documented human factors issue known as an 'inadvertent slip' and occurs when a person subconsciously carries out an action which is inappropriate or erroneous. Typically these actions are well-practised tasks being carried out under routine circumstances and are often a result of high workload. Given the student pilot's lack of familiarity with the aircraft type, it is likely that his mental workload was high during this phase of the flight. The instructor's non-standard callout during the procedure may also have been contributory in acting as a trigger for the student's action.

The briefed procedure for the touch-and-go circuits highlighted the fact that the student pilot should keep his hands on the control column and throttles whilst the instructor prepared the aircraft for takeoff. This was clearly understood by the student and correctly executed during the first circuit. However, by maintaining the aircraft speed above 63 kt during the ground roll, the additional protection provided by the landing gear safety switch was removed. This allowed the student to move the gear selector switch inadvertently. This deficiency has been identified by the Head of Training for the flight training centre involved and the student/instructor briefings have been amended to highlight the importance of a speed check during the ground roll, to confirm a target IAS of below 40 kt prior to the instructor commencing flap retraction.

**ACCIDENT**

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|---|---|
| **Aircraft Type and Registration:** | Cessna 152, G-BWEV |
| **No & Type of Engines:** | 1 Lycoming O-235-L2C piston engine |
| **Year of Manufacture:** | 1979 |
| **Date & Time (UTC):** | 13 April 2008 at 1311 hrs |
| **Location:** | Full Sutton Airfield, Yorkshire |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - None |
| **Injuries:** | Crew - None Passengers - N/A |
| **Nature of Damage:** | Damage to right wing, fin, spinner and propeller |
| **Commander's Licence:** | Private Pilot's Licence with IMC rating |
| **Commander's Age:** | 57 years |
| **Commander's Flying Experience:** | 994 hours (of which 983 were on type)<br>Last 90 days - 30 hours<br>Last 28 days - 9 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot |

**Synopsis**

As a result of reduced visibility in light rain, the pilot landed deep into the runway. Braking action was poor on the wet grass and the aircraft ran off the end of the runway onto soft ground and slowly nosed over.

**History of the flight**

The aircraft was on a flight from Andrewsfield in Essex to Full Sutton. This had been uneventful, although the pilot noted that IMC (Instrument Meteorological Conditions) existed to the north of Skegness. He called Full Sutton Radio with the airfield in sight, and was informed of the runway in use and the QFE. The pilot described the visibility in light rain as "not good", but the entire area of the airfield was visible from the downwind position.

On final approach to Runway 22, which has a length of 772 metres, the pilot considered he was too high, so he reduced the engine power to idle and lowered full flap. The reduced propeller wash resulted in a build-up of raindrops on the windscreen, which further reduced the visibility; this in turn caused the pilot to flare the aircraft slightly high and land well down the runway, although he still considered there was enough room to stop. However, braking performance on the wet grass was poor and the aircraft ran off the end of the runway onto soft ground, where it slowly nosed over. The pilot, who was uninjured, released his harness and exited the inverted aircraft through the normal door.

In his statement, the pilot considered that the accident was the result of being too high on approach, coupled with a failure to make an early decision to go around.

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Cessna 172M Skyhawk, G-TRIO |
| **No & Type of Engines:** | 1 Lycoming O-320-E2D piston engine |
| **Year of Manufacture:** | 1976 |
| **Date & Time (UTC):** | 23 February 2008 at 1515 hrs |
| **Location:** | Farthing Common, Kent |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - 1 |
| **Injuries:** | Crew - 1 (Minor) Passengers - 1 (Minor) |
| **Nature of Damage:** | Substantial |
| **Commander's Licence:** | National Private Pilot's Licence |
| **Commander's Age:** | 58 years |
| **Commander's Flying Experience:** | 225 hours (of which 121 were on type)<br>Last 90 days - 9 hours<br>Last 28 days - 4 hours |
| **Information Source:** | AAIB Field Investigation |

**Synopsis**

The pilot was flying on a cross-country flight when the weather conditions deteriorated. When the aircraft entered cloud, the pilot tried to regain visual flight conditions by turning and descending. As he did so the aircraft flew into and came to rest in some trees. Both occupants escaped unassisted with minor injuries.

**History of the flight**

The pilot had arranged to fly the aircraft, from a flying club several days before the flight. On the day of the accident, when he arrived at the airfield, he asked another pilot, who had already been flying, about the height of the cloudbase in the local area. The reply from the other pilot was that he had been able to fly clear of cloud at 2,000 to 2,200 ft amsl.

Having decided that the weather was suitable, he planned a local cross-country flight of about one hour taking a passenger. Before departure he refuelled the aircraft to full tanks. He took off at 1447 hrs, having advised Rochester Information that his flight would be of approximately 60 minutes duration. This is a mandatory requirement at Rochester Airport to enable prompt overdue action to commence, introduced as a result of a previous AAIB investigation.

Only short sections of the aircraft's route were recorded on radar but the pilot advised that he initially flew south towards Bewl Water and then turned east towards Ashford and Dover. While enroute he had been able to maintain between 1,800 ft and 1,500 ft amsl and remain below cloud, but occasionally he had needed to descend for a short time to remain clear. At 1510 hrs, overhead Ashford, the pilot contacted Manston ATC and advised that he was at 1,500 ft, maintaining VFR proceeding to Dover and then Canterbury. Manston ATC offered the pilot a Flight Information Service and assigned the aircraft a squawk of 4250.

A short while later the pilot descended in an attempt to keep below cloud but then found that there appeared to be a "wall of cloud" ahead. He decided to turn left towards Rochester and descended in an attempt to remain clear of the cloud. He recollected being at about 900 ft amsl at this time. He described looking through his side window towards the ground and noticed that his altimeter was reading 650 ft amsl. He then saw trees ahead that he was unable to avoid. The aircraft flew through the upper parts of a number of trees before finally descending into a large evergreen tree. These trees were at an elevation of approximately 600 ft amsl.

The pilot and his passenger were both able to escape from the aircraft unaided and suffered minor cuts and bruises.

**Pilot information**

The pilot held a National Private Pilot's Licence (NPPL) for which he qualified in 2003. In 2002 he had tried to obtain a Class II medical for a PPL but this was refused. Since qualifying for his licence he had flown regularly and for the last two years almost exclusively in a Cessna 172; all the recorded flights in his logbook for the last year were from and to Rochester. The pilot did not hold an IMC rating and said that normally when flying cross country he would fly at around 3,000 ft. On the day of the accident he had been concerned about the cloudbase but on hearing the other pilot's report, he was content that he would be able to maintain clear of cloud at 2,000 ft amsl.

The pilot, in a statement to the police, described himself as a regular heavy cannabis user, smoking a large amount each evening. Loss of precision skills and slowed reactions are two documented effects of cannabis use which make it incompatible with flying.

The Air Navigation Order, Article 65, states that:

> *'A person shall not, when acting as a member of the crew of any aircraft or being carried in any aircraft for the purpose of so acting, be under the influence of drink or a drug to such an extent as to impair his capacity so to act.'*

**Meteorological information**

The synoptic situation showed that the south-east of England was affected by a warm front, moving east to the southern North Sea. The Met Office forecast for the area indicated good visibility in most areas with occasional reductions to 3,000 m near sea coasts and upslopes, a broken or overcast layer of cloud with a base at 1,500 ft to 2,000 ft and tops at between 3,000 ft and 6,000 ft. Occasional broken stratus cloud with a base of 400 ft to 1,000 ft was forecast around sea coasts and upslopes.

The weather conditions at Rochester Airport (elevation 426 ft amsl) were such that aircraft in the circuit were able to maintain around 1,000 ft aal and remain just below the cloud. Reports from the local flying area were that visibility below the cloud was good.

The METAR's at Lydd, 10 nm to the south west of the accident site, were:

> 1450Z Surface wind from 230º/19 kt, visibility 9,000 m, drizzle, scattered cloud at 800 ft, broken cloud at 1,800 ft, temperature 9ºC, dewpoint 9º C, and pressure 1026 mb.

1520Z Surface wind from 220º/16 kt, visibility 10 km, few cloud at 800 ft, broken cloud at 2,100 ft, temperature 9ºC, dewpoint 8º C, and pressure 1025 mb.'

A satellite photograph for the area at the time of the accident showed general cloud cover over southern England with an additional layer lying along the coast from Folkestone to Ramsgate.

**Witnesses and recorded information**

There were two witnesses, both qualified pilots, who reported seeing the aircraft during its flight. One saw it flying "low", he estimated at 500 ft to 600 ft agl, close to the M20 motorway east of Ashford. The other saw it flying in an area about 2 nm to the south of the accident site, heading in a north-north-westerly direction. He had first seen the aircraft low to the south, then saw it climb a little to clear a line of pylons before it disappeared from his view to the north.

Recordings of the radiotelephony communications between G-TRIO and Manston ATC were available. Small sections of the track of the aircraft were recorded on radar, however, the lowest recorded coverage of primary returns in the area, in the prevailing conditions, was around 1,300 ft amsl. There were no secondary radar contacts.

**Site and wreckage examination**

The aircraft passed low over the roof of a house before impacting a succession of four mature trees immediately beyond it and extending over a distance of 46 m into the garden of a neighbouring house. It also severed a set of mains electricity distribution cables. Its height at this stage remained constant, at approximately 8 m above ground level. It then continued a further 20 m, following a descending trajectory and passed through the canopy of smaller trees at a height of about 5 m above ground level before falling through the canopy and coming to rest in the forked base of a sixth tree, a short distance beyond and 70 m from the first impact. The aircraft was brought to rest in a steep nose-down attitude with its cabin two metres above ground level, wedged into the multi-forked base of the tree. The deceleration during its final arrest was sufficient to cause the engine to tear from its mountings and fall to the ground and the aircraft came to rest with one of the tree's multiple trunks very close to the passenger's head position.

In the initial tree impact, the right outer wing struck the trunk of a conifer some 10 cm in diameter, breaking it and severing the outermost 30 cm of the wing and tip fairing and tearing away the outer half of the right aileron. The subsequent tree impacts, involving a mixture of conifer and deciduous trees, caused the progressive disruption and separation of most of the remaining right wing, including most of the wing strut and the right fuel tank. These latter items followed a separate ballistic trajectory before coming to rest against the side of a large commercial greenhouse approximately 25 m beyond the resting place of the main wreckage, ie some 95 m from the initial tree impact.

Despite the disruption of the right wing and fuel tank, and the severing of the mains electricity distribution cables, there was no fire.

The path of the aircraft through the trees, and the pattern and distribution of damage, suggested that the aircraft was banked to the right at an angle of at least 35° when it struck the first tree. The extent of its initially horizontal trajectory through the trees, together with overall throw of the wreckage, was indicative of significant momentum consistent with a high airspeed: it certainly was not suggestive of a loss of engine power, nor of a reduced airspeed.

The wreckage was examined in detail in situ. It was confirmed that the aircraft had been intact when it first struck the trees, with all flying controls attached and their operating circuits connected. The flaps were fully retracted. The elevator trim indicator in the cockpit showed a setting approximately 40% between neutral and fully nose-down and the angle of the trim tab surface was consistent with this setting. The magneto was switched to BOTH and the throttle, mixture, and hot air controls were all fully forward; however, these controls could have been pulled into their fully forward positions by the engine as it tore from its mounts in the final impact. The altimeter pressure setting was 1024 mb, and the transponder was set to ALT. The transponder code setting knobs had all been broken off in the impact, and the digits showing in the display windows had evidently moved slightly as a consequence: post-accident, they read '4-3', '3-2', '1', and '0'.

The passenger's seat was partially detached from its floor rails but both seat harnesses, which were of a modified type each having dual shoulder straps branching from a single retention strap fixed to the structure, survived intact and the buckle of each had been opened.

There was no fire and the occupants' survival was attributed to the progressive deceleration imparted to the aircraft by its passage through each of the tree canopies and subsequently during its decent into the canopy of the final tree before it was caught in its forked base. By chance, the aircraft suffered no significant frontal impacts or penetrations of the cabin space by tree or wing debris.

**Analysis**

The pilot reported that he had been turning to the left in an attempt to regain VMC when the aircraft hit trees. The evidence from the accident site suggested that the aircraft had been in a banked turn to the right of at least 35º at the time of impact.

The weather at the time of departure from Rochester appeared to the pilot to be reasonable for a cross-country flight. Other aircraft were flying under VFR in the area. As the aircraft tracked to the east, the weather deteriorated necessitating a track reversal to maintain VMC. The pilot described being suddenly confronted with a wall of cloud, although he had already descended below his chosen altitude several times.

The radar evidence suggests that most of the flight was conducted below 1,500 ft amsl although the pilot had wanted to maintain 2,000 ft amsl. Two witnesses saw the aircraft flying low below cloud in the final five minutes. Therefore the conditions for much of the flight were worse than those anticipated by the pilot.

The pilot considered the weather and made the initial decision to go on the flight but then appears to have delayed his decision to turn back as the conditions deteriorated.

The possibility that cannabis may have impaired his judgement and/or handling of complex tasks cannot be excluded.

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Cessna F177RG Cardinal, G-BFPZ |
| **No & Type of Engines:** | 1 Lycoming IO-360-A1B6D piston engine |
| **Year of Manufacture:** | 1973 |
| **Date & Time (UTC):** | 24 April 2008 at 1611 hrs |
| **Location:** | Swansea Airport |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - 2 |
| **Injuries:** | Crew - None Passengers - None |
| **Nature of Damage:** | Damage to the landing gear and tailplane |
| **Commander's Licence:** | Private Pilot's Licence |
| **Commander's Age:** | 68 years |
| **Commander's Flying Experience:** | 892 hours (of which 58 were on type)<br>Last 90 days - 12 hours<br>Last 28 days - 1 hour |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot, follow up telephone inquiries, and in-situ examination by the AAIB of the main landing gear downlocks |

**Synopsis**

On landing, both main landing gears retracted. Upon recovery of the aircraft, the master switch was selected ON, following which the landing gear completed its deployment cycle and locked down; the green GEAR DOWN light also illuminated. A visual check of the landing gear revealed no evidence of failure or defects, although at the time the aircraft was recovered, full functional testing could not be carried out.

**History of the flight**

The pilot reported that the aircraft had been flown without incident earlier on the day of the accident, and that both the departure from Yeovil and the flight to Swansea were uneventful. The front seat passenger was also a PPL holder and acted as 'co-pilot' on the flight, handling the radio and navigation.

Upon contacting Swansea they were informed that Runway 22 was in use, with a right-hand circuit and, with no other traffic in the circuit, they elected to join on a left base leg. After slowly retarding the throttle on base leg, the gear horn sounded as the airspeed reduced through around 100 kt and the pilot moved the landing gear selector lever to the down position. After doing so, he recalled the amber 'gear unsafe' light illuminating and then extinguishing as the gear extended, accompanied by what he described as the "usual audible rumble and clonks". He asked the passenger to check that he could see both the nose and right main wheels, using a convex mirror beneath the right wing. The passenger confirmed that he could. The pilot then glanced down to his left to check the main wheel on the left side, which he could see, but he omitted to check that the single green GEAR DOWN light was illuminated.

Just before turning finals at 90 kt, the pilot selected first stage flaps and at the commencement of final approach he reported that his passenger called "finals three greens". The pilot was occupied with his approach checks at this stage and omitted to confirm the gear down indication, selecting second stage flaps at 80 kt. The final approach and initial touchdown both felt normal but, as the aircraft settled onto the runway and the nosewheel contacted the ground, there was a scraping sound from the tail. Glancing over his shoulder, the pilot realised that the main wheels had retracted. At the same time, the aircraft started to veer left towards the Alpha taxiway intersection. The ignition and master switches were turned to OFF, and the aircraft came to a halt without further incident on the left edge of the runway at the taxiway intersection, having left a scrape mark on the runway some 156 m in length. All three occupants evacuated the aircraft without difficulty.

**Aircraft examination**

The aircraft owner, who was involved in recovering the aircraft from the runway, reported that after lifting the aircraft clear of the ground, he turned on the master switch. The landing gear then proceeded to continue its cycle and lock down, and the green landing gear safe light illuminated.

The pilot was unable to explain the collapse of the main landing gear but acknowledged that, as PIC, he had at least two opportunities to check that the GEAR DOWN light was illuminated, but failed to do so.

In light of prior instances of main landing gear down lock failure on Cessna 177RG aircraft, the down locks on G-BFPZ were examined in situ for visual signs of malfunction or failure, following the aircraft's recovery and the lowering of the gear by the owner. Both lock assemblies, which were of the later hydraulically (as distinct from electro-mechanically) actuated type, appeared normal, and each was fully engaged. Functional checks could not be carried out in situ due to lack of suitable jacking equipment, but in the event that further information as to the cause of the landing gear collapse becomes evident during repair of the aircraft, an addendum will be issued in a future AAIB Bulletin.

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Cessna R182 Skylane RG, G-BOWO |
| **No & type of Engines:** | 1 Lycoming O-540-J3C5D piston engine |
| **Year of Manufacture:** | 1978 |
| **Date & Time (UTC):** | 6 October 2007 at 1600 hrs |
| **Location:** | Wolverhampton (Halfpenny Green) Airfield, W Midlands |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - 2 |
| **Injuries:** | Crew - None Passengers - None |
| **Nature of Damage:** | Damage to left main landing gear and tailplane |
| **Commander's Licence:** | Commercial Pilot's Licence |
| **Commander's Age:** | 45 years |
| **Commander's Flying Experience:** | 2,463 hours (of which 25 were on type)<br>Last 90 days - 46 hours<br>Last 28 days - 15 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot and metallurgical examination of components |

**Synopsis**

The aircraft landed with the left main landing gear not fully down. Metallurgical examination showed that this was due to the separation of the landing gear pivot assembly which had resulted from a cyclic fatigue mechanism. There is a history of similar failures on the R182 and the 172RG which share a similar, but not identical, design of the pivot assembly to that on G-BOWO.

**History of the flight**

The aircraft was approaching Wolverhampton following an uneventful flight when the pilot selected the landing gear down. However, he did not receive a green 'down and locked' indication. He re-cycled the landing gear several times, but to no avail. He then performed a low fly-past of the ATC tower and was informed that the left main landing gear was not fully down. He attempted to lower the landing gear using the manual hydraulic pump and attempted 'energetic' manoeuvres in roll and pitch in an attempt to dislodge the gear, all without success.

Having briefed the passengers, the pilot carried out a landing on the grass Runway 10; the aircraft continued in a straight line until the left wing began to drop and the aircraft then departed to the left, coming to rest on the side of the adjacent tarmac Runway 10.

**System description**

The aircraft has a hydraulically actuated, retractable, tricycle landing gear system; each landing gear leg is individually actuated by a hydraulic actuator supplied by an electrically operated hydraulic power pack. When the landing gear is selected DOWN, hydraulic pressure causes a rotary actuator to operate a pivot assembly via a splined shaft, and each main landing gear strut rotates forward and outboard (see Figure 1). Once the landing gear has locked down, microswitches for each gear leg trigger a respective green light in the cockpit, and the gear selector returns to the neutral position.

An emergency hand pump is available for emergency extension of the gear. A nose landing gear squat switch prevents inadvertent retraction whenever the nose gear strut is compressed.

**Recent maintenance history of the aircraft**

There had been a reported loss of hydraulic fluid from the right brake for some weeks prior to the accident, but no cause had been identified. Following recovery of the aircraft after the accident, the actuator assembly was removed, which revealed the surrounding area to be awash with brake fluid. There was no hydraulic leak from the landing gear actuators.

In September 2006 G-BOWO experienced a hard landing on the nose landing gear in gusty wind conditions, which was reported in AAIB Bulletin 12/2006, file ref EW/G2006/09/02. Damage was reported to be limited to the collapse of nose landing gear and damage to the propeller. No inspection was carried out on the main landing gear pivot assembly.

