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(ALL TIMES IN THIS BULLETIN ARE UTC)

ACCIDENT

Aircraft Type and Registration:	Bombardier BD700 Global Express, VP-CRC
No & Type of Engines:	2 Rolls Royce BR 710 series turbofans
Year of Manufacture:	2007
Date & Time (UTC):	29 January 2008 at 0808 hrs
Location:	London Luton Airport
Type of Flight:	Private
Persons on Board:	Crew - 3 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Left inboard main landing gear tyre burst, flap drive shaft and two hydraulic pipes fractured, wiring loom damaged and localised wing structural damage
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	36 years
Commander's Flying Experience:	3,759 hours (of which 92 hrs were on type) Last 90 days - 78 hours Last 28 days - 38 hours
Information Source:	AAIB Field Investigation

Synopsis

Following an extended period of heavy rain, VP-CRC took off from a dry runway for a long-range flight to London Luton Airport. During the subsequent landing roll, the left inboard main landing gear tyre suffered a slide-through failure resulting from an initially locked wheel. This tyre failure caused extensive damage to the flight control system. Although the aircraft landed safely, the investigation revealed a significant flight safety risk and four Safety Recommendations are made.

History of the flight

VP-CRC departed Van Nuys, California at 2240 hrs and arrived at London Luton at 0808 hrs on the following day. The flight had been without incident. Shortly after a normal touchdown on Runway 26, the crew became aware of a rumbling noise which they identified as a burst tyre. Simultaneously an aircraft at the holding point reported by radio that VP-CRC had suffered a tyre burst. The commander applied normal braking and 15 seconds after touchdown, the Nos 2 and 3 hydraulic system low pressure Engine Indication and Crew Alerting System (EICAS) messages displayed. The commander brought the aircraft to a stop on the runway using normal brakes and, as fire vehicles approached, shut down both engines.

Tyre failure and associated damage

The AAIB investigation revealed that an inboard main-wheel tyre suffered a slide-through type failure resulting from a locked wheel. This developed into a larger disruption of the tyre carcass which in turn resulted in flailing of a substantial section of both tread and carcass when the wheel then began to rotate. The flailing material struck the spray guard at the rear of the auxiliary spar below the inboard ground spoiler a number of times. This destroyed the guard, inflicted significant damage to the wing local auxiliary spar structure and fractured hydraulic pipes resulting in Nos 2 and 3 hydraulic systems becoming inoperable. It also fractured the flap drive torque tube, damaged a major wiring loom and caused metallic debris to be forced between and into contact with the two cables driving the left aileron.

The tyre in question was of the cross-ply type, sometimes known as a Bias ply type.

The landing took place on a dry runway of generous length for the aircraft type. Examination of the relevant components and the flight data recorder (FDR) led to the conclusion that the aircraft touched down with the left inboard wheel locked and that it became free to rotate shortly after the tyre ruptured. The locked condition of the wheel does not appear to have been the result of high hydraulic pressure being supplied to the associated brake. Between the touchdown and the tyre failure, the recorded brake pressure supplied to this unit remained low and almost identical to that supplied to the brake on the neighbouring wheel, the tyre of which was undamaged. Detailed examination and functioning of the brake unit from the wheel on which the ruptured tyre was mounted revealed no evidence of damage or malfunction. In particular the brake pistons released fully and correctly as hydraulic pressure was released, following every one of a series of simulated brake applications carried out on a test rig.

The AAIB is concerned that a similar failure sequence occurring during a 'touch-and-go' landing, or a comparable extent of tyre failure occurring, for different reasons, at a late stage during a takeoff run, could inflict damage to flying controls, hydraulic services and electrical conductors, sufficient to cause reduction or total loss of control either before or after takeoff.

The manufacturer's analysis of a similar failure is that the aircraft would remain controllable. They state that:

> *'a loss of control command to the spoiler control PCU's will cause the PCU's to default to safe mode (retracted) and redundant monitoring channels of the spoiler control system will prevent spoiler runaway. A loss of hydraulics would result in a slow and graduate drift of spoiler surfaces to aerodynamic neutral over time due to internal leakage.'*

The AAIB's rationale for their concern is described more fully later in this bulletin in the section titled 'Effect of damage on controllability'. The section 'Additional matters arising' is also relevant.

Slide-through tyre failures

A slide-through failure occurs in a tyre following an extended period of ground motion with a locked wheel. This results in concentrated local wear of the tread, creating an elliptical 'flat spot'. If the wear is sufficient for the centre of the elliptical area to penetrate into the carcass, the thickness of the latter will reduce locally, causing the stresses created by the inflation pressure to increase. With sufficient wear, these stresses will exceed the tensile strength of the remaining material in the region of the centre of the ellipse. Bursting failure thus occurs, with tearing of the carcass emanating from the centre of this wear pattern, generally radiating in four directions, each following the diagonal orientation of the tyre reinforcing plies.

In certain cases these diagonal tears extend through the tyre shoulder area, into and through the sidewall. On reaching the reinforcing beads at the junction of the sidewall and the wheel, the tear may change direction, again following the orientation of plies, propagating back towards the tread. Regions of sidewall, approximately V shaped, will remain attached to the separated section at the shoulder of the tread. The tread generally provides sufficient reinforcement to arrest the tear as it re-crosses the shoulder, leaving the separated section of tread and carcass securely attached, via the region of carcass below the tread, to the remainder of the tyre. Should the wheel become unlocked, rotational flailing of this attached section of tread and carcass inflicts damage on anything it strikes. The magnitude of the damage is dependant on the mass of the flailing material, local strength of the tyre chords and the wheel speed. Tyre strike angle influences the damage to a more limited extent and is affected by aircraft weight and speed at the time of failure.

Departure weather

The aircraft had been parked in the open at Van Nuys Airport, California for four days before its departure for Luton on the accident flight. During this period the wheels were chocked with the brakes off and approximately 118 mm of rain fell, 15.7 mm falling during the twenty-four hours prior to departure. Significant rain ceased eleven hours before takeoff and no rain fell during the last eight hours before departure. During the final eight hour period the surface wind averaged 10 kt, the temperature was +12° C and the dew point +3° C. It is therefore clear that although extensive heavy rainfall occurred during the stay at Van Nuys, the surface conditions were dry by the time the occupants boarded the aircraft. The FDR data shows that after engine start, the aircraft taxied with minimal brake application. After takeoff it climbed rapidly to FL 410 for the 9.5 hour cruise to the UK.

Taxi technique

It is common practice, in business jet operations, to avoid using brakes wherever possible. The manufacturer's Operations Reference Manual (ORM) for the BD700 includes a section titled 'adverse weather' which advises use of the brakes during the taxi to warm the wheels in order to avoid 'frozen brakes.' This advice states 'monitor BTMS (Brake Temperature Monitoring System) during taxi' but there is no information detailing to how high a figure the brake temperature should be raised. Situations where the aircraft is parked only a short taxi distance from the holding point are not considered and the manual advises a 10 kt taxi speed which would provide little kinetic heating of the brakes. This information only applies on surfaces 'contaminated or covered with water'. At the time of departure the weather conditions were not adverse and the runway was not contaminated or covered in water. It should be noted that the ORM is produced for training purposes only; the Airplane Flight Manual and the Flight Crew Operating Manual are the documents intended for use by the flight crew in normal operations.

Previous events

It is understood that a similar aircraft type suffered a tyre rupture on arrival in Switzerland from Saudi Arabia, having departed shortly after it was washed. No fault was found in the brake system and it was concluded that the tyre failure resulted from freezing of water in the brake area during the flight, leading to locking of a brake unit.

The manufacturer reported that the crew completing the washing was unsupervised and did not protect the brake assemblies as required in the recommended cleaning procedures. However, this event illustrates the effect a high level transit can have on initially wet carbon-carbon brakes.

A landing accident occurred in Taiwan to a similar aircraft when it is understood that a defect in a brake control valve led to locking of a wheel which produced a slide-through tyre failure followed by flailing damage. This resulted in fracture of lines serving two hydraulic systems together with destruction of the wiring looms supplying signals to the spoilers on the left wing. Loss of steering and brake supply pressure led to depletion of brake accumulator pressure during the landing roll, resulting in the aircraft leaving the paved surface at a low speed.