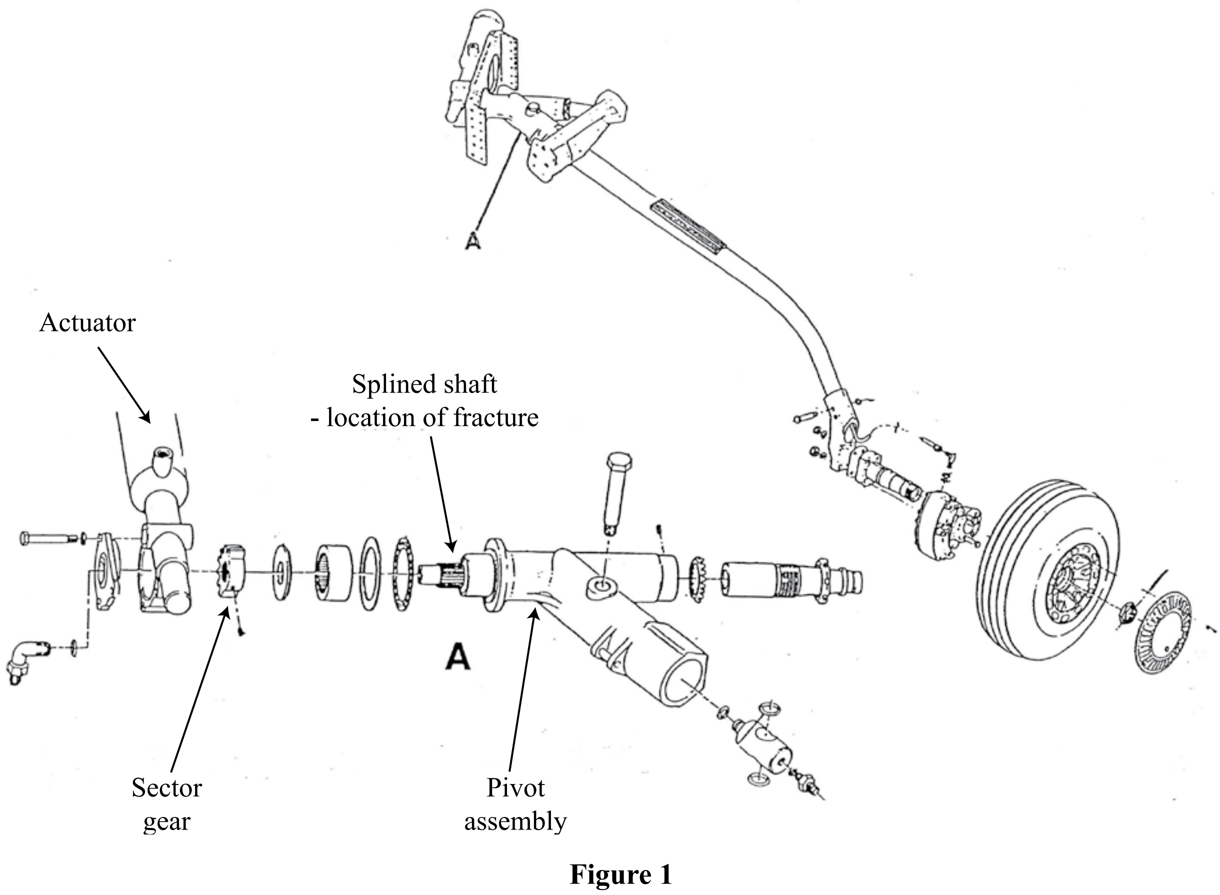


**Figure 1**

R182 Main landing gear pivot assembly

**Metallurgical examination**

The detached pivot assembly was returned to AAIB for metallurgical examination. The pivot assembly had separated in the area of the splined shaft. The fracture surface had been partially damaged by smearing during rotational movement, most likely caused during the repeated attempts to operate the gear prior to the landing. A number of fatigue fracture initiation sites were found at the edge of the fracture face, adjacent to a lubricating hole (see Figure 2). The examination concluded that the separation of the pivot assembly had resulted from a cyclic fatigue mechanism during normal functioning of the landing gear in service.

*Photo – HT consultants*

**Figure 2**

Edge of the fracture face adjacent to the lubricating hole which, although smeared, shows multiple fatigue initiation sites resulting in castellations

**Previous safety action**

A Service Bulletin (SB), reference SEB90-1 and entitled '*Main Landing Gear Pivot Inspection*', was published in 1990. It is applicable to the Cessna 172 and 182 models with retractable landing gear, for which the pivot assembly design is similar, however G-BOWO, Serial Number R18200146, was amongst a number of R182 aircraft not affected by the SB. The SB required inspection of the main landing gear pivot for cracks in the spline area; replacement pivots were available which were designed with an improved fatigue life. The SB also states that:

> *'this inspection must be repeated any time an airplane has experienced a landing gear overload condition or if the brakes have a "spongy" operation that cannot be attributed to brake component wear or improper servicing.'*

An accident occurred in 1991 to a Cessna Model 172RG, N9592B which made an intentional wheels-up landing at DuPage Airport, West Chicago, Illinois following repeated unsuccessful attempts to lower the landing gear. Metallurgical examination by the National Transportation Safety Board (NTSB) showed that:

> *'the splined aluminium shaft on the right main landing gear pivot assembly had failed in torsional overload. Cracks were observed at the roots of many of the spline teeth and were observed to have propagated a significant distance into the shaft.'*

The NTSB found that there have been a significant number of Service Difficulty Reports (SDRs) on the Cessna Model 172RG which indicated two failure modes related to the cracking or fracture of the pivot assembly shaft. They were, firstly, the loss of braking action or brake fluid due to cracks in the pivot assembly shaft, and secondly, mechanical separation of the pivot assembly due to the failure of the spline shaft. Several SDRs had also been submitted regarding spongy brake operation or loss of brake fluid in R182 aircraft due to cracked pivot assemblies. At that time on the R182, none of the cracks were related to accidents or incidents and there were no reports of failure of the main landing gear due to the fracture of the splined shaft. The view of the NTSB then was that the pivot assembly for the 172RG:

> *'is not adequate for long term service and that the design on the new pivot assembly's splined shaft should be changed to improve its structural integrity.'*

Three further SDRs were raised on R182 aircraft, in 1996, 2001 and 2002; all had cracked pivot assemblies and brake fluid leaks which were found during maintenance.

The NTSB issued two safety recommendations to the Federal Aviation Administration (FAA) in 1993. They recommended that the FAA issue an Airworthiness Directive (AD) to mandate Cessna SB SEB90-1 on Cessna Model 172RG aircraft with main landing gear pivot assemblies which have been in service for 2,000 hours to more, or which have been subjected to excessive side loads or other hard landing conditions (A-93-74). Secondly, NTSB recommended that the FAA should require Cessna Aircraft Company to change the design of the splined pivot shaft in order to improve its structural integrity and durability (A-93-75).

The FAA responded to the two recommendations in 1995 having completed an investigation into these failures. They conducted numerous cyclic tests using the original pivot assembly forging and the new improved forging; they reported no failures in 900,000 cycles. The FAA did publish a General Aviation Airworthiness Alert in Advisory Circular 43-16 which reminded pilots of the importance of reporting hard landing or other severe conditions, so that proper inspections could be carried out. The NTSB view was that there still a need for inspection of current pivot assemblies and classified the response as *'closed – unacceptable action*'.

In May 2001, the FAA issued an AD (2001-06-06) which mandated Cessna Service Bulletin SEB90-1 at Revision 3 on the 172RG, but not on the R182. Revision 3 introduced a service kit modification for the pivot assembly for the 172RG. For the R182, Revision 3 only required the removal of a bushing to facilitate the inspection if this had not been removed during an earlier inspection; if it had been removed, compliance with Revision 3 was not required. Due to minor design differences, Revision 3 is not effective for all R182 aircraft and G-BOWO, Serial Number R18200146, was one of those aircraft not affected.

**Discussion**

The metallurgical examination showed that separation of the pivot assembly had resulted from a cyclic fatigue mechanism during apparently normal functioning of the landing gear in service. Fracture of the splined shaft resulted in the separation of the pivot assembly and the gear strut from the hydraulic actuator, making mechanical extension of the landing gear impossible. The limited history of failures on the R182 might support the same conclusion on the R182 as the NTSB had made on the 172RG, ie that the design is not adequate for long term service; however the work done by Cessna and the FAA failed to reproduce the failure mode. Also, the in-service history of G-BOWO raises questions about the exact cause of the failure in this case. Nonetheless, the work done by Cessna and the FAA, as well as this accident, show that it is important for owners and operators to be aware of damage which can result from operation outside the normal operating envelope.

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Cessna T303 Crusader, G-CYLS |
| **No & Type of Engines:** | 2 Continental Motors Corp. TSIO-520-AE piston engines |
| **Year of Manufacture:** | 1982 |
| **Date & Time (UTC):** | 31 December 2007 at 1016 hrs |
| **Location:** | Guernsey Airport, Channel Islands |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - None |
| **Injuries:** | Crew - None Passengers - N/A |
| **Nature of Damage:** | Damage to aircraft nose and propellers |
| **Commander's Licence:** | Airline Transport Pilot's Licence |
| **Commander's Age:** | 39 years |
| **Commander's Flying Experience:** | 5,400 hours (of which 16 were on type)<br>Last 90 days - 52 hours<br>Last 28 days - 21 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot |

**Synopsis**

Shortly after touching down after a normal approach, the nose landing gear collapsed, causing substantial damage to the aircraft. It was established that the nose gear actuator locking lugs had failed, allowing the nose gear to unlock and collapse forward on touchdown. Evidence was found of pre-existing cracks in the locking lugs; however, it was not determined by what mechanism the cracks had propagated.

**History of the flight**

The pilot approached Guernsey from the north and was given clearance for a right-hand base leg join for Runway 27. On base leg, he selected the first stage of flap and lowered the landing gear and recalled hearing the usual noises and observing the normal trim changes. He confirmed three green 'down and locked' indications were showing and that the gear was actually down by looking in the landing gear viewing mirror. On final approach, he selected landing flap and received the clearance to land. The approach was reportedly stable, with no crosswind and the aircraft touched down on the runway just beyond the numbers. On lowering the nose, it continued to drop and it quickly became apparent from the nose-down attitude and the damage to the now stationary propellers, that the nose gear had collapsed. The aircraft travelled in a straight line with its nose scraping on the runway surface, coming to rest about 300 m along the runway. The pilot was uninjured and exited normally via the rear door.

## Aircraft information

*Background information*

The Cessna T303 Crusader is an all-metal, low-wing, six-seat, twin-engined aircraft with a tricycle landing gear. A total of 315 were manufactured. G-CYLS was serial number T303-00005 and was built in 1982. It held a current EASA Certificate of Airworthiness, valid until 18 May 2008.

## Aircraft damage

The aircraft sustained structural damage to its nose, which had buckled. It was also heavily abraded on its underside from sliding along the runway surface, Figure 1. The propellers were also badly damaged from striking the runway. Closer examination revealed that the locking lugs of the nose gear actuator had fractured, causing the gear to unlock and collapse forward as weight was applied to it on landing.

## Nose landing gear description

The nose gear, which retracts forwards, consists of a shock strut mounted in a trunnion assembly, a nosewheel, shimmy damper and a double-acting hydraulic actuator for extension and retraction. The upper end of the actuator is fixed to the aircraft structure and the end of the actuator ram is attached to the rear of the nose gear.

During gear extension, hydraulic pressure is ported to retract the actuator ram, causing the nose gear to extend rearward. When fully down, spring-loaded locking hooks on the end of the ram engage onto downlock pins on the body of the actuator. The gear is thus mechanically locked in the down position by the body of the actuator, which acts as a rigid drag strut. The downlock pins are located in locking lugs on the actuator body and are retained by roll-pins.

## Nose gear actuator information

The actuator fitted to G-CYLS was manufactured in 1981 and was identified with part number 1280514-11 and serial number 133. Enquiries of the aircraft manufacturer revealed that there are no overhaul or special inspection requirements for the nose gear actuator. It is therefore possible that the failed actuator had been on the aircraft since aircraft build.

**Figure 1**

Photograph of G-CYLS showing damage to nose of aircraft

## Nose gear actuator examination

The failed actuator was subjected to detailed metallurgical examination. Both locking lugs had fractured, liberating a segment of each lug and its downlock pin, Figure 2. However, the roll-pins had remained in the lugs.

Of the two fractures on each lug, one was solely the result of ductile overload and thus secondary to the initial failure; the other exhibited much less deformation. One of the two 'primary' fractures was very flat in appearance with no obvious signs of ductile overload and was also

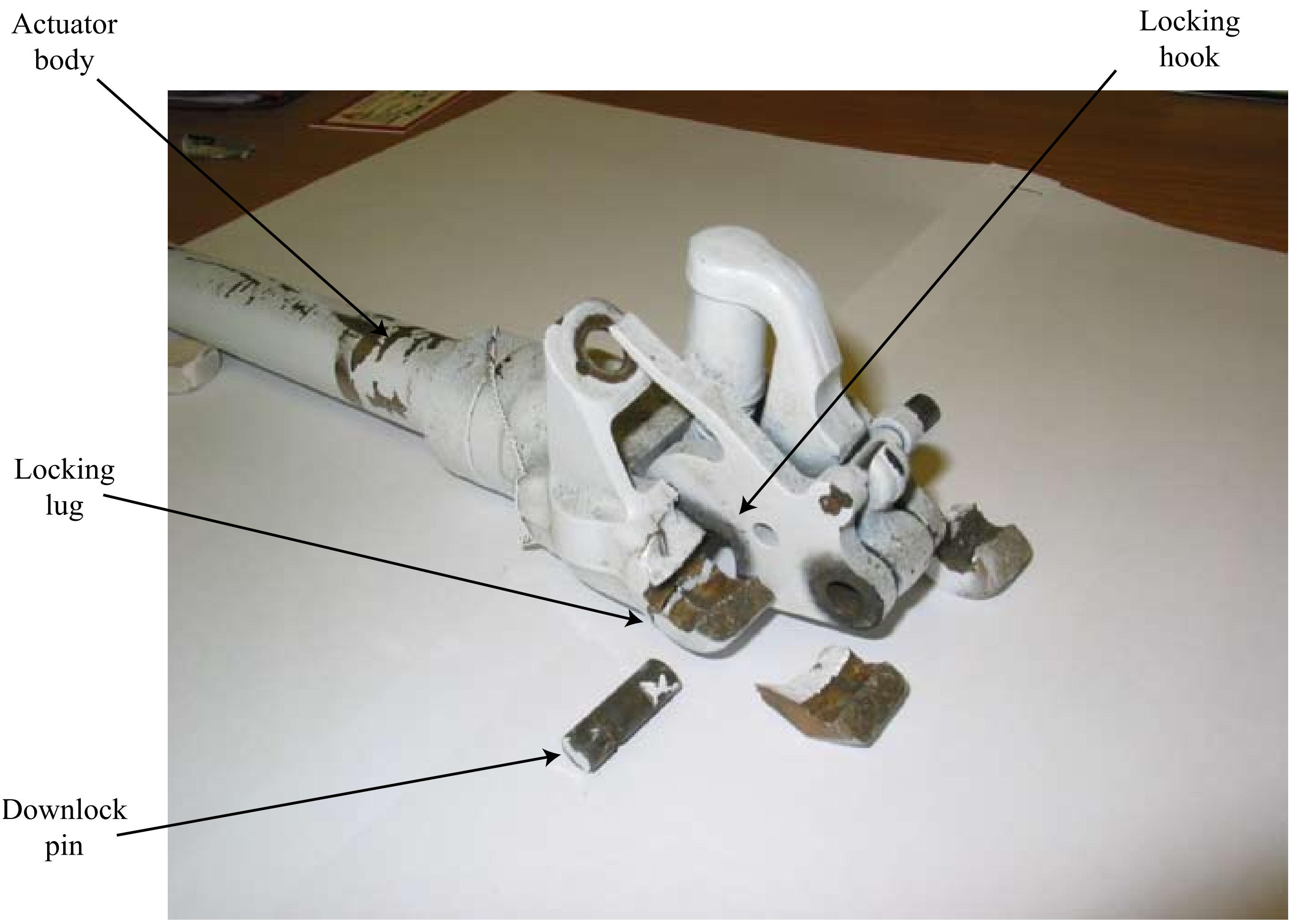


**Figure 2**

G-CYLS nose gear actuator showing fractured locking lugs
(actuator ram in fully retracted position)

considerably more discoloured by corrosion products than the other, Figure 3. The other primary fracture differed in having a lesser degree of discoloration and a clearly visible region of ductile overload.

Detailed fractographic examination, using optical and scanning electron microscopy, showed the primary fractures to be generally intergranular in nature, with no evidence of fatigue propagation. It was not possible to state with any certainty what mechanism had caused the primary fractures.

Metallographic examination of the lugs revealed an unfavourable grain orientation around the ends of the lugs, such that the applied loads were acting along the grain boundaries; this was evidenced by the directions of the primary fractures being parallel to the grain boundaries.

**Discussion**

The discoloration of the primary fractures of the actuator locking lugs is indicative that these had been present for some time, in contrast to the fresh appearance of the final ductile overload failures that resulted in the nose gear collapse. The cracks had therefore occurred over a period of time, but it was not clear what mechanism had caused the primary fractures. It is conceivable that

**Figure 3**

Photograph showing primary (A) and secondary (B) fractures of nose gear actuator locking lug

a discrete occurrence such as a shock load from a heavy landing, or mishandling during towing, may have been the initiating event.

The unfavourable orientation of the grain boundaries at the ends of the lugs is likely to have had a significant influence on the local strength of the material, effectively providing planes of weakness for crack initiation and propagation.

The aircraft manufacturer reported that they were aware of occurrences of lugs/pins failures on this actuator. In their experience, rough ground handling creates more damage than normal operations and they are of the opinion that the subject failure was likely to have been induced by earlier (rough) ground handling.

**Safety action**

In the original design, as shown in Figure 2, a groove was cut into the pin and the roll-pin engaged with this groove to retain the pin. In the new design, the groove was eliminated, as it acted as a stress concentration, and replaced by a hole through the pin into which the roll-pin is inserted.

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Cirrus SR20, G-TAAA |
| **No & Type of Engines:** | 1 Teledyne Continental IO-360-ES piston engine |
| **Year of Manufacture:** | 2005 |
| **Date & Time (UTC):** | 10 June 2008 at 1653 hrs |
| **Location:** | Denham Airfield, Buckinghamshire |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - 1 |
| **Injuries:** | Crew - 1 (Minor) Passengers - 1 (Minor) |
| **Nature of Damage:** | Damaged beyond economic repair |
| **Commander's Licence:** | Private Pilot's Licence |
| **Commander's Age:** | 61 years |
| **Commander's Flying Experience:** | 417 hours (of which 47 were on type)<br>Last 90 days - 26 hours<br>Last 28 days - 4 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot and further AAIB inquiries |

**Synopsis**

Following an approach to land flown with a higher than normal threshold speed, the aircraft bounced three times. The propeller struck the runway surface on the second and third bounces. After the third bounce, the pilot initiated a go-around and the aircraft started to climb. The flaps were raised fully but the aircraft crashed into a wood that lay beyond and slightly to the left of the end of the runway.

**History of the flight**

The aircraft departed the airfield at 1610 hrs for a navigation exercise, which was uneventful, and returned approximately 1 hour 50 minutes later. At the time of the approach the wind was 360º/10 kt giving a crosswind of approximately 9 kt from the left. The airfield was reporting CAVOK, a temperature of +20º C and a QNH of 1024 mb.

The approach to Runway 06 was flown with flaps at 100% in accordance with the pilot's operating handbook (POH). The pilot recalled that the approach was "good" except that he believed the threshold speed was between 80 and 85 kt rather than 75 kt as specified in the POH. The aircraft touched down and immediately bounced back into the air. The next contact with the ground was nosewheel first and the propeller struck the runway before the aircraft bounced again. The final contact with the runway was also nosewheel first and once again the propeller struck the runway before the aircraft bounced. The pilot decided to go around and applied full throttle, leaving the flaps at 100%. He was not aware that the propeller had struck the runway and he did not notice any lack of thrust compared to normal. At the point that the go-around was initiated, the aircraft was seen to be "close to the numbers on the Runway 24 threshold"[1].

The pilot reported that the aircraft climbed on a heading slightly to the left of the runway centreline. When he decided there was a positive rate of climb, he raised the flaps from 100% to 0% but the aircraft began to sink with its wings level. He did not remember the exact height or speed at flap retraction and did not report any indications of approaching the stall. The aircraft crashed into a wood that began approximately 100 m beyond the runway and slightly to the north of the extended centreline. Just prior to impact the pilot assessed that the nosewheel would clear the trees but not the main landing gear and the aircraft entered the trees "belly first". A witness saw the aircraft attempt to get airborne and also saw it "belly land" into the trees. It came to rest approximately 150 m beyond the end of the runway and 35 m to the left of the extended runway centreline.

There was no evidence of fire, fuel spillage or electrical burning at the accident site. Both occupants were wearing full harnesses and able to vacate the aircraft unassisted. The pilot ensured that the fuel and electrics were turned off and he inserted the safety pin into the ballistic recovery system (BRS). Later, the manufacturer's representative attended the site to ensure that the BRS was made safe.

**Footnote**

1 The painted numbers are 105 m from the end of the hard surface.

**Operating procedures**

The SR20 training guide states that:

> *'a stabilised approach is critical to a good landing. If a stabilised approach is not attained by 200 ft agl a go around must be executed.'*

A *'proper airspeed'* is included as one of the stabilised approach criteria. The guide advises that flaps should be raised to 50% prior to applying power on a touch and go or a stop and go landing. It also notes:

> *'the aircraft may or may not be trimmed for a normal takeoff when executing a stop and go / touch and go. Be very conscious of rotation speeds and pitch attitudes during the takeoff roll and climb. Re-trim the aircraft when time permits.'*

Following a go-around or balked landing, flaps should be retracted from 50% to 0%

> *'above 85 kt IAS; when clear of obstacles and terrain; and with a positive rate of climb.'*

**Performance information**

Following the accident, the Chief Flying Instructor (CFI) of the operator concerned carried out a trial at a safe altitude and achieved a rate of climb of 800 ft/min with 50% flap following a simulated go around. The rate of climb reduced to 200 ft/min when flaps were raised to 0%.

**Analysis**

Discussion with the pilot and CFI suggested that the slightly high approach speed caused the aircraft to float when the pilot checked the rate of descent prior to landing. Concerned that the aircraft was now using up available landing distance, the pilot probably lowered the nose in an attempt to land. This set up a rate of descent sufficient to cause the aircraft to bounce. A similar sequence of events followed but on these occasions the nosewheel contacted the runway before the main landing gear and the propeller struck the runway before the aircraft bounced.

The go-around was initiated with limited runway remaining and the flaps were left at 100% prior to applying full power. This meant the aircraft was climbing in a configuration unfamiliar to the pilot. He did not notice a reduction in thrust from normal full power but a marginal loss of thrust would only have served to reduce the climb performance of the aircraft. He noticed a sink when the flaps were raised but the wings remained level. Although the rates of climb observed by the CFI in his trial are not published figures, they give an indication of the decrease in climb performance that would have been caused by raising the flaps. In the accident event, the rate of climb achieved following flap retraction was not sufficient for the aircraft to clear the trees.

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | DH60G Gipsy Moth, G-ABDA |
| **No & Type of Engines:** | 1 De Havilland Gipsy 1 piston engine |
| **Year of Manufacture:** | 1931 |
| **Date & Time (UTC):** | 5 May 2008 at 1117 hrs |
| **Location:** | 1 km south of Perth Aerodrome, Perthshire |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - 1 |
| **Injuries:** | Crew - None Passengers - None |
| **Nature of Damage:** | Landing gear collapsed, engine detatched from fuselage, propeller broken, leading edge of wings and fuel tank damaged |
| **Commander's Licence:** | Commercial Pilot's Licence |
| **Commander's Age:** | 57 years |
| **Commander's Flying Experience:** | 2,442 hours (of which approximately 1,000 were on type)<br>Last 90 days - 30 hours<br>Last 28 days - 22 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot |

**Synopsis**

Shortly after takeoff, the pilot noticed the engine was running roughly and that power was decreasing despite full throttle being selected. As the aircraft was unable to maintain altitude, a MAYDAY was declared and a forced landing was carried out in a field of standing crop. The aircraft sustained substantial damage in the landing, but both occupants were uninjured and able to leave the aircraft unaided. Weather conditions at the time were highly conducive to the formation of carburettor ice.

**History of the flight**

The aircraft, a biplane of, primarily, fabric covered wooden construction, was on a touring trip from its base in southern England. It had arrived in Perth the previous day and was parked in a hangar overnight. The owner, together with a pilot accompanying him on the trip, arrived the following morning with the intention of making a short flight to Strathallan. Although not an instructional flight, the pilot, an experienced Tiger Moth instructor, was to fly the aircraft from the front cockpit to allow the owner, a qualified private pilot with limited time on type, to gain experience flying the aircraft from the rear cockpit.

The planned departure was delayed to allow the early morning mist to clear sufficiently for the flight to proceed. The aircraft was parked on the grass apron where the engine was started without any problems with the owner in the rear cockpit operating the controls, and the pilot outside hand-swinging the propeller. The aircraft is not fitted with brakes so, as usual, the engine warm-up and power checks, which were satisfactory, were conducted in the parking position using chocks to prevent the aircraft moving. The pilot then removed the chocks and boarded the aircraft.

As the aircraft is not fitted with wheel brakes, the pilot taxied the aircraft across the grass to holding point 'B' for a departure off Runway 09. After completion of the pre-takeoff checks, the aircraft was lined up on the runway, which enabled approximately 420 m of the 609 m runway to be used. The pilot considered this to be sufficient for the takeoff and avoided the need to complete a back-track manoeuvre as, due to the landing gear design, the aircraft has limited turning ability on the ground. He also wished to avoid scraping the tail skid on the hard runway surface.

The takeoff and initial climb appeared normal. At approximately 300 ft, the pilot asked the owner to confirm that the carburettor air heat was in the OFF position as the engine appeared to have lost power, the only control for this being in the rear cockpit. Shortly afterwards, at between 300 ft and 400 ft, the engine was still loosing power and the aircraft had started to descend, despite full throttle being selected. The pilot turned the aircraft approximately 30° left to avoid houses and power lines, and prepared for a forced landing in a large field of oilseed rape crop. A MAYDAY was declared with Perth Radio. In focussing upon the landing, the pilot reported that the carburettor air heat control remained in the OFF position.

The landing was made in a three-point attitude. The initial landing run was normal until a deep furrow was encountered by the left wheel, causing the aircraft to yaw left. The aircraft suffered substantial damage and came to rest tipped on to its nose. Both occupants were uninjured and able to leave the aircraft unaided. There was no fire.

On hearing the MAYDAY, the radio operator alerted the Airport Fire Service, who arrived quickly on the scene. The radio operator then attempted to contact the aircraft, but a reply was received only when the pilot determined it was safe to return to the aircraft.

Initial examination of the aircraft's engine revealed no obvious signs of any failure.

**Discussion**

In the absence of any obvious defects or failures, the pilot, with hindsight, considers that carburettor icing may have been one potential cause of the engine's loss of power. He reported that the heat control remained in the OFF position for the duration of the flight. The flight had waited for the early morning mist to clear but the grass in the parking area, where the power checks were made, and along the taxi route, were wet. Both of these are cited as indicators of high humidity and, therefore, a high risk of carburettor icing would have existed in these conditions, reference CAA Safety Sense Leaflet No 14b, *Piston Engine Icing*. The weather report from the nearest major airfield, RAF Leuchars, 17 nm to the east, indicated similar conditions. The surface temperature was reported as 20°C.

This accident highlights some human factor issues related to the configuration of the aircraft. Many Tiger Moth aircraft have an automatic carburettor air heat system, whereas the accident aircraft had a manual carburettor air heat control, with the operating lever fitted to the rear cockpit only. Thus, whenever the aircraft is flown from the front cockpit, any selection of the control has to be made by the occupant of the rear cockpit at the handling pilot's request. The pilot on this occasion considers that, on reflection, his familiarity with a similar type of aircraft which has the automatic carburettor heat system, and the lack of a carburettor air heat control in the front cockpit to act as a trigger for its use, may have contributed to it not being used before takeoff. However, the pilot did ask the owner to check the carburettor heat control was selected to OFF when initially trying to diagnose the loss of power[1].

If any relevant failures are identified during subsequent repair/overhaul activity, they will be reported upon in a future AAIB Bulletin.

**Footnote**

[1] Selecting carburettor air to hot directs unfiltered warmed air into the carburettor, to melt any ice that may have formed; the warm air, however, causes a reduction in power output, and may cause the engine to run more roughly as the consequent water is ingested by the engine.

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Europa, G-RICS |
| **No & Type of Engines:** | 1 Subaru EA81 piston engine |
| **Year of Manufacture:** | 1997 |
| **Date & Time (UTC):** | 10 May 2008 at 1710 hrs |
| **Location:** | Wellcross Farm, Horsham, West Sussex |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - None |
| **Injuries:** | Crew - None Passengers - N/A |
| **Nature of Damage:** | Broken undercarriage leg and propeller strike |
| **Commander's Licence:** | National Private Pilot's Licence |
| **Commander's Age:** | 62 years |
| **Commander's Flying Experience:** | 250 hours (of which 130 were on type)<br>Last 90 days - 4 hours<br>Last 28 days - 4 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot |

**Synopsis**

The aircraft touched down well beyond the threshold on a short grass strip. During the landing roll the pilot lost directional control and the aircraft went into a ditch.

**History of the flight**

The aircraft was built in 1998 from a kit, and originally had a mono-wheel undercarriage; later that year it was modified to have a conventional tricycle undercarriage in a tail-wheel configuration. The aircraft was described by experienced pilots who had flown it as 'being an aircraft which needed careful handling on the ground, particularly at speeds below 40 kt.'

On 10 May 2008 the pilot flew the aircraft flew from Old Sarum, Salisbury, and joined the circuit pattern for Runway 22 at Wellcross Farm. Runway 22 was 650 m long by 40 m wide and its surface was short grass. The runway was on a hill, with its highest point being approximately the runway midpoint. The weather conditions were described as good with a light and variable wind.

The aircraft was positioned onto its final approach and the pilot noted that the airspeed was 10 kt faster than the normal approach speed and that the approach path was also steeper than usual. He selected full flap and reduced the power to idle, but was still unable to touch down where he intended, so he accepted a landing point further down the runway. As he flared the aircraft to land the airspeed was still between 5 and 10 kt fast and the aircraft floated for some distance before touching down; it then bounced and became airborne again. The aircraft finally landed with what the pilot estimated was about 200 m remaining, and he applied the brakes. The aircraft yawed to the right then rapidly to the left. The pilot was unable to control the aircraft's direction and it slid into a drainage ditch at approximately 10 kt. The aircraft's undercarriage and propeller were damaged.

The pilot considered that the cause of the accident was his unstable approach and touching down beyond his normal touchdown point with a higher than normal airspeed. He also considered that the high temperatures and a light tailwind may have been contributory factors.

**Comment**

CAA Safety Sense Leaflet No 1 ('*Good Airmanship Guide*') states that a good landing is the result of a good approach. If the approach is poor, the pilot should make an early decision and go-around. Pilots should plan to touch down at the correct speed, close to the runway threshold, and should go around if not solidly 'on' in the first third of the runway.

A tail-wheel undercarriage configuration is generally more difficult to control on the ground than a conventional tricycle undercarriage configuration, because the center of mass is located behind the front landing gear. It seems that, in this case, the pilot lost directional control whilst attempting to stop the aircraft in less than his normal stopping distance.

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Europa XS, G-FIZY |
| **No & Type of Engines:** | 1 Rotax 912-UL piston engine |
| **Year of Manufacture:** | 2007 |
| **Date & Time (UTC):** | 30 March 2008 at 1415 hrs |
| **Location:** | White Oxmead, 4 miles south west of Bath |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - None |
| **Injuries:** | Crew - None Passengers - N/A |
| **Nature of Damage:** | Damage to landing gear, left wing, engine and propeller |
| **Commander's Licence:** | National Private Pilot's Licence |
| **Commander's Age:** | 61 years |
| **Commander's Flying Experience:** | 135 hours (of which 7 were on type)<br>Last 90 days - 7 hours<br>Last 28 days - 4 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot |

**Synopsis**

Immediately after lifting off from an undulating grass runway, the aircraft's right wing dropped. The pilot applied left aileron to correct the roll, which resulted in the aircraft rolling sharply to the left. As it passed over the left edge of the runway, the aircraft struck a hedge and came to rest in an adjacent field. The pilot was uninjured.

**History of the flight**

During the takeoff, the pilot applied slight back pressure to the control column as the aircraft accelerated past 50 kt. It then passed over a series of undulations in the runway surface which caused it to lift off and, as the aircraft rotated towards its climbing attitude, the right wing started to drop. The pilot applied left aileron to correct the roll and this resulted in the left wing dropping rapidly and the aircraft turning to the left. After crossing the edge of the runway the aircraft struck a boundary hedge and came to rest on its nose in a field of standing crops approximately 40 m beyond the hedge. The pilot was uninjured and was able to leave the aircraft unassisted.

The reported weather in the area at the time of the accident gave the wind direction as 240° with a wind speed of 5 kt gusting to 15 kt. In view of the undulating nature of the runway surface it is possible that the aircraft became airborne before reaching its required takeoff speed. In this situation, any decrease in airspeed due to the gusty nature of the wind may have resulted, momentarily, in the right wing becoming partially stalled, before responding to the left roll demand.

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Grob G115D 2, G-BVHF |
| **No & Type of Engines:** | 1 Lycoming AEIO-320-D1B piston engine |
| **Year of Manufacture:** | 1994 |
| **Date & Time (UTC):** | 6 May 2008 at 1431 hrs |
| **Location:** | Dundee Airport |
| **Type of Flight:** | Training |
| **Persons on Board:** | Crew - 1 Passengers - None |
| **Injuries:** | Crew - None Passengers - N/A |
| **Nature of Damage:** | Damage to the engine, propeller, spinner and leading edge of port wing |
| **Commander's Licence:** | Student pilot |
| **Commander's Age:** | 18 years |
| **Commander's Flying Experience:** | 11 hours (of which 11 were on type)<br>Last 90 days - 11 hours<br>Last 28 days - 11 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot and flying club staff |

**Synopsis**

The student pilot was unable to control a left yaw which developed during the takeoff roll on her first solo flight. The aircraft crossed the side of the runway and struck a perimeter fence before she could bring it to a halt.

**History of the flight**

The student pilot had successfully completed two circuit training sessions on the day of the accident after which the instructor decided she was ready to undertake her first solo. After briefing her, the instructor vacated the aircraft and went to the control tower to monitor the flight. The student completed the power and pre-take off checks before back-tracking and lining up on Runway 10.

She commenced her takeoff roll with the surface wind reported as 070/12 kt. As the aircraft accelerated, the student applied right rudder but was unable to control a developing yaw to the left. The aircraft crossed the side of the asphalt runway onto the grass verge and hit a perimeter fence at slow speed before stopping. The student was uninjured in the accident which was quickly attended by the airport emergency services.

The flying school considered that if the nosewheel was not centred after the lining-up manoeuvre, the tendency of the aircraft to yaw left under power would have been exasperated. The wind direction would also have added a further left yaw effect.

## ACCIDENT

| | |
|---|---|
| **Aircraft Type and Registration:** | Piper PA-22-160 Tri-Pacer, G-ARDT |
| **No & Type of Engines:** | 1 Lycoming O-320-B2B piston engine |
| **Year of Manufacture:** | 1958 |
| **Date & Time (UTC):** | 18 May 2008 at 1230 hrs |
| **Location:** | Northside, 5 miles SW of Aberdeen |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - 2 |
| **Injuries:** | Crew - None Passengers - 1 (Serious) 1 (Minor) |
| **Nature of Damage:** | Substantial: left wing destroyed, right wing damaged, landing gear severely damaged, engine shock-loaded, propeller damaged, cowlings and struts disrupted. Aircraft damaged beyond economic repair |
| **Commander's Licence:** | Private Pilot's Licence |
| **Commander's Age:** | 51 years |
| **Commander's Flying Experience:** | 675 hours (of which 176 were on type)<br>Last 90 days - 5 hours<br>Last 28 days - 4 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot and subsequent AAIB enquiries |

### Synopsis

The pilot made an approach, with a tailwind, to a private strip which had significant uphill slope. At about 50 ft aal, he decided to go around, and intended to selected the flaps from FULL to HALF, but accidentally selected the flaps to UP. The aircraft sank and touched down, ran into obstacles, and sustained substantial damage.

### History of the flight

The aircraft departed from Oban on a private flight to its base at Northside, a private air strip near Aberdeen. The pilot, who was also the aircraft owner, was familiar with both the aircraft and destination.

The weather was fine with good visibility, no low cloud, and a northerly breeze, and the flight was uneventful until the final approach to the strip. The strip was orientated north/south, 425 m long, and of short mown grass. Telegraph lines ran across the southern end of the strip, and so all takeoffs were to the north and landings to the south. The centre and southern portions of the strip sloped upwards towards the south at an angle of about 25º to the horizontal. A copse, a short distance north of the northern end of the strip, necessitated an 'S' turn on the final approach.

Approaching Northside, the pilot contacted ATC at Aberdeen, and was informed that the surface wind there was 350º/12 kt. The pilot realised that this meant he would have to land with a tailwind, but felt that the shelter offered by the copse, and the upslope of the strip, would allow a safe landing. He decided that if he was not satisfied with his approach, he would go around and divert to another nearby strip.

The aircraft was established on the approach with FULL flap at an IAS of 65 mph (56 kt). The GPS showed a tailwind component of about 8 kt. Following his turn onto the final approach, and at about 50 ft aal, the pilot became unhappy with the aircraft's position, and decided to go around.

The pilot applied full power and established the aircraft in a climb at 70 mph. He reached down with the intention of reducing the flap setting from FULL to HALF, but instead completely retracted the flaps. The aircraft immediately began to sink, tracking over rising ground towards a windsock. Although the pilot began a turn to avoid the windsock, the aircraft touched down and bounced "violently" before touching down again. The aircraft's right wing struck the windsock and the left wing then struck and demolished the door support structure on a poly tunnel adjacent to the strip. The aircraft ran over a dry stone wall and came to rest.

The pilot and one passenger vacated the aircraft with minor injuries. The rear seat passenger, who was wearing a four-point harness, had sustained a serious back injury and was assisted from the aircraft. There was a petrol leak into the cockpit, but no fire developed.

**Aircraft design**

The aircraft was fitted with wing flaps, selected by means of a mechanical lever similar to a car handbrake. A sprung button in the lever end released a ratchet to enable the flaps to be selected from FULL to HALF, or from HALF to UP. There was no baulk to prevent retraction directly from FULL to UP.

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Piper PA-28-181 Cherokee Archer II, G-BHZE |
| **No & Type of Engines:** | 1 Lycoming O-360-A4M piston engine |
| **Year of Manufacture:** | 1978 |
| **Date & Time (UTC):** | 16 April 2008 at 1140 hrs |
| **Location:** | White Waltham Airfield, Berkshire |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - None |
| **Injuries:** | Crew - None Passengers - N/A |
| **Nature of Damage:** | Damage to propeller, nose landing gear leg, forward fuselage underside, and firewall |
| **Commander's Licence:** | Private Pilot's Licence |
| **Commander's Age:** | 42 years |
| **Commander's Flying Experience:** | 188 hours (of which 166 were on type)<br>Last 90 days - 41 hours<br>Last 28 days - 14 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot |

**Synopsis**

The aircraft bounced on touchdown and then bounced four more times with increasing severity and increasing nose-down attitude. The nose gear leg sheared on the fourth touchdown, and on the fifth and final touchdown the propeller and spinner dug into the ground bringing the aircraft to an abrupt stop.

**History of the flight**

The pilot was carrying out circuits at White Waltham using Runway 11 which has a grass surface of 930 metres. The weather conditions were good and there was a light wind from approximately 110º. The pilot had already completed five or six touch-and-go landings when the accident occurred. He was lined up on final approach at approximately 70 KIAS with full flap. On passing the runway threshold he closed the throttle and initiated the flare by progressively applying back pressure on the yoke. The aircraft floated down the runway for approximately 100 to 200 metres, then touched down on its main gear and bounced back into the air. The aircraft bounced again during the second touchdown with increased pitching, and then bounced three more times with increasing severity. On the fifth touchdown the propeller and spinner hit the ground, bringing the aircraft to an abrupt stop. This occurred because the nose gear leg had sheared. The pilot reported the accident on the radio, turned off the electrics, shut off the fuel cock, and then exited the aircraft.