Water flow analysis

It has been determined that when stationary, water on the wing upper surface flows inboard and aft until it reaches the hinge line of the spoilers. It then descends between the fixed structure and the spoilers and onto an aft projection of the bottom wing skin. This has a cusped rear edge, creating a gutter. The water then flows inboard along the gutter as a result of the wing dihedral.

Close to the wing root, the water encounters a number of projections which dam the flow. This has previously resulted in puddling, leading to extensive local corrosion. In 2004 a modification was introduced on production aircraft and made available retrospectively. This involved drilling a drain hole to allow the puddled water to escape. It has been found in practice, however, that after passing through the drain hole, much of the water flows inboard along the lower skin of the wing. Only when it encounters a flush skin joint which creates a small gap in the surface, does some or all of the water fall from the wing surface. This point is above the main landing gear and the water tends to fall onto the outboard wall of the inner tyre. This mechanism is believed to have resulted in water migrating onto the face of the exposed stator and entering the cavity in the wheel within which the brake stators and rotors are housed.

Water absorption by carbon brakes

The brake manufacturers have confirmed that the materials of the rotors and stators, both being carbon type structures, are porous and slightly absorbent. After extensive water soaking they require a prolonged period of exposure to dry warm conditions to ensure that full drying takes place. Alternatively, significant braking action must be deliberately applied during taxiing before departure to ensure brake drying. It is important to be aware that, on this type, rainfall can cause wetting of the brakes even in light wind conditions when the brakes would normally be assumed to be sheltered by the wing structure. It is also important to be aware that the brakes remain saturated with water for a lengthy dry period after rainfall ceases and runways and taxiways become dry.

The FDR shows that only a brief and light application of the relevant brake took place during taxiing (at a speed of approximately 3 kt). Automatic brake application on the type then occurs for four seconds during retraction. It is concluded that the contact faces of the brake stators and rotors of the brake unit in question remained both wet and in close proximity as the aircraft climbed and the temperature in the wheel bay cooled to a sub zero level. The cruise took place at ambient temperatures below -25° C, which is presumed to have caused stationary and moving components to become firmly frozen together, leading to wheel locking and tyre slide-through on landing. Application of sustained torque to the locked wheel, or some effect of the tyre rupture process, presumably caused failure of the ice bond, allowing the wheel to rotate and the damaged tyre section to flail and destroy areas of structure and critical aircraft systems.

Additional matters arising

The AAIB was involved in the investigation of a catastrophic failure in a cross-ply tyre, leading to a fatal take off accident to a Concorde aircraft on 25 July 2000. This has drawn attention to considerable differences between possible tyre failure modes in practice and those assumed for certification purposes. The accident to VP-CRC has demonstrated the vulnerability of flight critical systems on the BD 700 to impact damage from flailing sections of tyre when failure of the carcass occurs. Such flailing can, in addition to the wheel locking cause described above, result from lateral cutting of tread and carcass following contact with debris. The kinetic energy imparted by flailing tyre carcass sections, to any aircraft components within the radius of flail, is a function of speed. Should such tyre damage occur at the higher runway speeds associated with takeoff, the resulting airframe and control system damage could be very much greater than that experienced by VP-CRC. Although the leading edge of the flap provides more shielding and protection to the auxiliary spar area when takeoff flap is selected than it does with landing flap (as in the case of the Luton event), it is not clear that the flap structure has sufficient strength to deflect a flailing portion of tyre and prevent systems damage.

The EASA certification rules dealing with consequences of tyre failure apply to a small section of the thin, relatively low strength tread material dis-bonding from an otherwise intact carcass. Failures arising from slide-through tyre ruptures and from lateral cutting inflicted by debris can involve partial or complete separation of large sections of total carcass thickness, incorporating substantial portions of sidewall. The flailing section therefore has considerable mass and is reinforced by the chords of the tyre carcass. It will thus inflict greater damage at a given speed than that considered in the certification assumptions. The failure on VP-CRC also demonstrates the greater vertical distance into the wing structure to which damage can be inflicted in practice, compared with the situation assumed by the certification rules.

During crew conversion training, the aircraft is likely to conduct a series of touch-and-go landings. A tyre failure occurring during such a landing for either of the above causes also presents the possibility of the aircraft becoming airborne with the damaged systems described above.

Effect of damage on controllability

Loss of Nos 2 and 3 hydraulic systems results in failure of half the spoilers associated with roll control, together with loss of one of the two ailerons and one of the two elevators. In addition the operating control surfaces retain only a single control actuator rather than the two or three units normally in use. The manufacturer commented that:

> *'Simulated double hydraulic failure flight testing has shown that adequate controllability exists for continued safe flight and landing.'*

The damaged wiring loom on VP-CRC contained conductors supplying signals to the multi-function spoilers on the left wing. If such control signals are lost in addition to the hydraulic system damage experienced on this occasion, the degree of reduction of roll control capability to the left is almost total; that to the right is significantly reduced and control authority in pitch is also greatly reduced. Obstruction of aileron cables is presumed to cause some degree of movement restriction or change of roll control force, adding to control difficulties. Fracture of the flap drive results in loss of available flap movement. In addition to the above, a substantial proportion of other hydraulic services are inoperable when Nos 2 and 3 systems lose pressure.

Although it may be argued that, in ideal circumstances, the aircraft remains controllable even with a substantial proportion of the total flight control system inoperative, such a multiple failure event occurring at a time of high crew work-load will not necessarily have a benign outcome. Such a combination of failures and consequent control difficulty, together with changed aircraft response characteristics, occurring just prior to rotation speed, would be particularly demanding. The large number of warnings and alerts being displayed on the flight deck would also add to the complications faced by the flight crew, particularly on a departure in IMC.

The nature of the tyre failures discussed above apply to the cross-ply type of tyre construction. Tests have shown that the radial ply type of tyre does not possess this failure mode and that detached or flailing debris is likely to be significantly smaller and lighter.

Actions by the manufacturer

Following the accident, the manufacturer issued an Advisory Wire AW700-32-0244 on 19 March 2008, containing operational and maintenance information to counter the problem of freezing of wet carbon brakes. The Advisory Wire includes the following information:

> *'Description*
>
> *Flight crews and maintenance personnel are reminded that carbon brakes can absorb or retain moisture. If a wet brake is not heated sufficiently to evaporate moisture from the disk surfaces, there is a possibility after in-flight cold soak or parking in known freezing conditions that the brake disk surfaces may freeze together. Should this occur, a subsequent taxi might produce a flat spot on the tyre or the subsequent landing may result in a tyre burst.*
>
> *Action*
>
> *Maintenance personnel are reminded to protect aircraft wheels and brakes from direct washing spray and inform the flight crew if the aircraft or landing gear has been washed recently.'*

In accordance with the relevant Flight Crew Operating Manual, if the brakes have been exposed to moisture, flight crews are reminded to:

> *'During taxi, use light brake applications to warm the brakes before takeoff. Monitor BTMS during taxi.*
>
> *When landing, carry out a positive landing to ensure initial wheel spin up and breakout of frozen brakes if icing has occurred.*
>
> *During the landing roll and subsequent taxi, use brakes to prevent progressive build up of ice on the wheels and brakes. Monitor BTMS during taxi.*
>
> *Following takeoff or landing on wet, snow or slush covered runways and taxiways: tyres should be inspected for flat spots prior to the next flight.'*

Follow-up action

Following this accident, the manufacturer has published Advisory Wire AW700-32-0244 Revision 1. This includes the following additional information to the original advisory wire:

'Description:

Rainfall can cause wetting of the brakes, even in light wind conditions when the brakes would normally be assumed to be sheltered by the wing structure. After exposure to moisture, a prolonged period of dry warm conditions is required to ensure full drying takes place. Alternatively, brake applications must be deliberately applied during taxi, before departure, to ensure the moisture is evaporated away.

It is important to be aware that the brakes may remain saturated with water for a lengthy dry period after the rainfall ceases and the runways and taxiways have dried.

Action:

During taxi, use firm brake applications to warm the brakes before take off.