An eyewitness to the accident was positioned at the hold to Runway 11. He reported that the approach appeared normal and then, on landing, the aircraft bounced approximately 3 to 4 feet back into the air. He saw the nose lower and thought that the second touchdown was slightly nosewheel first and was followed by another bounce of 3 to 4 feet. The nose attitude then lowered considerably and a significant nosewheel-first contact occurred on the third touchdown. The aircraft then bounced 6 to 8 feet. After the fourth touchdown, which was also nosewheel first, he noticed damage to the nose gear leg. The fifth, and final, touchdown resulted in the damaged gear leg digging into the ground.

**Pilot's assessment of the cause**

The pilot could not recall with certainty the control inputs he made after the initial bounce but he was certain that he kept the throttle closed. He believes that he applied back pressure on the yoke after the first and subsequent bounces in an attempt to land back on the main wheels. He had always successfully recovered from bounced landings in the past using this technique. He assumed that the severity of subsequent bounces was caused by the nosewheel hitting before the main wheels during the second touchdown, and he believed that this was due to him applying insufficient back pressure on the yoke.

**AAIB comment**

Different techniques are required depending upon the severity of a bounce during landing. Small to moderate initial bounces may be recoverable by appropriate technique where sufficient runway is available. A good technique for dealing with a heavy bounce is to go around.

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Piper PA-28-181 Cherokee Archer II, G-KITE |
| **No & Type of Engines:** | 1 Lycoming O-360-A4M piston engine |
| **Year of Manufacture:** | 1984 |
| **Date & Time (UTC):** | 3 May 2008 at 1935 hrs |
| **Location:** | Popham Airfield, Hampshire |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - 1 |
| **Injuries:** | Crew - 1 (Minor) Passengers - 1 (Minor) |
| **Nature of Damage:** | Slight damage to propeller, engine shock-loaded, both wings torn off |
| **Commander's Licence:** | Private Pilot's Licence |
| **Commander's Age:** | 44 years |
| **Commander's Flying Experience:** | 249 hours (of which 249 were on type)<br>Last 90 days - 6 hours<br>Last 28 days - 6 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot |

**Synopsis**

After landing long on a wet grass runway, with a tailwind component, the pilot was unable to stop the aircraft. It ran through the boundary fence before being arrested by a substantial hedge, during which both wings were torn off.

**History of the flight**

The pilot reported that after changing radio frequency from Farnborough Radar to Popham, he was unable to raise any reply and, without first checking the windsock, elected to carry out a direct approach for Runway 26. The approach to this runway is offset, to avoid over-flying a petrol filling station close to the end of the runway, and the aircraft landed long. The grass surface was damp and the pilot found that he could not stop the aircraft in time before overrunning the end of the runway. The aircraft passed through the boundary fence, crossed one lane of an airfield access road beyond, and was arrested by a substantial hedge, which tore both wings from the fuselage.

The pilot's assessment of the cause of the accident was commendably honest, attributing it to a combination of factors that included: a degree of tiredness after a two-day tour combined with "…a feeling that the end was in sight"; failure to observe the wind sock, which would have shown that the wind was approximately 9 kt from 150°, giving a tailwind component when landing on Runway 26; and the fact that the aircraft landed long, on damp grass.

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Piper PA-28R-200-2 Cherokee Arrow II, G-AZSF |
| **No & Type of Engines:** | 1 Lycoming IO-360-C1C piston engine |
| **Year of Manufacture:** | 1972 |
| **Date & Time (UTC):** | 6 May 2008 at 1515 hrs |
| **Location:** | Wellesbourne Mountford Airfield, Warwickshire |
| **Type of Flight:** | Training |
| **Persons on Board:** | Crew - 2 Passengers - None |
| **Injuries:** | Crew - None Passengers - N/A |
| **Nature of Damage:** | Propeller damaged and engine shock-loaded, damage to underside of fuselage and flaps |
| **Commander's Licence:** | Airline Transport Pilot's Licence |
| **Commander's Age:** | 48 years |
| **Commander's Flying Experience:** | 6,778 hours (of which 200 were on type)<br>Last 90 days - 65 hours<br>Last 28 days - 23 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot |

**Synopsis**

Whilst carrying out an assessment flight for the issue of a Certificate of Competence, the aircraft was landed with the landing gear in the retracted position. Due to a misunderstanding, the candidate and the examiner each assumed the other had completed the final pre-landing checks.

**History of the flight**

The aircraft was being flown from the front left seat by the candidate pilot under the supervision of an examiner in the right seat. The purpose of the flight was to carry out a post-training skills test to enable the examiner to issue a Certificate of Competence, CAA form F170A. This is a prerequisite for undertaking a CAA skills test for the issue of a Commercial Pilot's Licence.

The bulk of the assessment tasks had been completed and the aircraft had returned to the airfield to complete the remaining circuit elements. During the first circuit, the examiner reminded the candidate to call the 'reds, blues and three greens' check, out loud. This is a final check before landing, to ensure the engine mixture and propeller controls are set to the correct position and the landing gear is locked down.

The second circuit was a bad weather circuit. This entails flying closer to the airfield and at a lower level than normal, to enable an aircraft to remain in sight of the airfield in poor visibility. The examiner called out "reds, blues and three greens" with the intention of reminding the candidate to call the checks out loud. The candidate understood this call to mean these checks had been completed.

The aircraft landed with the landing gear retracted and slid to a stop on the runway. The aircraft was shut down and the two uninjured occupants disembarked.

**Comment**

The examiner reported that he had been closely monitoring the candidate's bad weather circuit and approach, and had not noticed that the landing gear remained retracted.

The candidate on hearing the instructor call 'reds, blues and three greens', assumed this meant the checks had been completed. In this high workload environment the assumption may well have been subconsciously reinforced by the cross-cockpit authority gradient and that during training a student becomes used to following directions from an instructor.

The result was that the candidate and the examiner each assumed the other had completed the final pre-landing checks.

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Yak-50, G-YKSO |
| **No & Type of Engines:** | 1 Ivchenko Vedeneyev M-14P piston engine |
| **Year of Manufacture:** | 1979 |
| **Date & Time (UTC):** | 16 June 2008 at 0956 hrs |
| **Location:** | White Waltham Airfield, Berkshire |
| **Type of Flight:** | Training |
| **Persons on Board:** | Crew - 1 Passengers - None |
| **Injuries:** | Crew - None Passengers - N/A |
| **Nature of Damage:** | Propeller destroyed, engine shock loaded, lower cowling and oil cooler damaged |
| **Commander's Licence:** | Private Pilot's Licence |
| **Commander's Age:** | 40 years |
| **Commander's Flying Experience:** | 927 hours (of which 312 were on type)<br>Last 90 days - 49 hours<br>Last 28 days - 14 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot |

**Synopsis**

Following a local aerobatic training flight, where coaching was received by the pilot from a ground observer, the aircraft landed with the landing gear retracted. The pilot candidly disclosed that, due to distractions, the 'downwind' and 'finals' checks were inadvertently omitted.

**History of the flight**

The aircraft was returning to the airfield, having completed a short duration flight during which aerobatic manoeuvres had been practised in a designated area to the west of the airfield. The pilot had transferred to a discrete radio frequency, to receive coaching from a ground observer, but returned to the airfield radio frequency to obtain traffic information, prior to making an approach to land.

He elected to join the circuit on base leg and heard another aircraft call "downwind". The pilot identified the other aircraft and then concentrated on slowing and descending rapidly to position behind it. Because of the limited forward visibility, he kept the other aircraft in view to ensure it had cleared the runway before he turned onto final approach. As he approached the runway extended centreline, the pilot saw the other aircraft climbing away after executing a touch-and-go landing.

He then turned onto final approach and made a radio call announcing his intention to land and shifted his attention to maintaining the correct approach speed accurately, to avoid landing too fast and bouncing on the bumpy grass runway.

The pilot flared the aircraft and, in order to achieve a smooth touchdown, flew just above the runway at low power, to allow the aircraft to slow and settle onto the runway. The aircraft then appeared to stall and the tailwheel touched down with a bump, pitching the aircraft forwards. The propeller struck the ground and disintegrated, shock-loading the engine. The aircraft slid along the runway for approximately 100 m, damaging the lower cowling and oil cooler, before coming to rest. The pilot advised the airfield radio operator of the accident and shut down the aircraft systems, before vacating the aircraft normally. The pilot was not injured. The airfield fire crew attended but there was no fire. It was noted that the landing gear selector lever was in the UP position.

**Comments**

The pilot candidly notes that, having carried out a training flight which required mental capacity rather than any great physical demands, he considered the landing a formality and had already started to think about the debrief. In his opinion, three 'minor' distractions occurred; joining the circuit on base leg, being high and fast and the need to position behind the other traffic. In combination, these were sufficient for him to inadvertently omit the 'downwind' checks and his focus on a smooth landing lead to the omission of the 'finals' checks.

The UK AIP entry for White Waltham, section *EGLM AD2.22 (d) – Flight Procedures*, notes that normal circuit joins are overhead at 1300 ft QFE. This information is also reflected in local airfield operating procedures. This standard joining procedure, see CAA Safety Sense Leaflet 6d - *Aerodrome Sense*, is designed to provide; better visibility and therefore better traffic separation, reduced pilot workload by allowing more time for the aircraft to be slowed and positioned for landing, and spatial position and radio call queues to prompt the completion of 'downwind' and 'finals' checks.

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Yak-52, G-CBOZ |
| **No & type of Engines:** | 1 Ivchenko Vedeneyev M-14P piston engine |
| **Year of Manufacture:** | 1981 |
| **Date & Time (UTC):** | 19 June 2008 at 1840 hrs |
| **Location:** | Lashenden Airfield, Kent |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - None |
| **Injuries:** | Crew - None Passengers - N/A |
| **Nature of Damage:** | Broken propeller, engine possibly shock-loaded, broken gear uplock release catch |
| **Commander's Licence:** | Private Pilot's Licence |
| **Commander's Age:** | 47 years |
| **Commander's Flying Experience:** | 683 hours (of which 474 were on type)<br>Last 90 days - 3 hours<br>Last 28 days - 3 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot |

**Synopsis**

The aircraft was deliberately landed wheels-up, following the failure of the right main landing gear to deploy. Bird remains were found embedded in the left gear uplock mechanism which had prevented its normal operation.

**History of the flight**

On arrival at Headcorn, the pilot had selected the landing gear to DOWN. The green 'down and locked' indications indicated that the nose and right main landing gears were correctly positioned; however, there was no green indication for the left main landing gear. He carried out a low flypast to confirm these indications with ground personnel. The pilot then performed numerous landing gear retractions and extensions, high g manoeuvres and emergency system extensions in order to attempt to lower the left main landing gear, but without success. He then elected to carry out a wheels-up landing and alerted the emergency services, circling to burn off excess fuel. He landed on an area of long grass adjacent to Runway 29 and, having touched down, the aircraft continued for about 100 m before coming to rest. The pilot was uninjured and exited the aircraft without difficulty.

Bird remains were subsequently found embedded in the left gear uplock mechanism, which had prevented its normal operation, precluding extension of the gear.

The main landing gear on the Yak-52 retracts forward and, when retracted, the legs remain exposed beneath the forward fuselage and wings. The pilot commented that he had carried out a low, fast flypast at Headcorn prior to selecting the landing gear and, although he had not been aware of any birds, he considered that the birdstrike was likely to have occurred during this manoeuvre.

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Zenair CH 601HD Zodiac, G-BVPL |
| **No & Type of Engines:** | 1 Continental Motors Corp O-200-A piston engine |
| **Year of Manufacture:** | 1996 |
| **Date & Time (UTC):** | 30 December 2007 at 1548 hrs |
| **Location:** | Near Selkirk, Scottish Borders |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - None |
| **Injuries:** | Crew - 1 (Fatal) Passengers - N/A |
| **Nature of Damage:** | Destroyed |
| **Commander's Licence:** | Private Pilot's Licence (A) |
| **Commander's Age:** | 65 years |
| **Commander's Flying Experience:** | 310 hours (of which 130 hours were on type)<br>Last 90 days - 11 hours<br>Last 28 days - 1.5 hours |
| **Information Source:** | AAIB Field Investigation |

**Synopsis**

After a local flight lasting approximately 50 minutes from Midlem Airstrip, control of the aircraft was lost and it crashed approximately ½ nm from the airstrip. It impacted the ground in an area of gorse bushes at relatively high speed and in a nose-down attitude. The weather in the area at the time was both unlikely to have been suitable for VFR flying and highly conducive for carburettor icing. No technical or medical causal factors were identified during the investigation.

**History of the flight**

The pilot had told his family that he intended to carry out a local flight, possibly as far south as the Otterburn danger area as it would be closed during the holiday period. He checked the weather and NOTAMS in the morning using the internet, before leaving home for Midlem airstrip, where he had based his aircraft for the previous two years. During the morning, the airfield owner noticed the pilot's car was by his hanger and went to speak with him; the pilot was just finishing refuelling his aircraft and they had a short conversation.

Around noon, G-BVPL departed Midlem. A microlight pilot at Huntleywood private strip, some 10 nm to the northeast of Midlem, heard the noise of an aircraft engine which he judged as being made by a Continental engine. He saw an aircraft of similar size to G-BVPL, apparently cruising normally, twice in a ten minute period at around 1240 hrs. At 1545 hrs, some 2½ hours after the accident, two dog walkers discovered the wreckage of G-BVPL in a thick area of gorse, approximately ½ nm from Midlem airstrip. They could see the pilot in the wreckage and called to him, but received no reply. One of them then ran to the nearest house and contacted the emergency services and the airfield owner, who was quickly on the scene. Despite the strong smell of fuel and the risk of fire, they managed to force their way through the gorse to the aircraft, but it appeared to them that the pilot had been fatally injured.

**Pilot's history**

The pilot had held a PPL since 1997, but had flown relatively infrequently for several years after gaining his licence. However, he began flying on a regular basis since purchasing G-BVPL in 2005, completing some 130 hours in the two years prior to the accident. A considerable number of the 130 hours had been spent operating G-BVPL from Midlem.

A post-mortem examination revealed no evidence of a medical nature which could have been causal in the accident, and that this was a non-survivable accident.

**Airfield information**

Midlem is a grass airstrip, 600 ft amsl, located at the western end of the Tweed valley, in southern Scotland. To the north, within 500 m of the runway, the ground rises sharply to a ridge some 200 ft aal. The main runway is orientated 24/06 and is 2,000 ft in length. There is a secondary strip 23/05, also 2,000 ft in length, for use in strong crosswinds.

**Weather**

The pilot is reported to have checked the weather in the morning using the Met Office website. During his brief discussion with the airfield owner, the local weather was mentioned and there is no reason to believe the pilot had not made himself aware of the weather forecast for the Midlem area.

**Aftercast**

An aftercast was obtained from the Met Office and compared with the forecast conditions and reports from other pilots operating in the area.

The general weather situation at 1200 hrs was an occluded front running north-south and moving east across the Scottish Borders. By 1600 hrs, the front would have been a short distance to the southwest of the accident site. During the time between takeoff and the wreckage being discovered, the accident site would have experienced variations in the weather conditions between dry periods to slight drizzle. The high ground in the vicinity was likely to have been covered in patches of cloud (hill fog). The visibility was probably in the region of 20-30 km in the east and around 2,000 m closer to the occlusion. In hill fog, the visibility may have been 200 m. Cloud cover was considered to have been, at best, patches of stratus with a base of 1,100 ft amsl, with broken or overcast stratocumulus base 2,500 ft amsl. It is possible that, on occasions, cloud cover could be scattered or broken stratus at 900 ft amsl. The poorer conditions were reported as being likely towards the end of the period (1600 hrs) and the estimated winds were light and variable. Using the airfield at Midlem as a reference, at 1,000 ft agl the temperature was estimated at +2.6ºC and the dewpoint -1.1ºC, giving a relative humidity of 77%. This relative humidity would have risen to 86% at 1,500 ft and 97% at 2,000 ft.

**Pilot report**

The airfield owner, himself a pilot, stated that in his estimation the weather started to close in around 1200 hrs to 1230 hrs, such that he could no longer see the hills (some 20 km to the south) by 1400 hrs. At that time, the cloudbase was very low and it had started to drizzle.

**Flight plan and communications**

The pilot of G-BVPL did not file a flight plan, and was not required to do so. According to the airfield owner, the pilot's normal practice was to maintain a listening watch on the Scottish Information frequency; no ATC agency reported any communications with G-BVPL on the day of the accident. The airspace surrounding Midlem is uncontrolled and radar coverage in this area is poor at low levels. As G-BVPL returned to the area of Midlem airstrip it is likely that the pilot would have changed frequency to the local Safetycom[1]. This frequency is unmonitored and any distress call would have relied on another pilot being in the local area on the same frequency.

**Accident site examination**

The aircraft had come to rest nose-down in a gorse thicket on the summit of a small hillock. There were no witness marks on the land surrounding the thicket to indicate that the aircraft had touched down prior to the thicket. The gorse bushes surrounding the aircraft were undamaged. After clearing the gorse to allow access, examination revealed that the right wing had been subject to a relatively uniform load which had crushed the leading edge, Figure 1; its inboard trailing edge section and aileron had been buckled under a compressive load. The left wing exhibited two areas of damage to the leading edge, one just outboard of the left main landing gear, caused by impact with a large gorse bush, the other the left wingtip, which had been subject to a significant impact. The rear section of the left wing, outboard of the landing gear, had been


**Figure 1**

Photograph illustrating impact damage to the wings and forward fuselage

**Footnote**

1 Safetycom is a radio frequency that pilots may use to announce their intentions in the absence of any ATC/ATIS/AG unit.

pulled away from the inboard section of the wing and the rear fuselage and tail had been bent upwards and to the right. The main landing gear was undamaged and no evidence was found to indicate that they had made contact with either the gorse or the surrounding field prior to the impact. The engine had been pushed upwards and rearwards, causing severe damage to the bulkhead and the forward area of the cockpit.

There was a strong smell of fuel at the accident site and there was clear evidence of fuel contamination of the soil. The propeller was found to be relatively undamaged, with one blade broken from the hub; there was no evidence of propeller/engine rotation at impact. The subscale setting of the barometric altimeter was 1008 hPa, and the ASI was showing 55 kt.

**Detailed wreckage examination**

Inspection of the aircraft's flight controls showed no evidence of pre-impact damage or restriction. Examination of the cockpit revealed that, although the magneto switch was selected to BOTH, the fuel tank selector valve was in the OFF position. The aircraft was fitted with two throttle controls, one on each side of the instrument panel. The control on the left side of the aircraft was found in the fully forward position with its friction lock fully applied.

Examination of the engine showed that it had not suffered from any major mechanical failure and that the carburettor butterfly valve had been in the fully open position at impact. At the accident site, the carburettor air heat control was found in the COLD position. However, examination of the remains of the carburettor air intake showed that it was probable that the heat valve had been in the HOT position at the time of impact, despite the position of the cockpit control. Carburettor heat is selected to HOT by pulling the control knob away from the instrument panel and the control is not fitted with a locking device. The disparity was considered to have been the result of the significant disruption of the forward fuselage. The aircraft had been fitted with a carburettor intake temperature gauge which, when tested, was found to function correctly. The engine's magnetos were removed but damage prevented functional tests being carried out. Strip examination revealed no evidence of any pre-impact mechanical/electrical failure within either unit.

The fuel selector valve fitted to the aircraft was a four-position unit which allowed the selection of fuel from the left, right and main fuel tanks or to OFF. The valve was found to move freely between the three fuel tank positions but, in order to select OFF, it is necessary to lift a knob whilst turning the selector. No evidence was seen of any pre-impact fault with this valve, or of any evidence that it had been forcibly moved to the OFF position in the impact. A general examination of the fuel system revealed no evidence of any pre-accident defects.

Disassembly of the artificial horizon revealed the presence of witness marks on the unit's gyroscope consistent with it having been spinning at the time of the impact. The remaining flight instrumentation also appeared to have been serviceable.

**Recorded information**

A GPS receiver, a Garmin GPSmap295, was recovered from the aircraft. The unit was damaged, preventing normal download; however, the recorded GPS track was recovered with the assistance of the BEA[2]. The aircraft's ground speeds were derived from the position and timestamp data recorded. All times quoted are UTC.

**Footnote**

[2] Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile (BEA), the French equivalent of the AAIB.

The aircraft departed from Midlem airstrip at 1222 hrs and carried out the flight as shown in Figure 2. As it returned to the airstrip, the recording showed a slow descent starting at 2,200 ft amsl, 28 km from the runway, which averaged around 100 ft/min. Approximately 2.5 km from the airstrip, on a track not in-line with the runway, the descent rate started to increase and the ground speed, which had been steady at approximately 90 kt, started to reduce. Between 44 and 49 seconds later, a left turn was initiated during which the ground speed reduced to 48 kt. This was followed, during the last five seconds, by an increase in ground speed.

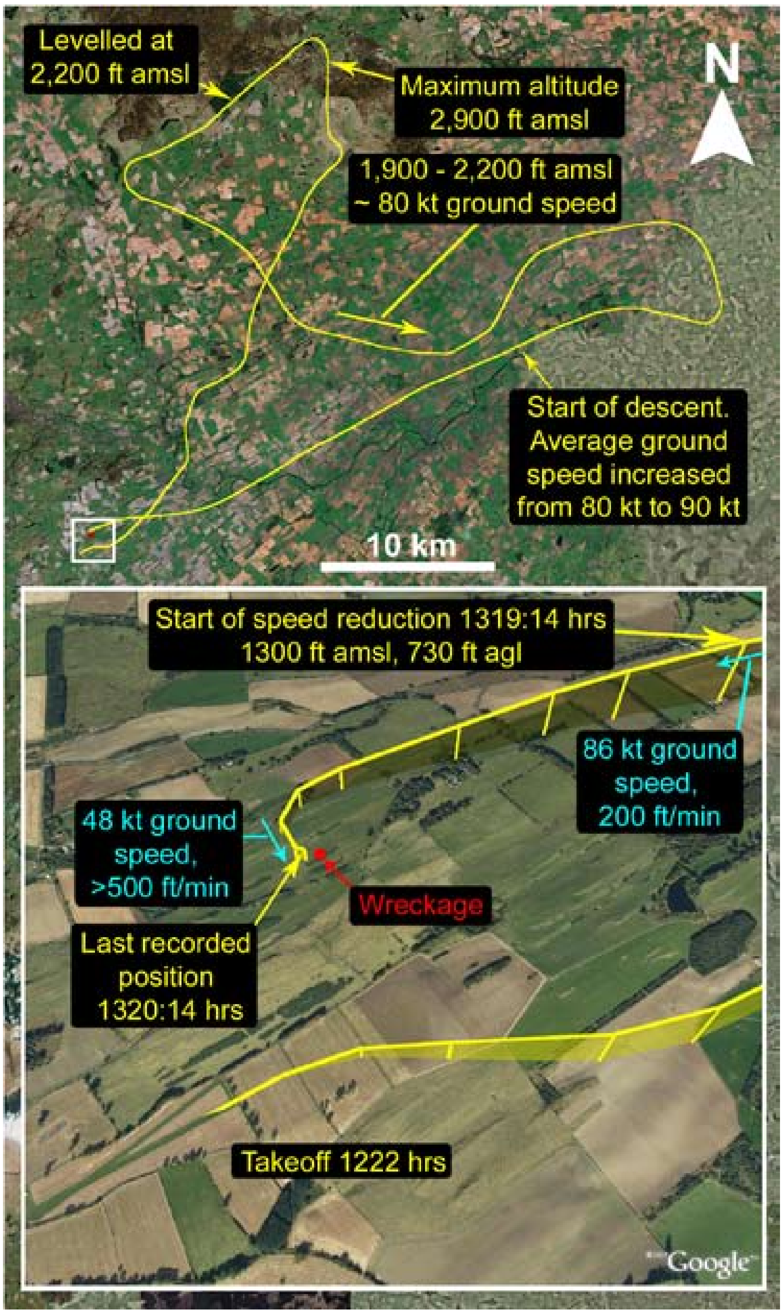


**Figure 2**

Google Earth ™ mapping service / Large image - © 2008 Europa Technologies, © 2008 InfoTerra Ltd & Bluesky, © 2008 Tele Atlas and © 2008 TerraMetrics / Inset image © Getmapping Plc, www.getmapping.com

The recorded track ended just short of the wreckage site. The derived altitude rate indicated a steady descent rate of approximately 500 ft/min. However, whilst the lateral manoeuvre described by the last few points of the track were consistent with reaching the wreckage point before the next GPS track sample could be recorded, the derived altitude rate is inconsistent with this, requiring a doubling of the descent rate after the track finished and before impact. GPS vertical accuracy is not as good as its lateral accuracy under normal conditions. During the final turn, the GPS would have been losing and reacquiring use of satellites, as the right wing effectively blocked the signal path of satellites near to the horizon. These factors make the final trend in derived altitude rate unreliable. It is likely that the average descent rate was nearer to 1,000 ft/min during the final turn and that the GPS track terminated within approximately one second of the impact.

**Analysis**

*Engineering aspects*

The damage to the aircraft was consistent with it being in a nose-down attitude, and travelling at a relatively high speed, when it struck the ground. It appeared to have made contact initially with the gorse with its left wing tip, which resulted in it rotating about the left wing and causing the nose and the right wing leading edge to strike the ground heavily. The witness marks found on the artificial horizon gyroscope confirmed that it had been spinning and that the instrument was probably operating correctly when the aircraft struck the ground. The setting of 1008 hPa on the altimeter subscale would, given the atmospheric pressure in the region at the time of the accident, have been appropriate for operation from Midlem airstrip.

No evidence was found to suggest that the engine had suffered from a mechanical failure prior to impact and the position of the carburettor butterfly valve at impact suggests that the pilot had selected maximum power. As there was no evidence of pre-impact damage to either magneto, a complete failure of the engine's ignition system is considered unlikely but, as the units could not be tested, it cannot be entirely discounted.

Given the lack of rotational damage to the engine and the fuel selector being found in the OFF position it is almost certain that the engine was not producing any significant power at the time of impact. The design of the fuel selector valve, which prevents the inadvertent movement to OFF, and the lack of any evidence that it had been forcibly moved to that position in the accident, strongly suggests that the pilot deliberately turned off the fuel prior to the accident. The strong smell of fuel and fuel contamination of the soil around the wreckage indicated that the aircraft had not run out of fuel.

Whilst the carburettor temperature gauge fitted to the aircraft would have given the pilot an indication of the possibility of carburettor icing, the weather conditions prevalent at the time of the accident were conducive to the formation of carburettor icing over a very wide range of power settings, including cruise power[3]. The position of the carburettor hot air valve confirmed that carburettor heat had been selected at some point prior to the impact. Any periodic application of carburettor heat for short periods of time (typically less than 10 to 15 seconds) during cruise power checks, may not have been sufficient to completely remove any accumulated ice, given the temperature and relative humidity conditions in which the aircraft was operating. Any build-up of carburettor icing would probably have resulted in the engine losing power and running roughly; the application of carburettor heat in

**Footnote**

[3] Ref: CAA Safety Sense Leaflet 14, *Piston Engine Icing*.

this situation would result in an increase in the rough running and further power loss, until all of the ice had dissipated. However, with the engine at low power, the effectiveness of carburettor heat would have quickly diminished as the engine exhaust manifold cooled. In the event of a significant build-up of ice, it is possible that the engine may have stopped before any ice could be cleared.

In summary, no evidence was found to suggest that the aircraft had suffered any pre-accident technical defects. There was no evidence of any engine power at impact, but the aircraft had not run out of fuel. It was concluded that the fuel selector valve had been moved to OFF by the pilot prior to the impact, possibly as part of a 'crash' drill.

*Operational aspects*

The weather at the time of departure was almost certainly suitable for a short local flight. However, with the worse weather approaching from the west there was a reasonable risk of G-BVPL becoming 'weathered-out' from Midlem. There were a number of other suitable airstrips further east and, indeed, it appears the pilot overflew Huntlywood twice during his flight.

The pilot was operating without a flight plan, although one was not required, and was not in communication with any ATC unit. He had left no definite plan of his route at his point of departure, and no note of either planned duration or fuel on board. Although this accident was non-survivable, had the pilot not received fatal injuries overdue action may not have been commenced within time to effect a rescue, as no indication of the time of return or the nature of the flight was available to potential rescuers. The ability to operate freely in the open FIR brings with it an increased risk to pilots/passengers should an accident occur. It is up to individual pilots operating in remote areas to determine how much risk they wish to bear and choose the risk mitigation strategy best suited to themselves.

The GPS recorded flight path appears to show a descending turn as the final flight manoeuvre. This may have simply been, for example, the pilot's attempt to turn back into what little wind there was in order to carry out a forced landing. However, had significant reduction in the available power occurred, this would have removed an option for the pilot to fly to a landing area with better weather and escape from conditions that may have been unsuitable for visual flight.

Other reasons considered for the descending turn were that the pilot could have been making an avoiding manoeuvre due to a real or perceived threat, or that loss of control occurred due to poor visibility or entry into full IMC.

**Conclusions**

In the absence of any pre-impact technical defect being identified from the examination of the wreckage, it was concluded that the pilot may have lost control of the aircraft after entering IMC or an area of poor visibility. It was also considered possible that the engine lost power due to the effects of carburettor icing, resulting in an attempted forced landing, and which would have precluded a diversion to an airfield with more suitable weather conditions.

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Brantly B-2, N276SA |
| **No & Type of Engines:** | 1 Lycoming IVO-360-AIA |
| **Year of Manufacture:** | 1967 |
| **Date & Time (UTC):** | 17 October 2007 at 1340 hrs |
| **Location:** | Flixton Airfield (Disused), near Bungay, Suffolk |
| **Type of Flight:** | Training |
| **Persons on Board:** | Crew - 2 Passengers - None |
| **Injuries:** | Crew - 1 (Minor) Passengers - N/A |
| **Nature of Damage:** | Aircraft destroyed |
| **Commander's Licence:** | Airline Transport Pilot's Licence |
| **Commander's Age:** | 66 years |
| **Commander's Flying Experience:** | 9,330 hours (of which 85 were on type)<br>Last 90 days - 76 hours<br>Last 28 days - 12 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the examiner and statement made by the operator |

**Synopsis**

The pilot and examiner were carrying out a practice engine failure as part of a Licence Proficiency Check, when the engine stopped. The examiner took control and made an engine-off landing during which the skids dug into soft ground, causing the aircraft to roll on its side. The cause of the engine failure has not been identified but was probably due to mishandling of the throttle. A mechanical failure cannot be ruled out as the operator did not provide maintenance records for the aircraft.

**History of the flight**

The pilot had engaged an examiner to carry out his Licence Proficiency Check (LPC). The aircraft departed Beccles Airfield, where it was based, at about 1300 hrs and flew to a private site 3 nm from the airfield to commence the test. The wind at the time was from the north-west and reported at 10 kt by the examiner and in excess of 28 kt by the pilot under test. Visibility was good with FEW clouds at 2,500 ft.

At the private site the pilot conducted various landings under the supervision of the examiner. The examiner then requested the pilot to carry out an engine-off landing at the site but the pilot was concerned about the presence of some wires and so the examiner instructed him to fly to a disused airfield at Flixton to carry out the exercise instead.

With the aircraft over the disused airfield at 1,500 ft agl, the examiner asked the pilot to carry out a practice engine failure. The pilot did so, recovering from the autorotation at about 600 ft agl before climbing back to 2,000 ft agl. The examiner believed the pilot had not used the throttle appropriately during the first practice engine failure and after having briefed him, instructed him to carry out the exercise again. It appears that there was disagreement between the two pilots over the proper use of the throttle for the exercise. The pilot entered a further autorotation, during which the engine stopped.

Once the examiner realised the engine had stopped he took control and continued the autorotation with the intention of carrying out an engine-off landing on the disused airfield. The examiner stated he commenced a flare at about 100 ft agl, judging that the aircraft was going to touch down just short of a taxiway which was running across its path. He was concerned that the aircraft skids might hit a raised edge to the taxiway whilst running on and so decided to attempt to clear it by stopping the flare. The aircraft cleared the taxiway before touching down and running on for a short distance. The front of the skids then dug into the soft ground, rolling the aircraft onto its side, the main rotors cutting through the tail and hitting part of the canopy. The examiner received minor injuries as a result of the impact but both pilots were able to vacate the aircraft unaided before contacting the emergency services by mobile telephone. The pilot reported that the emergency services arrived approximately 20 minutes later, having had difficulty locating and accessing the accident site due to the disused status of the airfield.

**Aircraft maintenance and insurance status**

The pilot could not provide any evidence that the aircraft had either valid insurance or had been maintained in accordance with the necessary requirements. He stated that whilst he was the operator, the aircraft was owned by a trust in the USA with which he had no connection and to which he made no financial contribution to be able to use the aircraft. The aircraft was also registered in the USA.

The pilot stated that the owners would send an engineer over from the USA to carry out scheduled maintenance, but that he had no information available to him informing him when such maintenance was due. Similarly, he stated that the aircraft's insurance was dealt with by the trust and again, he had no information about it.

Enquiries by the AAIB revealed that the aircraft was owned by a trust based in Cornwall, UK which is used by various people to register N registered aircraft operating in the UK. Article 8(1) of the Air Navigation Order (ANO) requires an aircraft flying in the UK to be registered and in possession of a valid Certificate of Airworthiness. The USA Certificate of Airworthiness is non-expiring and for aircraft of this weight, is normally rendered valid by an appropriate annual inspection/check. The pilot was unable to provide evidence of when the last inspection/check was conducted.

**Brantly Flight Manual**

Under a section entitled 'POWER OFF LANDINGS' the manual states the following:

> *'The throttle should not be cut back to idle as it might result in engine stoppage. An engine speed of 2,000 RPM is recommended. Abrupt throttle changes should be avoided.'*

**CAA Flight Examiners' Handbook (Helicopters)**

This handbook provides a reference for examiners to ensure flight tests are carried out using current and standardised procedures. Annex 6 relates to the LPC and requires the examiner to check aircraft documentation prior to conducting the test and for the pre-flight briefing to include instructions on how the throttle should be used during simulated malfunctions.

**ANO 2005 Article 126**

This requires that all flight instruction and testing for the purpose of becoming qualified for the grant of a pilot's licence or the inclusion of an aircraft rating must be carried out at a licensed aerodrome or at a UK Government aerodrome. Testing for the renewal of an existing rating does not fall under the provision of this article.

**Analysis**

Statements by both the examiner and the pilot suggest the engine stoppage was caused by the incorrect use of the throttle during autorotation. However, at the time of writing there has been no inspection made of the engine, which itself was possibly overdue maintenance action and a mechanical failure cannot therefore be ruled out.

Had a complete pre-flight brief been conducted any difference in opinion about the operation of the throttle should have been resolved prior to the flight taking place. Equally any deficiency in the aircraft's insurance or maintenance status would have become apparent had the appropriate documents been checked.

Whilst it might be argued a lack of insurance has no direct flight safety implications, a lack of appropriate cover can have devastating effects on those who suffer the consequences of an accident.

Finally, the forced landing resulting from the engine failure might have been more successful had it been conducted over an area with a surface more suited to run-on landings. This, combined with the presence of dedicated emergency services, makes the use of a licensed airfield for such exercises prudent whether required by the regulations or not.

**INCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Schweizer 269C Schweizer 300, G-WARK |
| **No & Type of Engines:** | 1 Lycoming HIO-360-D1A piston engine |
| **Year of Manufacture:** | 1989 |
| **Date & Time (UTC):** | 5 May 2008 at 1600 hrs |
| **Location:** | Private landing ground 3 nm east of Sherburn-in-Elmet, Yorks |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - 1 |
| **Injuries:** | Crew - None Passengers - None |
| **Nature of Damage:** | Extensive airframe damage |
| **Commander's Licence:** | Private Pilot's Licence |
| **Commander's Age:** | 45 years |
| **Commander's Flying Experience:** | 350 hours (of which 330 were on type)<br>Last 90 days - 30 hours<br>Last 28 days - 9 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot |

**Synopsis**

Following an uneventful flight from Bagby, the pilot landed the helicopter on the landing site at his house near Selby. He was reducing the engine speed prior to shutting down, when an empty cement bag blew up into the main rotor. The bag was of the woven fabric variety, capable of holding approximately one cubic metre, or one tonne of material, and thus represented a substantial object in terms of bulk. Damage was sustained by a rotor blade, causing it to fly out of track, and the associated imbalance resulted in extensive damage to the airframe, including the cabin and tail boom.

Building work was being conducted at his premises and he considered that the bag was associated with this work.

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Schweizer 269D Configuration A (Schweizer 333), G-TAMA |
| **No & Type of Engines:** | 1 Rolls Royce Allison 250-C20W turboshaft engine |
| **Year of Manufacture:** | 2004 |
| **Date & Time (UTC):** | 4 February 2008 at 1455 hrs |
| **Location:** | Sheffield City Airport |
| **Type of Flight:** | Aerial Work |
| **Persons on Board:** | Crew - 1 Passengers - None |
| **Injuries:** | Crew - None Passengers - N/A |
| **Nature of Damage:** | Significant component and airframe damage |
| **Commander's Licence:** | Commercial Pilot's Licence |
| **Commander's Age:** | 40 years |
| **Commander's Flying Experience:** | 1,125 hours (of which 75 were on type)<br>Last 90 days - 131 hours<br>Last 28 days - 49 hours |
| **Information Source:** | AAIB Field Investigation |

**Synopsis**

After landing on a post-maintenance flight, the helicopter suffered a seizure of the main rotor gearbox pinion outer bearing due to oil starvation. The main rotor gearbox had been replaced during the recent maintenance. It was determined that maintenance personnel had inadvertently caused metallic debris to enter the bearing oil supply gallery during their attempts to remove a blanking plug from the gearbox low oil pressure switch port, which had been overtightened.

**History of the flight**

The incident occurred after landing on a post-maintenance flight to check the tracking and balance of the main rotor. The engineer disembarked the helicopter with the rotors still running, leaving the pilot to shut down the aircraft. As she commenced the shutdown procedure, there was a loud 'bang' and the aircraft immediately began to shake severely, rocked violently and yawed 45 degrees nose left. She held the collective lever fully down, experiencing some difficulty as this required a large amount of force even with full friction applied. The throttle was closed and the fuel shutoff valve was selected off after the main rotor blades had come to a stop. The helicopter remained upright and the pilot was able to exit the aircraft normally.

**Aircraft information**

*Background information*

G-TAMA, Figure 1, was manufactured in 2004 and had completed 1,681 flying hours since new at the time of the incident. The helicopter, serial number 0051A, held a current EASA Certificate of Airworthiness valid until 12 June 2008. The incident occurred on the second post-maintenance flight after completion of an 800-hour scheduled maintenance check, during which the main rotor gearbox (MRGB) was replaced. The replacement gearbox, part number 269A5175-39 serial number S0030, was supplied by the helicopter manufacturer.


**Figure 1**

Photograph of G-TAMA

*Aircraft description*

General

The Schweizer 269D Configuration A, generically referred to as a Schweizer 333, is a three-seat helicopter powered by a single Allison 250-C20W turboshaft engine. It is equipped with a three-bladed main rotor with elastomeric lead-lag dampers and a conventional two-bladed tail rotor.

Power is transmitted from the engine to the main rotor and tail rotor via a ‘Vee’ belt, which drives a pulley on the rear of the MRGB. The pulley is attached to the MRGB input shaft and also drives the tail rotor driveshaft.

Main rotor gearbox (MRGB)

The two-part MRGB housing is manufactured from cast magnesium and is comprised of upper and lower housings. A pinion gear on the gearbox input shaft drives a ring gear, providing the required reduction gearing for the main rotor. The pinion gear is supported by inner and outer tapered roller bearings.

A pump within the gearbox provides pressurised oil for lubrication of the MRGB components. Oil is supplied to the pinion outer bearing via an oil gallery in the gearbox upper housing. The oil enters the bearing via an orifice in the bearing retainer, which must be aligned with the oil feed orifice in the gallery.