Bombardier will be revising the Global Express and Global Express XRS Flight Crew Operating Manual (FCOM) Vol 1. to introduce brake warming guidelines by revision 58, while the Global 5000 FCOM will be revised by revision 19. These revisions are scheduled for release September 15, 2008.'

These revisions have subsequently been released.

The following Safety Recommendations are made:

Safety Recommendation 2008-071

It is recommended that Bombardier introduce modifications to the BD700 to reduce the extent of concentrations of water pouring onto the outboard faces of the inboard main-wheel tyres and then onto the brakes when the aircraft is parked in rain.

Safety Recommendation 2008-072

It is recommended that Bombardier either

(a) Develop and implement modifications to the BD700 to effectively shield vulnerable flight critical hydraulic, electrical and mechanical systems in the vicinity of the main-wheel tyres against damage inflicted by items of large, full thickness, high velocity flailing tyre material and / or re-route some systems to minimise vulnerability to such events.

Or alternatively,

(b) Develop and require fitment to the BD700 and other Bombardier aircraft with similar features, a type of tyre that does not have such a flailing failure mode.

Safety Recommendation 2008-073

It is recommended that the Federal Aviation Administration, the European Aviation Safety Agency and Transport Canada raise awareness of the vulnerability of carbon brakes to freezing in flight following exposure to moisture on the ground, emphasising the significance of the slow drying rate of saturated brakes even in warm, low humidity conditions.

Cockpit Voice Recorder

The CVR was a solid state, 2-hour recorder which captured the last two hours of flight into Luton. The CVR system was powered by the aircraft DC essential power supply. The system included an 'impact' or 'g' switch interlock, designed to cut the power to the CVR in the event of a significant crash impact. The switch operates by sensing acceleration and removing the power supply to the CVR in the event of the acceleration exceeding 3g. The switch was mounted in the rear section of the aircraft, at a 45 degree incline to the longitudinal axis. The 3g threshold was therefore a combination of the aircraft's normal and longitudinal accelerations.

Upon arrival in Luton, the CVR recording ceased just after the nose landing gear touched down. The FDR recording showed a peak normal acceleration at touchdown of 1.2g and longitudinal acceleration peak, just prior to the loss of CVR, of -0.22g. When downloaded, the CVR operated normally and no cut in the aircraft DC essential power supply was reported. Maintenance records did not confirm the operation of the 'g' switch but system troubleshooting suggested that it was the most likely cause of the CVR stopping. The switch was subsequently removed from the aircraft and tested by the component manufacturer. Results confirmed that the switch operated successfully only when exposed accelerations in excess of 3g.

If the 'g' switch had operated, the FDR recorded accelerations did not show any evidence to support this. Equally, flight crew reports did not suggest a heavy landing and damage sustained by the aircraft was not consistent with a heavy impact. One explanation was that the accelerations recorded by the FDR 3-axis accelerometer may not correlate directly to those experienced at the 'g' switch. The FDR accelerometer was mounted in the landing gear bay, closer to the aircraft centre of gravity and accelerations were only recorded eight times a second. In the event of a high acceleration spike at some point during the landing roll, the FDR may not have recorded it.

According to the manufacturer, the 'g' switch was included to satisfy a certification requirement to stop the CVR automatically within 10 minutes of a crash impact. In the event of the 'g' switch operating, a red light illuminates on the switch and it then has to be manually reset by the ground crew.

While continued CVR recording would not have contributed significantly to this investigation, AAIB experience in the use of 'g' switches in CVR systems suggests they are not a reliable means of stopping the CVR.

The CVR system on VP-CRC was certified taking into account EUROCAE document ED56A (Minimum Operational Performance Specification (MOPS) for Cockpit Voice Recorder Systems). Section 6.2.11 of ED56A details 'Recorder Operation' and suggests that reliable means should be available for starting and stopping the CVR. To stop the CVR, ED56A includes a number of suggestions:

> '*a detection of loss of oil pressure on all engines together with loss of airspeed,*
>
> *b airframe crash sensors*
>
> *c water immersion sensors e.g. to detect ditching of the helicopter.'*

Specifically mentioned in ED56A is:

> *'The use of negative acceleration sensors ('g' switches) is not considered to be a reliable practice.'*

Although ED56A states that the use of 'g' switches is not 'reliable practice', it does not prohibit their use. The AAIB has encountered a number of instances in previous investigations[1], where 'g' switches have resulted in the loss of essential recorded information. Also, some foreign investigation authorities have encountered cases where flight recorders have stopped after the initial part

Footnote

1 G-TIGK- AAIB Formal Report 2/97, G-BWZX - AAIB Bulletin November 1999, G-BMAL - AAIB Bulletin October 2001.

of a hard / crash landing so the remainder of the landing and /or passenger evacuation was not recorded.

As a result of the investigation and report into the accident to a Super Puma (G-TIGK) on 19 January 1995, the AAIB recommended to the CAA that the Combined Voice and Flight Data Recorder (CVFDR) 'g' switch was rendered inoperative (Safety Recommendation 97-32). The CAA did not accept this recommendation on the grounds that some recorders may continue running after an accident resulting in a crash impact, thus overwriting the recorded data.

As stated in the G-TIGK report, the AAIB was, and continues to be, unaware of any accidents where recorders would have continued to run after the crash impact had no 'g' switch been fitted. However, several accidents were encountered where premature operation of the 'g' switch had impeded the accident investigation. As a consequence, a further recommendation (Safety Recommendation 99-24) was made to the CAA requesting a reassessment of their initial response to Safety Recommendation 97-32.

The CAA response was to await the outcome of EUROCAE Working Group 50 (WG50) whose task was to issue the MOPS to supersede ED56A. The outcome of WG50 was to issue ED112, a MOPS for *'crash protected airborne recorder systems'*. WG50 was made up of international representatives from accident investigation authorities, airframe manufacturers, component manufacturers and aviation authorities. ED112 was issued in March 2003 and specifically references 'g' switches but more definitively recommends against their use:

> *'Negative acceleration sensors ('g' switches)* ***shall not be used*** *because their response is not considered to be reliable.'*

As a result, the following Safety Recommendation is made:

Safety Recommendation 2008-074

It is recommended that the Federal Aviation Administration and the European Aviation Safety Agency review the certification requirements for automatically stopping flight recorders within 10 minutes after a crash impact, with a view to including a specific reference prohibiting the use of 'g' switches as a means of compliance as recommended in ED112 issued by EUROCAE Working Group 50.

ACCIDENT

Aircraft Type and Registration:	DHC-8-402 Dash 8, G-JEDU
No & Type of Engines:	2 Pratt & Whitney Canada PW150A turboprop engines
Year of Manufacture:	2004
Date & Time (UTC):	28 May 2008 at 1755 hrs
Location:	Paris Charles de Gaulle Airport, France
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 4 Passengers - 37
Injuries:	Crew - None Passengers - None
Nature of Damage:	Rear underside of main fuselage damaged on touchdown
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	48 years
Commander's Flying Experience:	8,706 hours (of which 2,783 were on type) Last 90 days - 120 hours Last 28 days - 34 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

Synopsis

The aircraft was operating a scheduled flight from Exeter Airport, Devon, to Paris Charles de Gaulle Airport, France. The commander was line training the co-pilot, who was the handling pilot. During the final approach, at approximately 120 ft aal, the IAS reduced below V_{REF} without any significant increase in power from the co-pilot or intervention from the commander. The aircraft subsequently landed on its tail, 11 kt below V_{REF}, causing damage to the underside of the fuselage.

The commander had recently returned to work after an illness and subsequently felt he should have been advised to have a longer recuperation period. The CAA subsequently issued additional guidance to Aviation Medical Examiners.

Background information

On 26 April 2008 the commander was admitted to hospital and discharged 12 days later, on 7 May 2008.

On 12 May 2008 the commander contacted his General Practitioner who signed him off as sick until 18 May 2008; at this time he also informed his Aviation Medical Examiner (AME) about his hospitalisation. The AME advised the commander that as he had finished his course of medication and it had been less than 21 days since the start of the illness[1] he could return to work when he felt fit and no medical examination would be required. The commander returned to work on 19 May 2008, 23 days after being admitted to hospital.