A low oil pressure warning switch is located in the oil gallery to the pinion outer bearing. The pressure switch port has a tapered thread to provide adequate sealing. Replacement gearboxes are supplied without a pressure switch installed and the port is blanked off with a threaded aluminium alloy plug, Figure 2.

The plug must be replaced with a pressure switch before installing the gearbox in the helicopter, although this is not mentioned in the maintenance manual procedure for MRGB removal and installation.

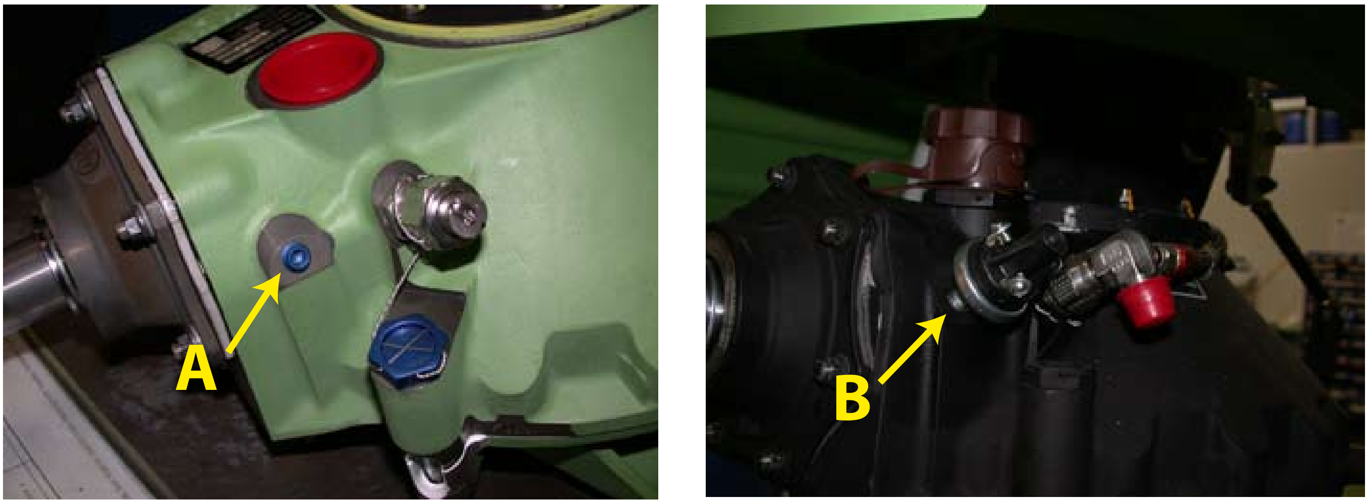


**Figure 2**

Photographs showing MRGB with blanking plug ('A') and low oil pressure switch ('B') installed

Note: gearbox on left has not yet been painted

**Aircraft examination**

*General*

Various components and parts of the airframe structure were damaged as a result of the abnormal loads experienced in the incident. The main rotor lead-lag dampers had failed and the tail rotor driveshaft exhibited a torsional overload failure consistent with the tail rotor driving against a restriction at the front of the driveshaft.

*MRGB damage*

The MRGB input shaft was found to be binding intermittently and felt rough when rotated by hand. The pinion outer bearing was badly damaged from apparent oil starvation and subsequent overheating (Figure 3). The bearing cage had fractured and the rollers exhibited a dull grey coloration, with some having partially melted. The bearing retention nut and washer were intact and correctly located. The oil feed orifice in the bearing retainer was correctly aligned with the oil gallery orifice and was free of obstruction. Some ferrous debris was found in the bearing oil drain passage. No other defects were reportedly found within the MRGB which could have restricted or blocked the oil supply to the pinion outer bearing.

Examination of the bearing oil supply gallery revealed the presence of oil, small shiny chips of non-ferrous debris and a single fragment of ferrous debris (Figure 4). This fragment, which measured approximately 3 mm in length with a diameter tapering from approximately 0.8 mm to 2.5 mm at its widest, was found to have a machined threaded/spiral finish closely resembling the tip of a stud extractor bit.

**Figure 3**

Photograph showing damage to MRGB pinion outer bearing

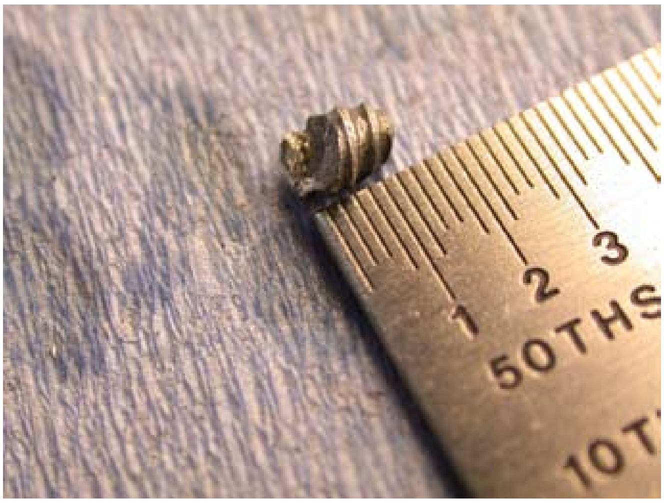


**Figure 4**

Photographs showing metallic debris in pinion bearing oil gallery (left)
and close-up view of ferrous fragment (right)

**Recent maintenance activity**

The helicopter had recently completed an 800-hour scheduled maintenance check, performed at the operators' maintenance facility at its main base at Sheffield City Airport. One of the tasks completed was the replacement of the MRGB.

The maintenance personnel involved in this task were interviewed by the AAIB. They reported having great difficulty removing the blanking plug from the pressure switch port in the pinion rear bearing oil gallery, which had been installed too tightly. Attempts to undo it with an 'Allen' key were unsuccessful and only served to damage the soft alloy plug. An attempt was then made to remove it with a stud extractor tool, but this also proved unsuccessful when the tool bit broke as it was being screwed into the plug. Finally, the plug was drilled at various points round its circumference to weaken it, after which it was possible to undo it. Care was taken to avoid debris entering the oil gallery.

**Examination of metallic debris**

The ferrous fragment and broken stud extractor bit were subjected to forensic examination.

When offered up to each other under a visual microscope, the fragment and broken tool bit were found to be a close geomteric match, however, an exact fracture match was not possible as some material was missing from the tool bit and the fracture surface of the fragment had been destroyed by mechanical damage.

An Energy Dispersive X-ray analysis was performed to compare the material of the fragment against that of the broken tool bit. The results showed the fragment to be a low alloy steel containing chromium with lesser amounts of manganese, molybdenum and silicon. The broken tool bit was found to be of a similar material. The surface of the fragment was also contaminated with what appeared to be an aluminium-copper alloy.

## Additional information

*Manufacturer's MRGB assembly procedure*

On reviewing its procedure for assembling the MRGB, the helicopter manufacturer found that it contained no instruction to install the blanking plug in the low oil pressure switch port and therefore no torque value was specified for the plug. It is also noteworthy that the MRGB is painted after the blanking plug has been installed.

*Maintenance organisation and personnel*

The organisation that had performed the maintenance is an EASA-145 approved maintenance organisation and is approved to perform base and line maintenance on Schweizer 269-series helicopters.

The maintenance personnel who carried out the task of replacing the MRGB were qualified to carry out the task and had performed it on a number of previous occasions.

## Discussion

The evidence suggests that the fragment removed from the gearbox was probably the tip of the broken stud extractor tool, indicating that the blanking plug was breached in the attempts to remove it. The non-ferrous debris in the oil gallery appeared to be shavings or chips from the damaged aluminium alloy plug.

The damage to the MRGB outer pinion bearing is consistent with the effects of oil starvation. It could not be determined whether this was caused by the ferrous fragment or the non-ferrous debris in the oil gallery, but the latter seems more likely as the smaller, lighter aluminium alloy chips would be have been more easily carried by the oil to a location where they could cause a restriction in the bearing oil supply.

The maintenance personnel had resorted to using unconventional methods to remove the blanking plug as they were unable to do so using normal tools because it had been installed too tightly. This is a common problem when installing plugs into tapered threads. A significant contributory factor is the lack of an instruction for installing the plug in the manufacturer's procedure for MRGB assembly. There is therefore scope for variation in how tightly the plug is tightened, depending on who installs it. Additionally, painting over the plug may make it more difficult to remove due to the adhesive effect of the paint.

## Safety action

This incident is unlikely to have occurred had the blanking plug not been overtightened, as unconventional methods used to remove it would not have been necessary. If such methods are used, metallic debris may enter the MRGB oil supply and cause gearbox seizure, as this incident demonstrated. Had the helicopter been airborne at the time, the seizure of the pinion outer bearing may have had catastrophic consequences.

In response to this incident, the manufacturer has stated that they are in the process of revising their gearbox build documents to reflect a maximum torque to be applied to the blanking plug prior to shipping.

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | ASH 25 Glider, 925 (BGA 3909) |
| **No & Type of Engines:** | Not applicable |
| **Year of Manufacture:** | 1992 |
| **Date & Time (UTC):** | 2 September 2007 at 1512 hrs |
| **Location:** | Tomintoul, Morayshire, Scotland |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 2 Passengers - None |
| **Injuries:** | Crew - 1 (Fatal) 1 (Serious) Passengers - N/A |
| **Nature of Damage:** | Glider destroyed |
| **Commander's Licence:** | None |
| **Commander's Age:** | 51 years old |
| **Commander's Flying Experience:** | 750 hours on all types (estimated)<br>Last 90 days - 30 hours<br>Last 28 days - 24 hours |
| **Information Source:** | AAIB Field Investigation |

**Synopsis**

Whilst competing in a gliding competition in Aberdeenshire, Scotland, the pilot (P1) of the glider was attempting to land in a field near Tomintoul, Morayshire. When the glider was on its final approach he realised that it was too high and likely to overshoot the field that he was planning to land in, he therefore entered an orbit to lose the excessive height. During this orbit the glider departed controlled flight at a low height, and crashed into a field. The P1 was fatally injured and the other pilot (P2) was seriously injured.

**History of the flight**

The P1 was competing in the annual UK Mountain Soaring Championship, based at Aboyne Airfield, Aberdeenshire, Scotland. The task on the 2 September 2007 was to fly a route of 252.5 km, consisting of four legs: from Aboyne via Huntly (Aberdeenshire), Kirkmichael (Perthshire), Grantown-on-Spey (Morayshire) and then back to Aboyne. Thirteen competitors took part in the task. Each glider was fitted with a GPS tracker that would log their route and times.

Glider 925 became airborne on an aero-tow at 1209 hrs, with the P1 in the front seat and the P2 in the rear seat, before being released at 3,500 ft amsl at 1219 hrs. The glider climbed to 12,500 ft amsl and commenced the prescribed route at 1317 hrs. The first two legs were completed uneventfully. As the glider approached Grantown-on-Spey the pilots discussed the approaching weather and lack of thermals on the route. After turning at Grantown-on-Spey the glider climbed to approximately 3,000 ft amsl, which was an adequate height for it to reach Tomintoul, an area known by the pilots to have suitable fields in which to land.

As the glider approached Tomintoul the pilots confirmed that they were unlikely to be able to gain enough height to return to Aboyne and they decided to land in the vicinity of Tomintoul. When approximately 3 nm north of Tomintoul they agreed on a suitable field, east of Tomintoul, which was virtually into wind, and the P1 positioned the glider on a down wind leg in preparation to land, and completed the before-landing checks. The glider then encountered some rising air and started to climb. The P1 responded by deploying the air brakes, but the glider continued to climb so he selecting landing flap before side-slipping the glider in an attempt to lose the excess height. When the glider was on its final approach it was clear that it was still too high and was going to overshoot the selected field, beyond which were some houses on the edge of Tomintoul. The P1 retracted the air brakes and entered an orbit to the right in a further attempt to lose the excess height. During the turn, at some stage below 230 ft agl, the glider departed controlled flight, entered a near vertical dive from which it did not recover and struck the ground.

Some witnesses and a local ambulance attended the scene soon after the accident. The P1 had received fatal injuries. The P2, who was seriously injured but conscious, was given first aid before being flown to Inverness Hospital by air ambulance about 20 mins later.

**Weather**

An aftercast was obtained from the Met Office for the area of the accident. It stated that the synoptic situation at 1200 hrs on 2 September 2007 showed a fresh to strong north-westerly flow in a polar maritime airflow. By 1800 hrs two troughs were indicated, suggesting enhanced instability across northern Scotland. Notwithstanding the unstable character of a classic polar maritime air mass, on this occasion there was evidence of some stable layers.

The available observations suggested an air mass visibility of between 30 km and 60 km. There was evidence of both lee-wave cloud and convective activity. The nature of the terrain meant that the wind and temperature would have varied quite markedly over the area. The gradient over Aviemore (15 nm west-south-west of the accident site) measured 24 kt from 320º at 1500 hrs, and over Glenlivet (6 nm north of the accident site) it was measured as 27 kt, also from 320º. The surface wind at Aviemore was from 290º at 6 kt, and that at Glenlivet was from 300º at 17 kt. The ‘Hills of Cromdale’ to the northwest of the accident site form a ridge with steep sides on both slopes. The ridge is relatively short in length and so whilst some of the flow would be displaced upwards and over the ridge, some may have been forced around each end. It is believed this would have produced marked turbulence over the accident site in the prevailing conditions.

As a result it was not possible to be certain of the wind at the accident site. As far as can be ascertained, the best estimate of the wind, and its possible variations, are given in Table 1.

These changes in wind might have been encountered over relatively short distances both vertically and horizontally.

**Personnel information**

| Height AGL | Wind Speed & Direction |
|---|---|
| Surface | 270º at 15 kt, gusting 25 kt; locally/occasionally variable direction at 5 kt |
| 500 FT | 280º at 20 to 25 kt; locally/occasionally variable in direction at 10 kt |
| 1000 FT | 280º at 20 to 35 kt; locally/occasionally variable in direction at 10 kt |

**Table 1**

Possible wind in the area of the accident

*Pilot's experience*

The P1 was an experienced cross-country glider pilot, who had competed in prestigious competitions on many occasions; he was qualified to FAI[1] Gold and Diamond Certificate level, which are internationally recognised qualifications. He was an Assistant Instructor at the gliding club based at Aboyne Airfield. The investigation was unable to locate his flying log book and his total flying hours have been estimated following discussion with his colleagues; his flying experience during the last 90 days was extracted from the aircraft records.

The P1 is known to have 'landed out' twice in Glider 925 during the 2006 UK Mountain Soaring Championship and on several other occasions in other types of gliders.

*Experience of the P2*

The P2 had been gliding for approximately 10 years and was qualified to FAI Silver Certificate level. He took control of the glider a number of times during this flight, but was not the handling pilot during the final approach and landing.

**Footnote**

[1] The Federation Aeronautique Internationale is the governing body for air sports and aeronautical world records.

**Surviving pilot's comments**

When it became apparent that the glider was too high to land in the nominated field and the P1 entered an orbit to the right, the P2 noticed that the air brakes had been retracted and the flap setting had been reduced, but he was not certain to what position the flaps had been set. He also recalled that throughout the circuit to land the flying conditions were very bumpy and turbulent. As the glider entered the turn the P2 concentrated on keeping visual contact with the selected field so his attention was directed out of the glider. During the turn he first became aware that something was wrong when the P1 called out. He then looked back out of the front of the glider and saw that the glider was in a near vertical dive immediately before it crashed.

**Eye witness**

A motorcyclist, travelling north-west towards Tomintoul on the A939, witnessed the accident (see Figure 1). He described seeing Glider 925 straight ahead of him, at approximately 2-300 ft agl, in a steep turn, when he was approximately one mile from the accident site. The glider then "quickly" entered a near-vertical dive before he lost sight of it just before it crashed.

**Medical examination**

The P1 had signed a declaration of medical fitness to fly which had been countersigned by his general practitioner in February 2003. While this certificate indicated that his next medical assessment was due on 21 February 2006, his declaration would have been valid for 5 years from its date of issue and was therefore valid at the time of the accident.

A post-mortem was carried out by a Crown Office pathologist. It concluded that the P1 had died of multiple injuries consistent with being sustained at the time the glider struck the ground and that the injuries were not survivable. The post-mortem revealed no evidence of natural disease which could have caused or contributed to the accident and toxicological tests for alcohol and drugs were negative.

**ASH 25 description**

The ASH 25 is a two-seat, mid-wing, high performance glider with a 25 m wing span. It is equipped with a retractable landing gear, air brakes which extend on the upper surface of each wing and five stage flaps that can be set between -9° and +38°. The flap operating handle in each cockpit is fitted with a spigot which locates in one of six holes corresponding to the six flap positions – five stages and landing flap. The four section wing is constructed from Carbon Fibre Reinforced Plastic (CFRP). The inner and outer wing sections join at 3.8 m along the span with a spar in the outer wing locating in a socket in the inner section. Locating spigots are also fitted to the inboard of the leading and trailing edges on the outer wings, corresponding sockets are fitted to the inner wing. The left and right wings are joined at the fuselage by a tongue and fork joint, and two cylinderical main pins. The wings are connected to the fuselage by spigots mounted on the fuselage and sockets on the wings inboard of the leading and trailing edge. Bladders for a water ballast system are located along the spar of each outer wing.

The fuselage is constructed from a mixture of carbon and aramide fibres, and the fin is constructed from Glass Reinforced Plastic and a hard foam sandwich. The horizontal stabilizer and conventional elevators are fixed to the top of the fin.

With the exception of the rudder, the flying controls, flaps and airbrakes are operated by push rods connected through a series of bellcranks. The rudder is operated by cables and a short push rod that connects the rudder to a bellcrank. Apart from the elevator, the flying controls can all be easily disconnected at the wing root by Hotellier type ball connectors. The elevators are connected to the controls by a tongue which sits in the elevator actuator at the top of the fin.

Because of its high performance, pilots of the ASH 25 generally do not get much practice at 'landing out' in fields. The pilot controls the descent rate by use of the airbrakes and the flaps. The landing flap position should not be selected until a landing in the selected field is assured.

An experienced ASH 25 pilot commented that, with practice, 200 m is a sufficient landing distance in which to land, with no other obstacles present; therefore a field with a minimum landing distance of 300 m should be selected to allow a margin for error. For less experienced pilots he suggested a minimum landing distance of 400 m.

## Wreckage and impact information

The glider crashed in an area of marsh land approximately 650 m east of Tomintoul on the west bank of Conglass Water. Sited approximately 150 m to the east of the accident site were pylons carrying 132 Kv electrical transmission lines; the tops of the pylons were approximately 106 ft above the accident site and the transmission lines ran in the direction 145°/325° M. A second row of pylons, carrying 11 Kv electrical transmission lines, were sited approximately 80 m west of the accident site; these pylons were approximately 29 ft high and ran towards Tomintoul in the direction 200°/020° M. (See Figure 1).

The wreckage trail was approximately 33 m long on a heading of 275° M. The right wing had failed at the wing joint inboard of the airbrakes and the leading edge of the outer section of the right wing had left a deep, curved witness mark in the soft ground. The nose section of the glider was found in a crater approximately 15.5 m from the right wing tip. The left wing was found 4.5 m from the crater with approximately 1.5 m of the wing tip driven under the surface vegatation. The glider fuselage, which was lying on its left side, and the inner section of the right wing were found approximately 4 m from the crater. Both canopy transparencies had shattered and had been thrown forward of the crater in an arc between 140° M and 165°M. Glider structure, instruments and equipment located in the forward cockpit was scattered between the crater and the fuselage.

Ground marks and damage to the wreckage indicate that the glider struck the ground in a very steep attitude with some sideways movement to the left, on a heading of 165°M. There was no evidence that the glider had struck any of the electrical transmission cables or pylons.

**Detailed examination of the wreckage**

The landing gear was in the down position and the cockpit area forward of the front seat had been extensively damaged; however, the rear instrument panel, the controls and cockpit area were mostly intact. In the front cockpit the control column had broken close to the pivot point, the rudder pedals had broken away from the structure and the flap operating lever had failed close to the P1's seat. The control rods at the wing root had all failed in a manner consistent with the wings detaching from the glider. The elevator bellcrank mounted on the rear face of the cockpit bulkhead and the structure to which it was attached had broken off the bulkhead. The damage indicated that this occurred when the control rods were pushed rearwards in the crash. Access to the control runs was obtained by cutting holes in the structure and the subsequent inspection established that at the time of the accident all the controls were correctly assembled and operated in the correct sense. Additionally, there were no witness marks on any of the controls aft of the front cockpit to indicate that there had been a control restriction.