After his return to work the commander worked for three days, followed by two days off, followed by five days on again. He flew four sectors on each of the last five days; the accident happened on the fifth day.

History of the flight

The aircraft was operating a scheduled flight from Exeter Airport, Devon, to Paris Charles de Gaulle Airport, France (CDG). The commander was line training the co-pilot, who was the handling pilot. The surface wind was 190º/10 kt, the visibility was in excess of 10 km and there were FEW clouds at 4,500 ft aal. V_{REF} for the approach was 114 kt.

The flight was uneventful until the aircraft was established on the ILS for Runway 27R at CDG. Having transferred to the Tower frequency, ATC instructed G-JEDU to maintain 180 kt until 4 nm; this the crew accepted. At 4 nm the IAS was 173 kt and the power levers were reduced to flight idle. They remained at flight idle until 120 ft aal and the IAS reduced at a constant rate. At 500 ft the IAS was approximately 136 kt (V_{REF} +22 kt).

At approximately 120 ft aal, with the aircraft fully configured with Flap 15 for landing, the IAS reduced below V_{REF}. The commander said "SPEED APPEARS TO BE A BIT LOW" to which the co-pilot responded by increasing the power levers by approximately one percent of torque to 8%[2]. The speed continued to decrease and the aircraft subsequently landed on its tail at 103 kt, (V_{REF} – 11 kt), illuminating the RUNWAY TOUCHED warning; there was no intervention from the commander.

The aircraft vacated the runway, taxied onto stand and the passengers disembarked normally. The commander inspected the aircraft where damage to the underside of the tail section was discovered before he reported the accident to ATC.

The commander attempted unsuccessfully to contact the operator's Flight Safety Manager and Fleet Manager; the accident occurred out of normal working hours. He contacted the operator's logistics department and discussed the accident with the duty manager. The duty manager asked the commander to operate another aircraft back to Exeter as part of the recovery programme and the commander accepted this request.

Commander's comments

The commander stated that during the preceding week, after his return to work, he did not feel unwell but was getting progressively more tired. He added that on the approach into CDG he recalled thinking more power was required, to the extent that he thought he needed to apply the power himself and yet he did not react to what was developing. He also remembered a sense of "why am I not reacting to this" and being puzzled by this.

At the time he did not realise that he was required to be grounded as a result of the accident and was happy to accept the request to fly another aircraft back to Exeter.

Footnote

[1] See CAA medical below.

Footnote

[2] An approximate power setting for a Flap 15 approach is 14-15% torque.

The commander felt that, in the absence of any specifc medical advice, he returned to work too early and by the end of the fve days work prior to the accident, was suffering from some form of post-infectious fatigue which had a detrimental effect on his reactions and decision making.

Co-pilot's comments

The co-pilot stated that as she had only fown with the commander since his return to work, after his illness, she could not compare his manner during the accident fight to that of previous fights.

Operations manual

Part B4 of the operator's Operations Manual (OM) states that at every 100 ft below 500 ft aal, the non-handling pilot is to call out the speed unless it is between +5 kt and -0 kt of that to be fown. It also states that in order to achieve a stabilised approach, the speed must not exceed 160 kt inside 4 nm and that the IAS must not exceed V_{REF} +15 kt at 500 ft radio altitude. At 500 ft the pilot fying is to call '500 ft' to which the non-handling pilot is to respond with either 'stable' or go-around', depending on the previous criteria.

Part A of the OM states that:

> *'following an accident or incident in which it is necessary to contact the Chief Inspector of Air Accidents, the crew are immediately grounded.'*

CAA medical

The CAA Aeromedical Section stated that an effect of the illness experienced by the commander could be an intermittent fatigue that can last for 6 weeks after the main symptoms of the illness have disappeared.

The reverse side of UK CAA JAA medical certifcates states the following:

> *'Decrease in medical ftness*
>
> *Holders of medical certifcates shall, without undue delay, seek advice of the AMS [Aeromedical Section], an AMC [Aeromedical Centre] or an AME when becoming aware of:*
>
> - *Hospital or clinic admission for more than 12 hours*
>
> *Holders of medical certifcates who are aware of:*
>
> - *Any illness involving incapacity to function as a member of a fight crew throughout a period of 21 days or more*
>
> *Shall inform the AMS, or the AME, who shall subsequently inform the AMS, in writing of such injury or pregnancy, and as soon as the period of 21 days has elapsed in the case of illness.'*

Analysis

As stated on the reverse of pilots' medical certifcates, the commander correctly informed his AME of his hospitalisation. However, as he was not incapacitated for greater than 21 days when he telephoned his AME, there was no need for his AME to inform the AMS.

The crew few faster than 160 kt to 4 nm as stated in the OM. The IAS was greater than V_{REF} +15 kt at 500 ft radio altitude and the co-pilot did not call "500 ft"; as a result there was no call of "STABLE" or "GO-AROUND" from the commander. Additionally the commander did not call out the speed every 100 ft below 500 ft even though the IAS was initially greater than +5 kt of that to be fown. The approach was not stable at 500 ft and should have been discontinued.

Once the commander brought the low speed to the attention of the co-pilot she only increased the power levers to 8% torque, 6-7% less than the suggested figure of 14-15%. This was not enough power to achieve V_{REF}, and the commander did not take control to stop the IAS further reducing below V_{REF}.

The commander's recent medical history and his post-accident comments suggest that his feelings during the final approach and his lack of intervention could be attributed to post-infectious fatigue. A lack of knowledge of post-accident procedures in the operator's logistics department allowed the crew to fly another sector.

Safety actions

The co-pilot undertook training in the simulator before continuing with her line training. After additional training sectors, this was successfully completed.

All the operator's logistics and engineering staff have been trained on the definition of an accident and serious incident and post-accident procedures.

Following this accident, the CAA's Aeromedical section sent the following notice to all AME's:

'Subject: ***AME assessment of professional pilots' fitness to return to flying after hospital treatment for illness.***

When giving return to work advice to professional pilots after illness you should satisfy yourself that the pilot is fully fit to return to full flight duties. If the pilot had required admission to hospital, in all but exceptional circumstances you should review a report from the consultant responsible for treatment to ensure full recovery has been achieved. You should consider all possible sequelae from the illness such as increased fatigability or susceptibility to infection prior to confirming fitness to fly. In many cases you may decide to personally examine the pilot before making a judgement on fitness. If you give advice remotely by telephone you must ensure that you document the advice you give. The documented advice will form part of the pilot's aeromedical record and should be kept in accordance with the records retention policy.'

SERIOUS INCIDENT

Aircraft Type and Registration:	SD3-60 Variant 100, G-GPBV	
No & Type of Engines:	2 Pratt & Whitney Canada PT6A-67R turboprop engines	
Year of Manufacture:	1988	
Date & Time (UTC):	19 August 2008 at 2018 hrs	
Location:	On departure from Inverness Airport	
Type of Flight:	Commercial Air Transport (Cargo)	
Persons on Board:	Crew - 2	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Nil	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	31 years	
Commander's Flying Experience:	2,960 hours (of which 250 were on type) Last 90 days - 74 hours Last 28 days - 15 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Synopsis

Shortly after departure the crew became aware of an electrical burning smell. They attempted to don their oxygen masks but had some difficulty in using them because they were different from the masks on which they had received their training. The crew returned to their departure airfield and landed safely.

History of the flight

During the takeoff the commander noticed a large amount of water spilling into the area around the flap lever. Shortly afterwards, whilst climbing through FL60, the crew became aware of an electrical burning smell and identified the source of the smell as coming from behind the flap lever. They attempted to don their oxygen masks and declared an emergency; when cleared by ATC they descended to 3,500 ft. The co-pilot was still having difficulties in donning his oxygen mask. The commander had his mask on, and it was supplying oxygen, but he had difficulties in communicating both with his co-pilot and with ATC.

During the pre-flight briefing the crew had stated that, in the event of an emergency, they would return to Inverness for an ILS for Runway 05. The crew followed this plan, landed safely and the aircraft was met by the fire crews and an aircraft engineer.