The five forward flap handle spigot locating holes in the rear cockpit were all round and relatively undamaged, whereas the rear face of the hole corresponding to the landing position had been damaged consistent with the spigot being pushed into it under a high load. The trim around the rearmost locating hole had also come away from the CFRP. It was not possible to establish the position of the airbrakes.

The spar and locating lugs connecting the inner and outer section of the right wing had sheared allowing the sections of the wing to separate. The trailing edge of the right wing root, which contained the wing spigot locating hole, had broken away from the wing and two of the three bearings in the spar tongue and fork assembly had pulled out of the spars allowing the two wings to separate. The spar between the inner and outer sections of the left wing had partially broken through the lower surface; however the two sections of the wings remained connected. The top left side of the fin was damaged and the tailplane securing bolt had pulled out of the fin. The rudder was damaged but remained intact. There was no water in the wing ballast tanks.

Both the P1 and the P2 had been wearing a four-point harness. As a result of the damage to the cockpit area, the attachment points for the P1's lap strap had broken away from the structure during the crash. However this failure would not have affected the survivability of this accident.

**Recorded data**

Glider 925 did not carry any form of crash protected recorder, nor was it required to do so. However, an HP iPAQ Personal Digital Assistant (PDA) containing a 256 MB Secure Digital (SD) card, together with a glider logger, a Cambridge Secure Flight Recorder model 25, were recovered from the glider. These were analysed for any recordings pertinent to the glider flight. The PDA was damaged and everything in its internal memory was lost. The SD card files were analysed and no traces were found of active logging of the flight.

The glider logger had suffered damage during the accident, but the anti-tamper measures, designed to remove power from the memory if the unit is opened, had not been disturbed. The glider logger was successfully downloaded and provided a recording of the accident flight.

The glider logger recorded position and altitude derived from a GPS, together with an assessment of the estimated accuracy. It also recorded the pressure altitude, noise level[2] and other system-related indicators every 8 seconds; there were also brief periods when the times between samples were reduced. Data from the logger forms the basis of the following description of the flight. All times are given in UTC; local time on the date of the accident was one hour ahead.

The log commenced at 1158 hrs at Aboyne Airfield. The glider was airborne at 1209 hrs and climbed to nearly 12,500 ft whilst manoeuvring over terrain approximately 4 km north-west of the airfield. The glider then flew north to Huntly, south-west to Kirkmichael, north to Grantown-on-Spey and then south-east to the accident site near Tomintoul. Figure 1 shows the end of the accident flight together with a comparison with other landings recorded on the day by other gliders of various types. Note that the vertical red poles indicate the actual recording points; the straight lines joining the top of these poles give the average track between these points and are not indicative of the heading of the glider at the recording points. It is thus quite possible that the glider was in a turn at the last recorded point rather than tracking straight.

The last recorded point was at 1511 hrs. The glider was 230 ft agl and descending at approximately 500 ft/min with a ground speed of just under 50 kt. The GPS accuracy was recorded as good. Comparisons with other glider landings that day indicate that the ground speed and rate of descent at the end of the recording were not unusual.

The distance from the last recorded point to the boundary of the nearest field was approximately 260 m. The field was 270 m in length and sloped up, so that the far end of the field was approximately 50 ft higher than the terrain the glider was over at its last recorded point. The shortest recorded distance from a height of 230 ft to touchdown of the other gliders that day was approximately 500 m, indicating that a straight-in approach to land on the field ahead was not viable.

**Footnote**

[2] The engine noise level parameter records the relative magnitude of ambient noise during a flight to determine whether an engine was in use during a competition flight.

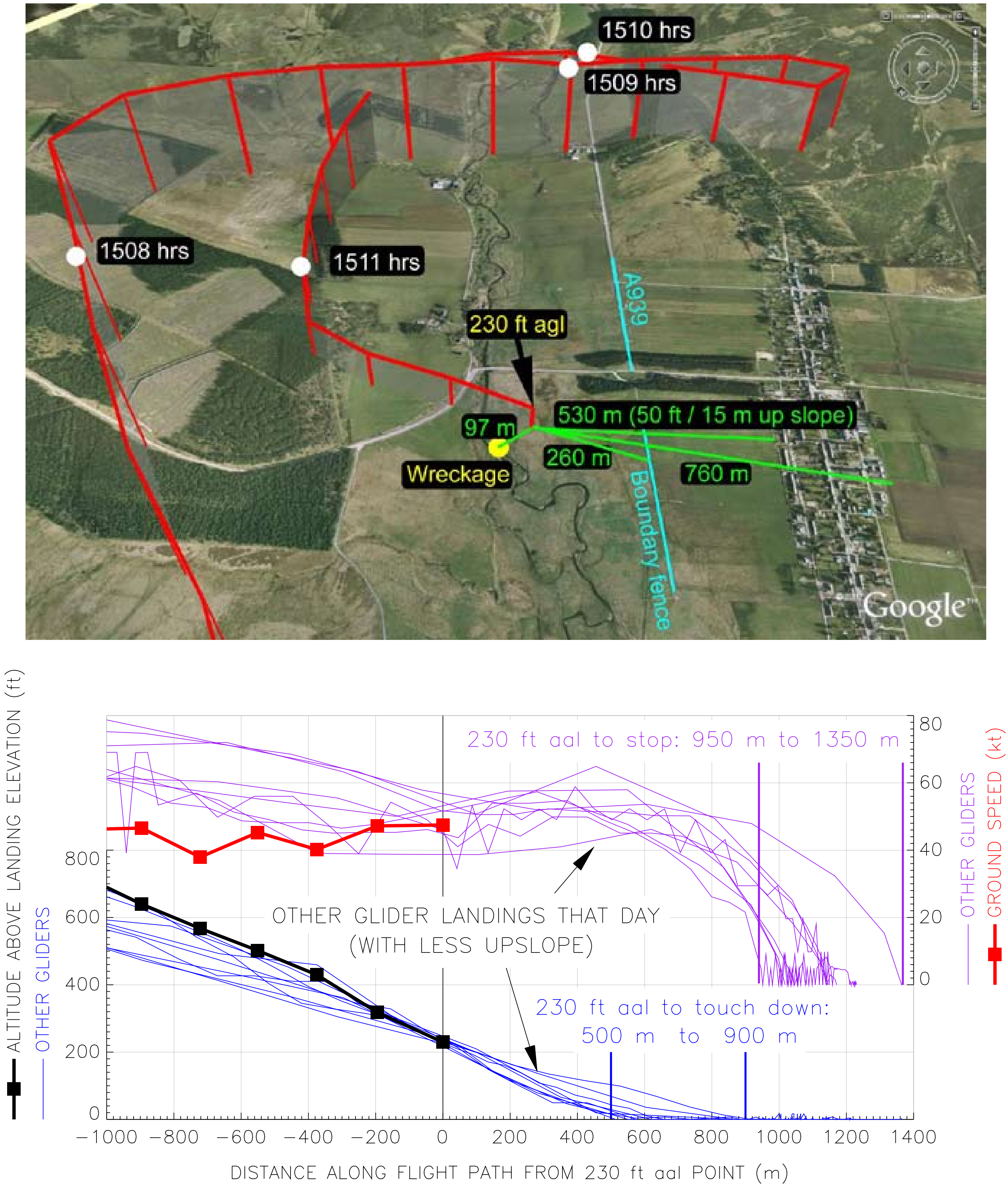


**Figure 1**

a) Glider path at the end of the flight as recorded by the glider logger
b) Landing data from other gliders flying during the competition

Google Earth ™ mapping service / imagery copyright Getmapping Plc, www.getmapping.com

Beyond the field were houses and then further fields. Taking into account the fact that the last recorded point was only approximately 180 ft above the elevation of the field beyond the housing, a landing there would not appear to have been a viable option since the furthest distance to touchdown recorded on the day was approximately 900 m, and this was over relatively flat terrain.

The wreckage was located 97 m from the last recorded point, to the rear and right of the track direction at that last point. This would indicate that a turn took place after the last recorded point. A circular orbit with a diameter of 97 m would have a track distance of 305 m, making a subsequent approach to the field directly ahead of the glider viable if the descent rate did not decay during the orbit.

Assuming the orbit was started just after the last recorded point, it would have taken less than 8 seconds to reach the wreckage location, making it a reasonable explanation as to why no other track points were recorded. To lose 230 ft before another track point could be recorded would require a descent rate in excess of 1,725 ft/min.

The glider logger recorded increased noise levels starting in the 180° turn onto the down wind leg of the approach. A further increase in noise was recorded when the glider turned onto its final heading. These may be associated with changes in configuration. The levels of noise were consistent with the levels of noise experienced during the towed climb at the start of the flight. Whilst the numbers associated with this noise parameter are not directly comparable with the same parameters recorded using other loggers and on other gliders, it is of note that the other ASH 25 competing that day also had increased noise levels prior to landing, comparable with its noise levels during its towed climb. Therefore, these changes in noise levels do not appear to be indications of any abnormality.

**Analysis**

The P2's recollections and eyewitness accounts indicate that the glider departed controlled flight whilst in a right turn and with insufficient height to make a safe recovery. It was established that the glider struck the ground right wing first in a very steep attitude with the landing gear in the down position and the flaps most probably set at the landing position. The cockpit was destroyed in the accident, and whilst the possibility of a control restriction within this area could not be eliminated, the investigation could identify no engineering reason why the accident should have occurred.

In a turn to the right, the right wing, on the inside of the turn, would have had a slower relative airflow over it compared to the left wing. As such, the right wing would have been closer to its stalling speed and would thus have been more susceptible to stalling before the left. A stall in this situation would have caused the glider's right wing to drop, which would have led to autorotation and a steep nose-down attitude. In addition, the wind at the time was likely to have been turbulent and variable in strength and direction. This may have had the effect of producing differing levels of lift along the glider's long wing and may also have masked the initial indications of a stall, which includes light buffeting of the aircraft.

The P1 had 'landed out' in an ASH 25 and other types of glider before, and, as such had some experience of the glider's handling and performance in this situation. It appears, however, that the glider was too high on the approach to the selected field and was unlikely to reach the field beyond the houses. The P1 therefore entered an orbit to the right in an attempt to lose the excess height.

Assuming the orbit was started just after the last recorded point, it would have taken less than 8 seconds to reach the wreckage location, possibly explaining why no other track points were recorded. To lose 230 ft within that time-frame would require a descent rate in excess of 1,725 ft/min, which is not unrealistic for a glider that has stalled and is in the attitude described by both the P2 and the eyewitness.

Whilst the P1 received fatal injuries the P2 sustained injuries of a serious nature. The difference in their injuries was most likely due to their relative seating positions. The front cockpit is likely to have effectively absorbed a significant proportion of the impact forces during its deformation, with the consequence that the peak deceleration experienced by the P2 would have been less that that of the P1.

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**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Gemini Flash IIA, G-MVTC |
| **No & Type of Engines:** | 1 Rotax 503 piston engine |
| **Year of Manufacture:** | 1989 |
| **Date & Time (UTC):** | 27 January 2008 at 1500 hrs |
| **Location:** | Arclid Airfield, near Sandbach, Cheshire |
| **Type of Flight:** | Training |
| **Persons on Board:** | Crew - 1 Passengers - None |
| **Injuries:** | Crew - None Passengers - N/A |
| **Nature of Damage:** | Severe damage to fuselage, wing and propeller, beyond economical repair |
| **Commander's Licence:** | Student pilot |
| **Commander's Age:** | 42 years |
| **Commander's Flying Experience:** | 226 hours (of which 20 were on type)<br>Last 90 days - 2 hours<br>Last 28 days - 2 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot |

**Summary**

On finals to Runway 29 at Arclid the pilot experienced a high rate of descent and contacted the ground before the runway threshold. The nosewheel dug into the ground and the aircraft cartwheeled.

**History of the flight**

The Gemini Flash is a two-seat flexible-wing microlight aircraft. The student pilot had performed several circuits and landings with a club instructor, using Runway 02 at Arclid. The instructor then briefed him for a solo exercise, with the instruction to change to the shorter Runway 29 for landing if the wind veered and increased in strength.

The pilot took off and completed the solo exercises. Returning to Arclid, he noted from the windsock that the wind had increased in strength from when he had taken off and was from the west. He joined the circuit, left-hand, for Runway 02 but found the approach turbulent, he applied power and performed a missed approach from a low height. He performed a second approach to Runway 02 but this was again turbulent and this time he performed the go-around at a greater height, positioning for a left-hand circuit for Runway 29. The surface wind, which was about 8 kt, had been forecast as being from 240° but, at this point, was from about 290°.

Turning onto base leg for Runway 29, the pilot saw the airspeed indicator showing 55 mph and considered that the height was correct. Turning finals, he passed over a line of trees and checked there was good clearance; he believes that the airspeed at that point was 60 mph. On final approach he checked the airspeed and saw 55 mph but also noticed a high sink rate, while still in a level attitude. The pilot applied full power and pushed forward the control bar, to climb away, but the aircraft hit the ground. The ground marks showed that the nosewheel sank into the ground, and the aircraft cartwheeled, coming to rest short of the threshold for Runway 29, with the pilot hanging in his straps. The pilot considers that a downdraft on finals certainly contributed to the high sink rate.

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Gemini Flash IIA, G-MWTG |
| **No & Type of Engines:** | 1 Rotax 582-2V piston engine |
| **Year of Manufacture:** | 1991 |
| **Date & Time (UTC):** | 30 April 2008 at 1000 hrs |
| **Location:** | Otherton Airfield, Staffordshire |
| **Type of Flight:** | Training |
| **Persons on Board:** | Crew - 2 Passengers - None |
| **Injuries:** | Crew - 1 (Minor) Passengers - N/A |
| **Nature of Damage:** | Aircraft extensively damaged |
| **Commander's Licence:** | Private Pilot's Licence |
| **Commander's Age:** | 49 years |
| **Commander's Flying Experience:** | 1,200 hours (of which 430 were on type)<br>Last 90 days - 120 hours<br>Last 28 days - 30 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot |

**Synopsis**

The microlight aircraft collided with a boundary fence during a forced landing in a field following an engine failure. The aircraft was extensively damaged and one pilot sustained minor injuries.

**History of the flight**

The accident occurred during a circuit training detail. The aircraft had already completed a number of uneventful circuits from grass Runway 11, and was climbing back to circuit height when, between 200 and 300 ft agl, the engine stopped suddenly. The instructor assumed control and executed a forced landing in a field, but was unable to stop in the distance available. The microlight struck a boundary fence at low speed before pitching over the fence, causing the wing to be badly damaged and the student pilot to sustain minor injuries.

The cause of the engine failure was not established. The microlight is reportedly uneconomical to repair, but should it be examined to determine the cause, then this will be reported upon in a future edition of the AAIB Bulletin.

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | 1) Jabiru UL-450, G-NIGC<br>2) Jabiru UL-450, G-BZHR |
| **No & Type of Engines:** | 1) 1 Jabiru Aircraft Pty 2200A piston engine<br>2) 1 Jabiru Aircraft Pty 2200A piston engine |
| **Year of Manufacture:** | 1) 2001<br>2) 2001 |
| **Date & Time (UTC):** | 8 June 2008 at 1430 hrs |
| **Location:** | North Coates Airfield, Lincolnshire |
| **Type of Flight:** | 1) Private<br>2) Private |
| Persons on Board: | 1) Crew - 1 Passengers - 1<br>2) Crew - 1 Passengers - 1 |
| **Injuries:** | 1) Crew - None Passengers - None<br>2) Crew -None Passengers - None |
| **Nature of Damage:** | 1) Minor damage to the tail fin<br>2) None |
| **Commander's Licence:** | 1) Private Pilot's Licence<br>2) Private Pilot's Licence |
| **Commander's Age:** | 1) 67 years<br>2) 75 years |
| **Commander's Flying Experience:** | 1) 1,200 hours (of which 50 were on type)<br>Last 90 days - 30 hours<br>Last 28 days - 12 hours<br><br>2) 1,473 hours (of which 309 were on type)<br>Last 90 days - 14 hours<br>Last 28 days - 12 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot |

**Synopsis**

The pilot of G-BZHR was taxiing his aircraft past a line of parked aircraft, which were on his right side, when his right wing tip contacted the tail fin of G-NIGC. The pilot had been following the wheel tracks in the grass made by other aircraft and was not monitoring his wing tip clearance.

**History of the flight**

The pilots of G-BZHR and G-NIGC were attending a 'fly in' at North Coates Airfield in Lincolnshire. The weather was good with CAVOK conditions and Runway 05 was in use. Having been cleared to taxi for the holding point of Runway 05, the pilot of G-BZHR left the main parking area. He followed the tracks in the grass which had been made by other aircraft that day. He was concentrating on the undulations of the taxiway because he was aware of the possible damage the ground could cause to the Jabiru's nose landing gear. On his right side was a line of parked aircraft facing away from him and, as he passed the last aircraft on the line, the right wing tip of his aircraft struck the vertical fin of that aircraft.

There was sufficient space on the left side of his aircraft to move to the left but as he was following the tracks in the grass and was not monitoring the clearance from G-NIGC he did not use it. After the impact both pilots closed down their aircraft and inspected the damage.

**Conclusion**

The pilot concluded that because his attention was fully occupied in looking forward and following the wheel tracks he did not appreciate how close he was to the other aircraft.

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | MCR-01 ULC, G-CENA |
| **No & Type of Engines:** | 1 Rotax 912 ULS piston engine |
| **Year of Manufacture:** | 2007 |
| **Date & Time (UTC):** | 21 April 2008 at 1815 hrs |
| **Location:** | Caunton Airfield, Nottinghamshire |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - None |
| **Injuries:** | Crew - None Passengers - N/A |
| **Nature of Damage:** | Substantial |
| **Commander's Licence:** | Private Pilot's Licence |
| **Commander's Age:** | Undeclared |
| **Commander's Flying Experience:** | 473 hours (of which 103 were on type)<br>Last 90 days - 6 hours<br>Last 28 days - 2 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot |

**Synopsis**

The aircraft made an uncommanded left turn on landing after encountering a gust of wind and was damaged when it entered a ditch.

**History of the flight**

The owner pilot was landing at Caunton Airfield, which has two perpendicular grass strips, one aligned east-west and the other which provides a north-north-easterly landing run. He chose the latter. He stated that the wind was from the north east at approximately 18 mph, with visibility of 7 km, a cloudbase at 2,100 ft and a temperature of +6.5ºC.

The pilot stated that, after landing, a gust of wind lifted the right wing and turned the aircraft towards a ditch at the left edge of the strip. He applied the brakes, switched off the engine and attempted to turn away from the ditch but found that "there was no response from the pedals or independent braking". He estimated that the aircraft entered the ditch at a speed of approximately 15 mph, sustaining damage to both wing leading edges and the landing gear. He vacated the aircraft without injury after switching off the fuel and electrical power.

The pilot's assessment of the cause was that a "freak gust of wind caught the right wing" and that subsequently he was unable to control the aircraft.

**Aircraft information**

The Dyn'Aero MCR-01 ULC is a high performance low-wing two-seat microlight of composite construction with a tricycle landing gear. Brakes on the main wheels are operated by a hand lever on the control stick and can be applied differentially according to the position of the rudder pedals. The pilot did not report having experienced handling problems prior to this accident or any mechanical defect that might have contributed to the loss of control. The '*MCR ULC Flight manual*' produced by the manufacturer states that the maximum crosswind in which operation of the aircraft has been demonstrated was 20 kt. The steerable portion of the nose gear leg will self-centre when the leg is unloaded, such as when airborne.

**Discussion**

The investigation was unable to determine why the aircraft turned left at the end of the landing run. The reported wind would have had a crosswind component of less than the maximum in which operation of the aircraft has been demonstrated by the manufacturer. If, as reported, the wind was from the north-east and the right wing lifted, there would be a natural tendency for the aircraft to turn into wind (ie right), as demonstrated in a similar accident to another MCR-01, G-NONE[1]. If the right wing was lifted so severely that the left wingtip contacted the runway then this might have caused a swing to the left which would have been difficult to control. There was no evidence of wingtip damage, however. If the nosewheel was not firmly on the ground the pilot may have had little or no direct steering control, but it should still have been possible to apply differential brake.