Throughout the emergency neither of the crewmembers was able to get their oxygen mask to work to their satisfaction.

Comment

The operator had three Short 360s, with this aircraft being the most recent to join its fleet. The other two aircraft had a different mask and oxygen system from that fitted to this aircraft, and the operating crew had no prior knowledge of this. During their initial and recurrent training on the aircraft, they had both used the masks and oxygen systems fitted to the other two aircraft.

The operator has confirmed that the cause of the electrical smell was water entering past the window seals and causing an electrical short circuit behind the flap lever. The leaking window seals have since been repaired.

The company stated that the oxygen masks were serviceable, and that the difficulties experienced by the crew were because of a lack of familiarity with the system. The company has now introduced additional training to ensure that all their crews are fully conversant with the differences between the aircraft in their fleet.

ACCIDENT

Aircraft Type and Registration:	Aeronca 7AC Champion, G-TECC
No & Type of Engines:	1 Continental Motors Corp C85-12 piston engine
Year of Manufacture:	1946
Date & Time (UTC):	26 July 2008 at 1215 hrs
Location:	East Side of Coningsby, Lincolnshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - None
Nature of Damage:	Landing gear collapsed, damage to cowlings and lower engine bay and windscreen, right wing strut bent through 90 degrees and some damage to the right wing
Commander's Licence:	Private Pilot's Licence
Commander's Age:	56 years
Commander's Flying Experience:	1,516 hours (of which 556 were on type) Last 90 days - 78 hours Last 28 days - 14 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

In performing a forced landing in a field, following a complete loss of engine power in flight, the aircraft touched down on a transverse ridge, causing the landing gear to collapse.

History of the flight

Prior to the flight, which was planned to be of approximately 2½ hours duration, both the main tank (fuselage mounted) and the auxiliary (wing) fuel tanks were filled and topped off with AVGAS.

Approximately 1¾ hours into the flight, which had been without incident in good conditions at an altitude of 1,200 ft, the fuel cock was opened to transfer fuel from the left wing to the main tank. Some 15 minutes later, with the main tank fuel gauge registering approximately 3/4 full, the fuel cock was closed and almost immediately, without vibration, rough running, or any other warning, the engine stopped. Carburettor heat had been applied regularly throughout the flight as part of the FREDA airmanship checks, the most recent application being some 10 minutes before the loss of power.

A field of pasture, with cows grouped in one section, was selected in preference to alternatives with standing crops or in proximity to power lines. Whilst trimming for best glide speed, the pilot made a single short call on the RAF Conningsby Radar frequency but, on receiving no response, concentrated on landing the aeroplane. On short final approach to the field, the pilot manoeuvred around some cows and turned slightly to align better with the longest landing upslope the field offered. The aircraft felt somewhat nose heavy on touchdown, and the landing gear collapsed. After coming to rest, the pilot was able to vacate the aircraft through the main cabin door. Police, paramedics, and fire crews attended the scene, the latter arriving apparently in response to a report of an aircraft crashing near buildings containing asbestos.

When the pilot inspected the landing area subsequently, it was found that the touchdown had coincided with a transverse ridge and that the landing gear had collapsed at this point. The carburettor, breather pipe and air box were found on the ground nearby, a short distance from the ridge.

The pilot reports that the farmer whose field it was, and who had previously allowed it to be used as a base for crop dusting operations, had remarked to her that he had heard her aircraft overhead and noted nothing untoward until the engine stopped.

The weather conditions at the time of the accident were reported as good, with light variable winds, a visibility of greater than 10 km in slight haze, and scattered/broken cloud at 1,500 ft. The temperature/dew point was reported as 25°C/16°C.

The engine had been overhauled and 'zero timed' at the last Annual Inspection, and a newly refurbished carburettor fitted some 120 hours prior to the accident. The pilot considered carburettor icing as a possible cause, but noted that there had been no rough running prior to the stoppage. Carburettor icing charts show that at the temperature and dew point in question, severe carburettor icing should be expected at glide power but not at cruise power. She also considered fuel contamination a possible cause of the stoppage, or a vapour lock, noting that the engine was running on AVGAS.

Subsequent examination of the engine by the owner revealed evidence from the exhaust stacks and spark plugs that the engine had been running with a very lean fuel/air mixture, although she reported that there had been no indication in flight of abnormally high oil temperature. Further inspection of the engine showed that the hose connecting the air intake duct to the No 3 cylinder to the inlet manifold, did not properly cover the end of one of the ducts, Figure 1.

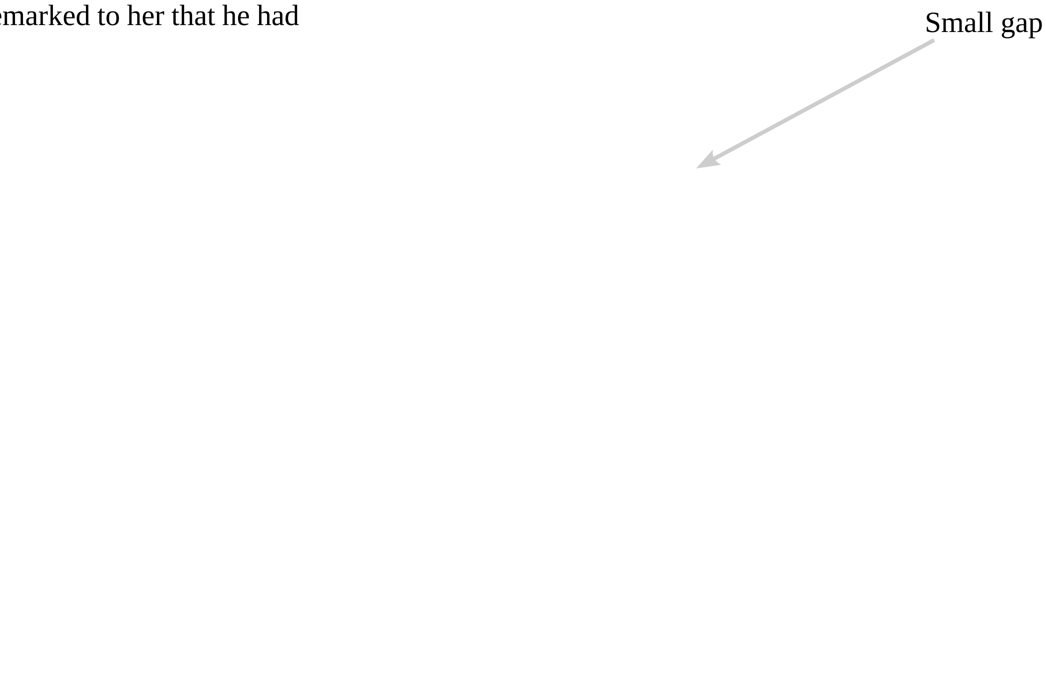

Figure 1

Hand pressure was sufficient to open up a significant gap between the hose and duct, Figure 2. It was possible, therefore, for air to be entrained through the joint and affect the mixture entering the engine, should the gap have opened whilst the engine was running.

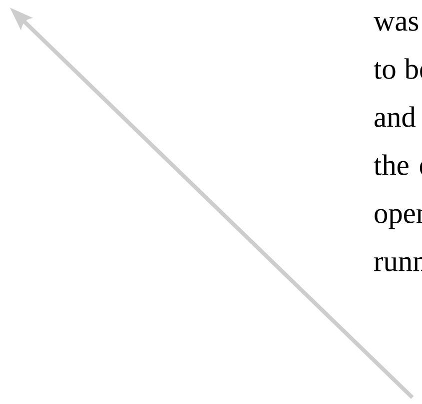

Figure 2

ACCIDENT

Aircraft Type and Registration:	Cessna 152, G-BTDW
No & Type of Engines:	1 Lycoming O-235-L2C piston engine
Year of Manufacture:	1978
Date & Time (UTC):	29 September 2008 at 1129 hrs
Location:	Runway 25, Carlisle Airport
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nose landing gear and propeller damaged
Commander's Licence:	Student
Commander's Age:	48 years
Commander's Flying Experience:	43 hours (of which 3 were on type) Last 90 days - 1 hour Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft touched down and bounced twice on Runway 25 at Carlisle Airport. On the third touch-down the nose landing gear collapsed and the propeller contacted the runway surface. The pilot assessed the cause of the accident as a combination of factors, but not executing a go-around after the first touchdown allowed the accident to occur.

History of the flight

The pilot was undertaking training for his Private Pilot's Licence. He had carried out three dual circuits satisfactorily and was then cleared to fly solo circuits. The weather was good with the surface wind from 270º at 13 kt, visibility in excess of 10 km, a few clouds at 1,000 ft, and scattered clouds at 1,900 ft. A large rain shower was in the vicinity of the airfield.

Having completed a normal circuit, the pilot established the aircraft on the final approach to Runway 25. The aircraft was correctly configured for landing and the approach was flown in a similar manner to the previous approaches. The pilot reported that during the latter stages of the approach the wind became gusty, probably due to the proximity of the rain shower. The pilot stated that the aircraft touched down in what appeared to be a similar fashion to the previous landings. However, the aircraft then became airborne again. He attempted to land the aircraft but the aircraft bounced again. As the aircraft touched down for the third time the nose landing gear collapsed and the propeller contacted the runway surface. The pilot turned off the electrical and fuel systems and vacated the aircraft through the left door. The Airfeld Rescue and Fire Fighting Service attended immediately.

Conclusion

The pilot assessed the cause of the accident as a combination of a sudden gust of wind and a lighter than usual aircraft causing the bounce. Despite having been taught to apply full power and go-around from such a situation, the pilot believed that a safe landing was still possible.

ACCIDENT

Aircraft Type and Registration:	Cessna 152, G-OFRY	
No & Type of Engines:	1 Lycoming O-235-L2C piston engine	
Year of Manufacture:	1978	
Date & Time (UTC):	18 September 2008 at 1040 hrs	
Location:	Dunkeswell Airfield, Devon	
Type of Flight:	Training	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Tailplane damaged	
Commander's Licence:	Student pilot	
Commander's Age:	37 years	
Commander's Flying Experience:	19 hours (of which 17 were on type) Last 90 days - 10 hours Last 28 days - 6 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Synopsis

On completion of two circuits and landings with an instructor on Runway 05, the pilot under instruction was to fly solo circuits and landings for the remainder of the detail. The initial takeoff and circuit was uneventful but the aircraft landed to the left of the centreline due to a slight crosswind from the right. Once stabilised in the ground roll, full power was applied and, as the aircraft accelerated, it began to 'pull' to the left. It departed the paved surface, and crossed disused Runway 17/35 before coming to rest. Subsequent examination found no defects with aircraft's wheel braking or control systems. The student's instructor attributed the accident to the student's insufficient use of right rudder to counteract the effect of the crosswind and propeller slipstream.

ACCIDENT

Aircraft Type and Registration:	DH82A Tiger Moth, G-AHVV	
No & Type of Engines:	1 De Havilland Gipsy Major I piston engine	
Year of Manufacture:	1943	
Date & Time (UTC):	14 September 2008 at 1320 hrs	
Location:	Runway 23, Dunkeswell Airfield, Devon	
Type of Flight:	Training	
Persons on Board:	Crew - 2	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Substantial	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	45 years	
Commander's Flying Experience:	13,000 hours (of which 8,200 were on type) Last 90 days - 120 hours Last 28 days - 40 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Synopsis

Shortly after takeoff, when at approximately 200 ft above ground level, the engine speed dropped to idle. The pilot lowered the nose of the aircraft to maintain flying speed and turned right to land in a suitable field. The aircraft cleared a sturdy barbed wire fence but, as the aircraft touched down, a cow ran under and struck the left wing, causing substantial damage to the aircraft. The cow was apparently uninjured. The aircraft rolled to a halt and the two occupants, who were uninjured, vacated the aircraft normally.

Investigation of the aircraft by a local engineer found corrosion debris in the carburettor float bowl, and this appeared to have originated from within the float bowl itself. The fuel tank, fuel lines and fuel filter were found to be clean.

It is likely that this debris had blocked the carburettor jets, causing the reduction in power, as the engine ran normally once the debris had been removed.

ACCIDENT

Aircraft Type and Registration:	Freeman CAN Jabiru SK, G-BYFC
No & Type of Engines:	1 Jabiru Aircraft Pty 2200A piston engine
Year of Manufacture:	1999
Date & Time (UTC):	26 July 2008 at 1030 hrs
Location:	Near High Fields, The Heywood, Diss, Norfolk
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Substantial, beyond economic repair
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	78 years
Commander's Flying Experience:	2,693 hours (of which 108 were on type) Last 90 days - 18 hours Last 28 days - 6 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The pilot mis-identified his destination airstrip, and made an approach to another site. Immediately before touchdown, the aircraft sank and struck the ground sustaining substantial damage. The pilot identified that thermal activity, in the form of updraughts from the adjacent cornfeld and corresponding down-draughts over the strip, may have accounted for the accident.

History of the flight

The pilot planned to fly from his base in Suffolk to a private strip, 600 metres long, approximately one mile west of Tibenham aerodrome in Norfolk. He had not previously visited the destination, but knew that it had a north/south grass runway. The weather was hot and fine with light winds, though there was *'considerable turbulence'* during the flight. As usual, the pilot navigated using a 1:500000 aeronautical chart and traditional methods; he did not use a GPS. Arriving in the area north of Diss (and with his destination still two or three miles ahead of him), he saw a grass airstrip aligned north/south and joined the circuit to land in a southerly direction.

On final approach, the pilot selected full flap and reduced speed to 60 kt. The approach proceeded normally, and the pilot noticed that the speed as he crossed the boundary fence was 55 kt. Almost immediately that the pilot started the flare, he found that the aircraft "sank rapidly from a height of about eight feet" and struck the ground heavily, sustaining substantial damage. The left main and nose landing gears collapsed and the left hand cockpit door opened. The aircraft slid along the ground for 130 metres before coming to rest, and the pilot exited the aircraft without difficulty. There was no fire.

In his report, the pilot stated "it was a hot summer's day with little wind. The airstrip has trees lining both sides with a field of corn next to it. I can only assume that there was rising hot air from the cornfield and corresponding descending air onto the airstrip causing the rapid loss of height."

Another pilot familiar with the strip had also experienced this phenomenon. The strip at which the pilot landed was approximately 300 metres long, and surrounded by trees.

CAA Safety Sense leaflet 5d *'VFR navigation'* contains valuable advice for pilots. In the section *'Approaching your destination'* it states:

> *'With your destination area in sight, do not put aside your chart until you have positively identified the* ***correct*** *aerodrome.'*

Significant landmarks, immediately adjacent to the pilot's destination, would have assisted the pilot in identifying and correcting his navigational error.

CAA summary

The pilot mis-identified his destination airstrip and made an approach to another site. Immediately before touchdown, the aircraft sank and struck the ground sustaining substantial damage. The pilot identified that thermal activity, in the form of updraughts from the adjacent cornfield and corresponding down-draughts over the strip, may have accounted for the accident.

ACCIDENT

Aircraft Type and Registration:	North American P-51D-20 Mustang, G-BIXL
No & Type of Engines:	1 Packard Motor Car Co Merlin V1650-7 piston engine
Year of Manufacture:	1944
Date & Time (UTC):	13 July 2008 at 1600 hrs
Location:	Duxford Airfield, Cambridgeshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Left landing gear axle, leg and tyre
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	56 years
Commander's Flying Experience:	13,500 hours (of which 140 were on type) Last 90 days - 168 hours Last 28 days - 71 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot, video evidence and further enquiries by the AAIB

Synopsis

G-BIXL was on a final approach to land on a grass runway when the engine began to run roughly. The pilot advanced the throttle which led to a marked reduction in power. The aircraft touched down on the grass short of the runway but was forced back into the air when it crossed the lip of a raised taxiway. During the following touchdown and deceleration, the left main gear was damaged and the propeller hit the ground before the aircraft came to a halt. The cause of the rough running and power loss was not positively determined at the time of publication of this report.