**Footnote**

1 Reported in AAIB bulletin 9/2005, reference EW/G2005/06/26.

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | MCR-01 ULC, G-TDVB |
| **No & Type of Engines:** | 1 Rotax 912 ULS piston engine |
| **Year of Manufacture:** | 2004 |
| **Date & Time (UTC):** | 12 January 2008 at 1230 hrs |
| **Location:** | Willingale Airfield, Essex |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - None |
| **Injuries:** | Crew - None Passengers - N/A |
| **Nature of Damage:** | Propeller and canopy shattered, T-tail flying surfaces damaged |
| **Commander's Licence:** | Private Pilot's Licence |
| **Commander's Age:** | 74 years |
| **Commander's Flying Experience:** | 2,064 hours (of which 557 were on type)<br>Last 90 days - 25 hours<br>Last 28 days - 8 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot |

**Synopsis**

A downslope landing on a wet grass runway surface resulted in a runway overrun and damage to the aircraft when it subsequently nosed over.

**History of the flight**

The pilot had flown from his home base at Plaistowes Airfield to Willingale. It was his first flight into Willingale and he joined through the overhead. During the join, he noted a westerly wind and was told by an unidentified person on the ground using the microlight Unicom, that Runway 02 was in use. The pilot made an approach to Runway 02 at 50 kt and touched down near the beginning of the runway. The braking was initially good but as the downslope increased, the runway surface became very soft and the braking less effective. G-TDVB overran the end of the runway by a few metres and nosed over. The pilot, who was wearing a full harness, was uninjured though trapped and was helped from the aircraft by local microlight pilots.

**Airfield**

Willingale Airfield has a single grass runway orientated 02/20 which is approximately 400 m long. The pilot reported that it has a slight downslope which increases towards the end of the runway.

**MCR-01-ULC performance**

The manufacturer's performance figures state that the MCR-01-ULC requires 270 m of hard runway for landing (including airborne distance). It also states that a factor of 20% should be added for grass and 40% for unimproved strips. Using the 20% addition, the landing distance required increases to 324 m and using the 40% addition, a landing distance of 378 m is required.

In Safety Sense leaflet 7 (*Aeroplane Performance*), the CAA recommend that 10% is added to landing distances for every one degree of downslope. There are also additional factors to add if the grass is wet.

The pilot of G-TDVB stated that he normally operates from a 350 m grass strip with no difficulties and routinely has, in his estimation, a ground roll of no more than 150 m on landing.

The aircraft manufacturer confirmed that for a full flap approach, 45.5 kt was the theoretical approach speed and that 50 kt was not unreasonable for normal approaches. The manufacturer also confirmed that a ground roll of 100 m to 150 m was normal for a full flap landing.

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Pegasus Quantum 15, G-CDHM |
| **No & Type of Engines:** | 1 Rotax 582-48 piston engine |
| **Year of Manufacture:** | 2004 |
| **Date & Time (UTC):** | 27 February 2008 at 1300 hrs |
| **Location:** | Private farm strip, Pentyrch, near Cardiff |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - None |
| **Injuries:** | Crew - 1 (Minor) Passengers - N/A |
| **Nature of Damage:** | Damage to wing structure, keel spar and landing gear legs |
| **Commander's Licence:** | National Private Pilot's Licence |
| **Commander's Age:** | 62 years |
| **Commander's Flying Experience:** | 258 hours (of which 80 were on type)<br>Last 90 days - 4 hours<br>Last 28 days - 3 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB |

**Synopsis**

The aircraft touched down long and fast on a 300 metre grass farm strip, causing the aircraft to bounce. The pilot applied full power to go around but was unable to clear a 2 metre hedge at the end of the runway. The aircraft's landing gear legs hit the hedge and the aircraft 'flipped' and landed on its left side. The presence of a gusty tailwind contributed to the long and fast landing.

**History of the flight**

The Pegasus Quantum 15 is a two-seat flex-wing microlight aircraft with a maximum takeoff weight of 409 kg. The pilot departed from Runway 28 at Swansea airport for a flight to a private farm strip, 0.5 miles east of Pentyrch, which was to become the aircraft's new base.

The pilot had landed at this farm strip on two previous occasions and had also carried out a visual inspection on foot – the runway surface was approximately 300 metres long in the direction 07/25. The wind on departure from Swansea was from about 260º but, passing the Port Talbot steelworks during the flight, the pilot noticed from the chimney stacks that the wind appeared to be more easterly. Therefore, on arriving at the farm strip, which was approximately 19 nm east of the steelworks, he decided to land in the direction of 070º.

The pilot reported that the wind was gusty and variable, which made flying the aircraft difficult and he suspected that a tailwind was present during final approach. His first two approaches resulted in go-arounds. During the third approach he was able to land, but the aircraft touched down fast and over halfway along the length of the available runway. It bounced heavily at touchdown so the pilot added full power to go around, but the aircraft had insufficient speed and had gained insufficient height to clear a 2 metre hedge at the end of the runway. The aircraft's landing gear legs hit the hedge and the aircraft flipped and landed on its left side, resulting in significant damage to the wing structure, keel spar and gear legs. An eyewitness confirmed that the wind was gusty and variable at the time of the accident.

**Pilot's assessment of the cause**

The pilot assessed the cause of the accident as his '*failure to address the strength and direction of the wind.*' He also considered that his slow application of power after the bounced landing contributed to the aircraft not clearing the hedge.

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Rans S6-ESD Coyote II, G-MYBA |
| **No & Type of Engines:** | 1 Rotax 503 piston engine |
| **Year of Manufacture:** | 1992 |
| **Date & Time (UTC):** | 10 May 2008 at 1321 hrs |
| **Location:** | Chilbolton Flying Club, Hants |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 2 Passengers - None |
| **Injuries:** | Crew - None Passengers - N/A |
| **Nature of Damage:** | Extensive: landing gear broken off, propeller shattered, engine and cowlings damaged |
| **Commander's Licence:** | National Private Pilot's Licence |
| **Commander's Age:** | 65 years |
| **Commander's Flying Experience:** | 360 hours (of which 7 were on type)<br>Last 90 days - 8 hours<br>Last 28 days - 4 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot and subsequent AAIB enquiries |

**Synopsis**

The aircraft stalled and struck the ground shortly after becoming airborne. The investigation showed that aircraft performance, a slight tailwind, high temperature and long grass on the runway contributed to the accident.

**History of the flight**

The pilot and his passenger boarded the aircraft for a private flight to a nearby airfield. With two occupants on board and 30 litres of fuel, the aircraft weighed 400 kg (its maximum takeoff weight was 430 kg). The weather was fine with a light north to north-easterly wind, good visibility, a temperature of +28°C and a QNH of 1012 mb. The pilot used Runway 24 for takeoff; this grass runway is approximately 490 m long with an uphill slope. Although the grass at the eastern end of the runway was only about 80 mm high, the grass at the western end of the runway was considerably longer, up to 230 mm high.

The pilot reported that although the engine rpm was normal during the takeoff roll, the aircraft seemed to accelerate less rapidly than expected. The aircraft became airborne but only reached a height of 30 ft and a speed of 50 mph (previously noted as its stalling speed) by the upwind end of the runway. Shortly after, the aircraft stalled and struck the ground in a level attitude. Although the aircraft was substantially damaged, both occupants were protected by the structure around the cockpit and vacated the aircraft without injury. There was no fire.

The aircraft manufacturer did not publish any performance information relevant to the aircraft type. However, an experienced Rans S6 pilot stated that on a short grass runway, he would expect the takeoff ground roll of this aircraft to be approximately 400 m. Examination of the aircraft's Permit to Fly flight test records, and those from similar aircraft[1], showed that the accident aircraft's climb rate was less than than the others.

The CAA's Safety Sense Leaflets 12d, entitled *'Aeroplane Performance'*, includes advice regarding the factors which influence takeoff distance. The high temperature, slight tailwind component and long grass would all have lengthened this distance. The pilot reported, some time after the accident, that he planned to have his aircraft repaired and fitted with a larger engine. He also stated that he had undertaken further training on stalling with a flying instructor.

**Footnote**

[1] Aircraft of the same type and fitted with the same engine and propeller.

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Rans S6-ESD Coyote II, G-MYLW |
| **No & Type of Engines:** | 1 Rotax 503 piston engine |
| **Year of Manufacture:** | 1993 |
| **Date & Time (UTC):** | 26 April 2008 at 1510 hrs |
| **Location:** | Priory Farm Airfield, Norfolk |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - None |
| **Injuries:** | Crew - None Passengers - N/A |
| **Nature of Damage:** | Nose landing gear and the underside of the fuselage |
| **Commander's Licence:** | Private Pilot's Licence |
| **Commander's Age:** | 57 years |
| **Commander's Flying Experience:** | 239 hours (of which 15 were on type)<br>Last 90 days - 10 hours<br>Last 28 days - 4 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot, engine test by the UK manufacturer's agent and an aftercast from the Met Office |

**Synopsis**

At about 100 ft on the climb-out the engine "faltered". The pilot levelled the aircraft, which was very rapidly followed by the engine stopping. Due to insufficient height, speed and time the pilot initiated the flare as the aircraft impacted the ground in a field adjoining the side of the runway. Following the accident no clear reason for the engine failure could be found.

**History of the flight**

The pilot/owner carried out a normal pre-flight check of the aircraft and found everything to be acceptable for flight. After starting the engine he ensured that it had reached its operating temperature, which took 8 to 9 minutes, before starting the takeoff. At about 100 ft on the climbout the engine "faltered". The pilot levelled the aircraft, which was very rapidly followed by the engine stopping. He applied nose-down pitch and steered the aircraft away from the hangars and parked aircraft that were in the overshoot area of the runway. Due to insufficient height, speed and time the pilot initiated the flare as the aircraft impacted the ground in a field adjoining the side of the runway, causing damage to the nose landing gear and the lower fuselage.

Following the accident the pilot could find no obvious reason for the engine failure. There was sufficient fuel of the correct type, the fuel and ignition were switched ON, the fuel filter was clean and the propeller was free to rotate.

**Engineering examination**

The engine was taken to the manufacturer's UK agent where it was examined and test run. A limited examination of the cylinders and pistons revealed no evidence of a 'cold' seizure. The engine was placed onto a test stand and test run. It was started on the second pull of the start cord and ran satisfactorily.

**Meteorological aftercast**

The aftercast showed that there was a shallow area of low pressure over Liverpool at 1200 hrs which moved northeast to cover Middlesbrough by 1800 hrs. A 'split' or 'upper' cold front was observed over Norfolk and Suffolk at 1200 hrs, which moved east to the coast by 1800 hrs. A surface cold front was seen moving from the Welsh border at 1200 hrs to just to the west of the meridian at 1800 hrs. The estimated ground level wind and temperatures relevant to the accident area at 1520 hrs were 180/10; temperature 16.5 to 17.4°C; dew point 9.5 to 10.4°C and humidity 60 to 67%.

These ground level temperature and humidity figures were plotted on the carburettor icing probability chart that is shown in the CAA General Aviation Safety Sense Leaflet 3A titled '*Winter Flying*' and Leaflet 14 titled '*Piston Engine Icing*'. They indicated that there was a possibility of moderate carburettor icing at a cruise engine power setting and serious icing at a descent power setting.

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Streak Shadow, G-CBGI |
| **No & Type of Engines:** | 1 Rotax 582 piston engine |
| **Year of Manufacture:** | 2006 |
| **Date & Time (UTC):** | 9 May 2008 at 2015 hrs |
| **Location:** | Wellow Lane, Hinton Charterhouse, Somerset |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - 1 |
| **Injuries:** | Crew - 1 (Serious) Passengers - 1 (Minor) |
| **Nature of Damage:** | Severe airframe damage |
| **Commander's Licence:** | Private Pilot's Licence |
| **Commander's Age:** | 67 years |
| **Commander's Flying Experience:** | 124 hours (of which 101 were on type)<br>Last 90 days - 6 hours<br>Last 28 days - 6 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot |

**Synopsis**

In attempting to make a precautionary landing due to rapidly deteriorating weather conditions and failing light, the pilot flared high and landed heavily. The aircraft cartwheeled and came to rest in an inverted attitude.

**History of the flight**

The aircraft departed a farm strip at Wadswick, close to Corsham, at approximately 1905 hrs for a flight to Glastonbury and back, the pilot having reviewed the weather at the Met Office website at around 1630 hrs. The flight was uneventful until the aircraft passed Radstock on the return leg, whilst following a north-easterly course. With approximately 12 miles to run, the pilot saw a flash of lightning ahead, together with a very dark sky and heavy rain. He decided to turn the aircraft to the south and make a precautionary landing. After a few minutes he selected a suitable field to the south of the village of Hinton Charterhouse and planned the circuit. Downwind, base leg and final approach were conducted without any problems; however, the light had suddenly deteriorated due to the nearby storm clouds, and this resulted in the pilot flaring the aircraft too high. The pilot became aware of a hedge "looming up" as the aircraft had by now flown a little too deeply in to the field. It struck the ground heavily and cartwheeled before coming to rest in an inverted attitude. The passenger sustained only minor injuries and exited the wreckage of the aircraft without difficulty. He then assisted the pilot, who received chest injuries, to vacate the aircraft via the broken canopy. The emergency services arrived promptly after being summoned using the pilot's mobile telephone.

In reviewing the circumstances of the accident, the pilot considered that there were three contributory factors. These were the sudden onset of the thunderstorm, the consequent poor light, making judgement of the aircraft's height above the ground during the landing flare difficult and, as a result, a heavy landing resulting in the cartwheel.

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Streak Shadow, G-CZBE |
| **No & Type of Engines:** | 1 Rotax 618 piston engine |
| **Year of Manufacture:** | 1996 |
| **Date & Time (UTC):** | 6 May 2008 at 1027 hrs |
| **Location:** | Hayton, near Retford, Nottinghamshire |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - None |
| **Injuries:** | Crew - 1 (Minor) Passengers - N/A |
| **Nature of Damage:** | Damage to landing gear and wings |
| **Commander's Licence:** | Private Pilot's Licence |
| **Commander's Age:** | 60 years |
| **Commander's Flying Experience:** | 746 hours (of which 149 were on type)<br>Last 90 days - 9 hours<br>Last 28 days - 3 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot |

**Synopsis**

The pilot carried out a forced landing, following an engine failure due to fuel starvation. As he approached his chosen field, he realised that it sloped downhill, there were buildings at the far end and that he would be landing downwind. During an attempt to turn through 180º at low level, the aircraft landed heavily in an adjacent field.

**History of the flight**

The flight was planned from Charterhall, in Berwickshire to Old Sarum, in Wiltshire, with a stop at either Sherburn or Retford; the distance for the first sector was 160 nm. The pilot reported that both fuel tanks were full on departure. As the aircraft was crossing the M62 motorway, approximately 20 nm from Retford, the pilot noticed that there was ⅓ of the fuel remaining in the lower fuel tank; the main tank was already exhausted. He decided to continue to Retford but, when approximately 10 nm from the airfield, he noticed that the tank was now almost empty. With approximately 7 nm to run, the engine stopped; the aircraft was at a height of around 1,000 ft. The pilot selected a grass field in which to carry out a forced landing, but realised late on final approach that there was a tailwind and that his chosen field sloped downhill, with buildings at the far end. He carried out a low-level 180º turn, before landing heavily in the adjacent field, which contained a standing rape crop. The pilot sustained minor injuries.

The pilot stated that the range for the Streak Shadow is around 260 nm. The pilot had carried out a number of long distance flights in another Streak Shadow, but this was his first in G-CZBE. He considered that the error in fuel planning was caused by the difference in fuel consumption between the model he was familiar with and the particular propeller/engine combination fitted to this aircraft. Also, there was a strong headwind on the day of the accident.

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Thruster T300, G-MYAR |
| **No & Type of Engines:** | 1 Rotax 503 piston engine |
| **Year of Manufacture:** | 1992 |
| **Date & Time (UTC):** | 8 July 2007 at 0930 hrs |
| **Location:** | Horse Leys Farm, east of Loughborough, Leicestershire |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - N/A |
| **Injuries:** | Crew - 1 (Minor) Passengers - N/A |
| **Nature of Damage:** | Minor |
| **Commander's Licence:** | Private Pilot's Licence |
| **Commander's Age:** | Not known |
| **Commander's Flying Experience:** | 378 hours (of which 105 were on type)<br>Last 90 days - 3 hours<br>Last 28 days - 0 hours |
| **Information Source:** | BMAA Accident Report Form submitted by the pilot and further enquiries by the AAIB |

**Synopsis**

During takeoff from a grass farm strip the aircraft suffered a loss of power. The pilot carried out a forced landing in a wheat field but the aircraft clipped a hedge and inverted. The pilot assessed the cause of the power failure to have been due to a blocked vent in the fuel tank cap.

**History of the flight**

The Thruster T300 is a two-seat three-axis microlight aircraft with a maximum takeoff weight of 370 kg. Its Rotax 503 piston engine is mounted on a pylon ahead of the wing. The accident flight occurred after two successful short flights while operating from a 480 metre grass farm strip. The two short flights were conducted with the 40 litre fuel tank half-full. The pilot had experienced some over-pressurisation of the carburettors using the electric fuel pump, which was causing fuel to drip onto the windscreen, so he had switched the electric fuel pump off and was using only the mechanical pump to supply the fuel. He reported that the fuel pressure had been fine during the first two flights with the mechanical pump. For the third flight the pilot filled the tank to full and was ready to depart approximately 10 minutes after landing from the previous flight.

The takeoff proceeded normally although the aircraft lifted off later than on the previous flights, which the pilot thought was due to the increased fuel load and some soft patches on the runway. At about 30 feet agl the pilot noticed that the engine power was starting to fade. By the time he realised what was occurring he had allowed the aircraft to drift to the left and was now over a hedge and standing mature wheat crop. He now had no power and did not have sufficient speed or height to return to the runway, so he elected to land straight ahead. The aircraft clipped a hedge and flipped inverted relatively gently, coming to rest in the wheat. At this point the pilot had not suffered any injuries but when he released his harness, he did not brace himself and fell out of his inverted seat. He was wearing a helmet but suffered a strained neck upon hitting the main fuselage tube.

**Pilot's assessment of the cause**

The pilot believes that the tank breather, which consists of a small hole in the top of the fuel cap, was probably blocked. This blockage would have caused a partial vacuum in the tank as the fuel level reduced, eventually reducing the fuel flow below a sufficient level to sustain the engine. The pilot was not able to confirm this theory because the vent hole, when examined, was not blocked. However, the pilot believes that when the aircraft inverted, the pressure of the 40 litres of fuel, which was now on top of the vent hole, may have cleared the blockage.

The pilot considers that a contributory cause of the accident was his allowing the aicraft to drift to the left of the runway while the power fade was distracting him.

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## 2007

4/2007 Airbus A340-642, G-VATL
en-route from Hong Kong to
London Heathrow
on 8 February 2005.

Published September 2007.

5/2007 Airbus A321-231, G-MEDG
during an approach to Khartoum
Airport, Sudan
on 11 March 2005.

Published December 2007.

6/2007 Airbus A320-211, JY-JAR
at Leeds Bradford Airport
on 18 May 2005.

Published December 2007.

7/2007 Airbus A310-304, F-OJHI
on approach to Birmingham
International Airport
on 23 February 2006.

Published December 2007.

## 2008

1/2008 Bombardier CL600-2B16 Challenger
604, VP-BJM
8 nm west of Midhurst VOR, West
Sussex
on 11 November 2005

Published January 2008.

2/2008 Airbus A319-131, G-EUOB
during the climb after departure from
London Heathrow Airport
on 22 October 2005

Published January 2008.

3/2008 British Aerospace Jetstream 3202,
G-BUVC
at Wick Aerodrome, Caithness, Scotland
on 3 October 2006.

Published February 2008.

4/2008 Airbus A320-214, G-BXKD
at Runway 09, Bristol Airport
on 15 November 2006.

Published February 2008.

5/2008 Boeing 737-300, OO-TND
at Nottingham East Midlands Airport
on 15 June 2006.

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