History of the flight

G-BIXL was part of a large number of 'Warbird' type aircraft flying in close formation at an air show and, at the end of the display, the aircraft broke into the circuit. The pilot elected to use the parallel grass runway as the aircraft ahead was using the paved runway. G-BIXL rolled out on final approach at 120 mph, with landing gear down and landing flap (FLAPS 50) selected, and with all other indications normal[1]. At about 300 ft aal the engine started to run "slightly rough" and, as the aircraft started to sink, the pilot moved the throttle approximately ¾ inch forward.

Footnote

[1] The propeller was selected to maximum rpm and the throttle was approximately half open. The right fuel tank, which contained 30 gal, was in use, the booster pump was on with a fuel pressure of 18 psi and the coolant temperature and oil pressure were normal.

There was no increase in power but a puff of white smoke emerged from the left side of the engine and a puff of dark smoke from the right side. The pilot moved the throttle forward another ½ inch and there was a marked reduction in power.

The pilot raised the flaps two notches to FLAPS 30 and changed fuel tanks. Changing fuel tanks had no effect but the pilot assessed that G-BIXL would now reach the airfield although not the runway. With the aircraft pointing just beyond the airfield boundary, speed was reducing but it crossed the boundary at between 95 and 100 mph and touched down in a three-point attitude. The touchdown point was approximately 210 m before the start of the grass runway and a raised taxiway crossed the path between the aircraft and runway threshold. The aircraft hit the lip of the raised surface and was thrown back into the air with a high nose attitude. The pilot lowered the nose and G-BIXL touched down again almost in a three-point attitude but right main wheel first. The left main wheel then dug into the ground causing the axle mounting casting to bend outwards, the oleo to press down onto the tyre and the aircraft to yaw left. The main wheels left the ground again and the pilot applied full right rudder to counteract the yaw. He also applied right brake after the main wheels contacted the ground once more. The aircraft began to skid right while still yawing left and during the deceleration the tail wheel rose up and the propeller struck the ground. The pilot released the right brake and the tail lowered back to the ground. The aircraft came to a halt in the normal landing attitude pointing approximately 90º left of the runway and displaced about 70 m left of the centreline.

During the sequence of events, the pilot transmitted: "ENGINE ROUGH RUNNING", "ENGINE FAILURE", and "STOPPED ON GRASS". None of the transmissions were heard due, in the pilot's opinion, to an intermittent fault in the press to transmit (PTT) switch.

Engineering history

G-BIXL's engine had been rebuilt after a previous accident and the propeller had been overhauled and given two replacement blades. The engine was ground run for five hours following the overhaul and no problems were observed. The aircraft was cleared for flight and flew approximately 11 hours, during which there were no engine problems.

The day before the accident, the pilot flew two display sorties. The first sortie involved a four Mustang tail chase and the engine performed normally. The second sortie was a multi-aircraft formation flight and, prior to landing, the pilot positioned downwind using the same configuration and a similar power setting to the accident flight. At about one mile on final approach the engine began to "run slightly rough". The pilot left the power set and landed normally on the paved runway with the throttle at IDLE. At about 20 kt the pilot opened the throttle slightly and the engine stopped. Further investigation found the booster pump fuel pressure to be normal in each tank and sufficient fuel in the tank in use. The engine was turned by hand and "good compression" was noted with no irregular noises. No water was found in the main fuel filter but some was found in the fuel filler cap rims.

The following day, the day of the accident, an engine ground run was carried out during which there were no symptoms of rough running. A flight test was flown in the overhead of the airfield in various configurations and at various power settings, including in simulated approach conditions, and the engine performed normally. The decision was made to return the aircraft to the display programme and it flew a display tail chase with three other Mustangs during which the engine performed normally. The accident occurred during the following flight.

Analysis

The fault in G-BIXL's engine was intermittent but the symptoms were similar each time: slight rough running followed by significant loss of power when the throttle was advanced. The symptoms did not occur during either of the tail chasing flights but occurred on both of the close formation flights. It is possible that engine handling techniques used in formation flying caused the engine fault to manifest itself. However, the cause of the rough running and power loss was not positively determined at the time of publication of this report.

ACCIDENT

Aircraft Type and Registration:	Piper L18C Super Cub, G-BJWZ
No & Type of Engines:	1 Continental Motors Corp C90-8F piston engine
Year of Manufacture:	1951
Date & Time (UTC):	8 June 2008 at 1745 hrs
Location:	Eshott, Northumberland
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Aircraft extensively damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	73 years
Commander's Flying Experience:	240 hours (of which 64 were on type) Last 90 days - 8 hours Last 28 days - 6 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The approach to land on Runway 01 at Eshott was normal. After touchdown the aircraft decelerated suddenly, veering to the right and tipping onto its nose before almost immediately coming to a halt, angled at about 45 degrees to the runway centreline, 40 metres past the threshold. The speed of events was such that the pilot was unclear what had happened.

On vacating the aircraft, the pilot, who was uninjured, noted that the left wheel had shed its tyre and tube during the landing run and that the left brake pipe had been severed. Since the aircraft is equipped with heel brakes, which require the pilot to move his feet backwards slightly before application, the accident pilot does not think he touched down with the brakes applied. He nonetheless considers he may have applied some braking once on the ground. This may have caused the aircraft to swing to the right given the damage inflicted to the left brake pipe. The Grove disc brake modification had been embodied on this aircraft. The routing of the pipe to the brake caliper is such that it passes below the disc, rendering it vulnerable to damage once the tyre has deflated.

The primary causal factor in the accident was the deflation of the left tyre.

ACCIDENT

Aircraft Type and Registration:	Piper PA-34-200T Seneca II, G-BOWE
No & Type of Engines:	2 Continental Motors Corp TSIO-360-EB piston engines
Year of Manufacture:	1978
Date & Time (UTC):	10 September 2008 at 0921 hrs
Location:	Runway 19, Oxford Airport
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Both propellers severly damaged and engines shock-loaded, light damage to underside of aircraft and left flap
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	63 years
Commander's Flying Experience:	8,700 hours (of which 3,500 were on type) Last 90 days - 118 hours Last 28 days - 39 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft was established on a steeper than normal final approach to Runway 19 at Oxford Airport. The instructor, whilst aware the approach checks had not been completed, took the opportunity to teach the student how to recover the situation. The landing flap was lowered but the landing gear was not and the aircraft touched down with the landing gear retracted.

History of the flight

The aircraft was returning from a training flight to the west of Oxford Airport. The student pilot was flying the aircraft from the left seat with an instructor in the right seat. They joined the circuit on a right base leg for Runway 19. The weather was good with a surface wind from 200° at 11 kt, visibility greater than 10 km, a few clouds at 1,500 ft, a temperature of 16°C and dew point of 13°C.

After positioning behind another aircraft on an ILS approach, the aircraft was high on the final approach; the instructor later reported that the aircraft had been at 1,500 ft QNH (approximately 1230 ft agl) whilst 2.7 nm from the airfield beacon. The indicated airspeed (IAS) was 115 kt and the landing checks, which include the flaps and landing gear, had not been completed. The instructor told the student to reduce airspeed and lower full landing flap when the IAS reduced below 107 kt.

To expedite the process, the instructor lowered 25° of flap and then full flap at 107 kt instructing the student to stabilise the IAS at 85 kt for the approach. The student tried to achieve this by closing the throttles to 15 inches of Manifold Air Pressure (MAP) and raising the aircraft nose.

At that stage, the instructor was aware that the landing gear was not in the DOWN position but decided to allow the student to continue the approach. He then concentrated on teaching the student the 'point and power' technique rather than him carrying out large pitch changes on the final approach. As the aircraft approached the runway threshold, the instructor told the student to set 15 inches of MAP and fly the aircraft level. The instructor then realised that the aircraft was too low, and before he could apply full power and execute a go-around the propeller tips contacted the runway surface. The instructor closed the throttles and the aircraft settled onto the runway. Neither pilot was injured and, having isolated the aircraft fuel and electrical systems, they vacated the aircraft through the normal exit. The airfield Rescue and Fire Fighting Service attended immediately.

The aircraft is fitted with a landing gear audio warning which alerts the pilot if the landing gear is not in the DOWN position when the MAP is reduced below 14 inches. At no time during the approach was the audio warning heard.

Conclusion

The instructor concluded that the cause of the accident was his decision to continue to instruct the student rather than complete the landing checks.

ACCIDENT

Aircraft Type and Registration:	Piper PA-34-200T Seneca II, G-JDBC
No & Type of Engines:	2 Continental Motors Corp LTSIO-360-E piston engines
Year of Manufacture:	1975
Date & Time (UTC):	30 June 2008 at 1458 hrs
Location:	Runway 23L, Manchester International Airport, Greater Manchester
Type of Flight:	Training
Persons on Board:	Crew - 3 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Failed left main landing gear attachments, damage to left flap, aileron, propeller and pitot head and horizontal stabilser tip
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	47 years
Commander's Flying Experience:	1,975 hours (of which 302 were on type) Last 90 days - 28 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and metallurgical examination of landing gear trunnion fitting

Synopsis

During a training flight, three touch-and-go landings were conducted at Tatenhill Airfield. The next landing was to be a full stop. However, on touchdown the aircraft veered to the right; the instructor took control and flew the aircraft off the ground. When the landing gear was subsequently retracted, an 'unsafe' indication was obtained and it was later observed that, with the gear extended, the left wheel appeared to be at 90° to the airflow, with the leg deflected in an aft direction.

The decision was made to return to the operator's base at Manchester, where, immediately prior to touchdown, both engines were shut down and the propellers feathered. Subsequent examination of the aircraft showed that the left landing gear forward trunnion fitting had broken into several pieces, thus releasing the leg from its location. Metallurgical examination indicated that the fitting had failed from a combination of loose attachment bolts and fretting damage.

History of the flight

The first flight on the day of the accident was an instrument training detail from the operator's base at Manchester to Blackpool Airport. Aboard were the instructor and two trainee pilots. The landing at Blackpool was uneventful and the aircraft subsequently departed to conduct an asymmetric power training detail. Some of this was carried out at high level, during which the landing gear was cycled six times. The aircraft then joined the circuit at Tatenhill, making three touch-and-go landings on Runway 26, with the purpose of conducting practice engine failures on departure. The surface wind was approximately 260° at 10 kt and the commander stated that the landings were smooth, with no lateral drift. The next landing was to be a full stop, in order to refuel before returning to Manchester. However, on touchdown the aircraft veered to the right and appeared likely to leave the paved surface. Accordingly, the instructor took control and flew the aircraft off the ground. When the gear was retracted the ‘gear unsafe’ light remained illuminated. The rear seat student then reported that he had heard a ‘bang’ during the touchdown.

The aircraft departed the circuit and the landing gear was cycled a number of times in attempt to clear the problem, but without success. When selected up, the gear unsafe light came on; when selected down, two greens (the nose and right main) illuminated. The emergency landing gear extension procedure was then conducted, at the appropriate speed of 84 kt, but the indications remained the same. During this time, the rear seat student observed that, with the gear extended, the left wheel appeared to be deflected at 90° to the airflow, with the leg bent rearwards. The commander then made his own visual inspection and agreed with the findings. The gear was cycled once more, whereupon, three green lights illuminated. By experimentation, it was found that the left wheel was fouling the left flap when set fully down.

It was by now clear that a normal landing could not be achieved, so it was decided to continue to Manchester where more comprehensive emergency services were available. Upon first radio contact with Manchester Approach, the commander explained the problem and the airport emergency services were placed on standby. The aircraft was held at a visual reference point (VRP) while preparations were made. During this time, the commander briefed the students as to what he expected from them and also debated whether to spend time burning off more fuel; approximately half the contents by now remained.

The commander took control of the aircraft and flew an off-set approach to Runway 23L; the surface wind was reported as 260° at 10 kt. He aimed to land on the right side of the runway in order to improve the chances of remaining on the paved surface in the event that the aircraft veered to the left. At approximately 250 ft agl and over the runway, the commander closed both throttles, feathered the propellers and selected the mixture controls to idle cut-off. Although the right propeller feathered quickly, the left continued to windmill. Only two stages of flap were selected in view of the fact that the left wheel fouled the flap at its full deflection. The commander held the aircraft off the ground for as long as possible, with the front seat student reporting the speed to be 60 kt on touchdown. Right aileron was applied to hold the left wing off the ground, with contact occurring at 40 kt. Right rudder and right brake were applied in order to keep the aircraft straight. As soon as it had halted the occupants vacated the aircraft; there were no injuries. The emergency services were in attendance almost immediately. The aircraft had sustained relatively little damage and there were no fuel or hydraulic fluid spillages.

Examination of the aircraft

The aircraft was recovered to the maintenance organisation's hangar, where an inspection revealed that the left landing gear forward trunnion fitting had broken into several pieces. Parts of the component were missing, although one piece was later recovered from the runway at Tatenhill. Figure 1 shows an illustration from the Illustrated Parts Catalogue, which shows details of the installation.

The fragments from the trunnion fitting were removed from the aircraft, Figure 2, and subjected to a metallurgical examination.

Figure 1

Drawing illustrating installation of the main landing gear trunnion fittings

Figure 2

Recovered trunnion pieces. Fragment marked 'X' was found at Tatenhill. Note damage around bolt hole (arrowed)

Metallurgical examination of the trunnion fitting

There was evidence, in the form of polished areas on the rear face of the trunnion fitting, of fretting, ie, small amplitude relative movement between the fitting and the wing spar surface to which it was bolted, Figure 3. Fretting had also occurred between the attachment bolts, the bolt holes, and the washers under the bolt heads. Some of the fracture faces around the bolt holes bore evidence of very low cycle, high peak stress fatigue cracking. It is considered that this occurred during the later stages of the failure sequence, after the fretting damage. It was not possible to establish a timescale for the failure process, but it is likely that it occurred over a number of landings, as opposed to progressing from initiation of the first crack to complete failure, on the day of the accident.

Aircraft history

Following an incident in Italy in 1995, the aircraft required a repair in which the right main landing gear forward and aft trunnion attachment fittings were replaced. There was no record of the left gear trunnion fittings having been replaced during the life of the aircraft.

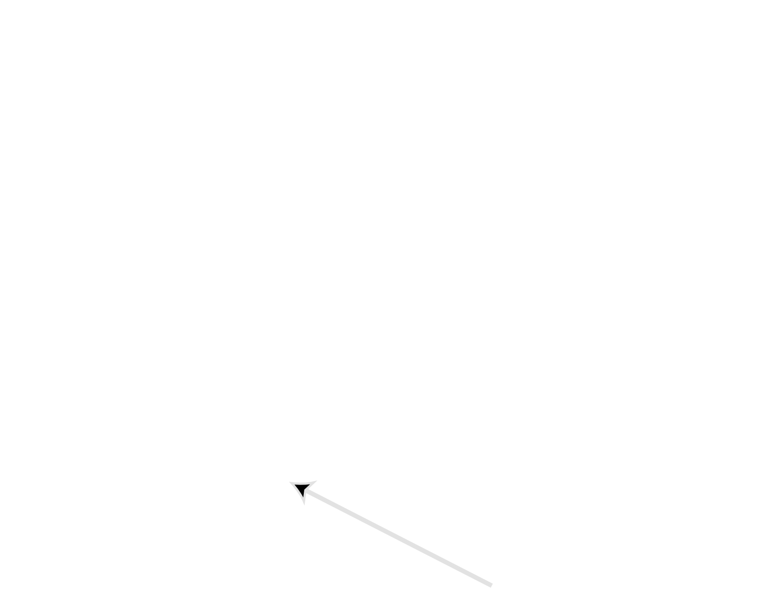

Figure 3

Fretting damage area on reverse side of fragment X (arrowed)

In March 1993, the aircraft manufacturer issued Service Bulletin (SB) No 956, which consisted of two parts. The purpose of the SB was to address the possibility of the trunnion fitting attachment bolts losing their assembly torque after prolonged service. The SB noted that:

> *'Left uncorrected, the bolt holes in the attach fittings and wing spar may become elongated, possibly resulting in damage to the wing structure or the failure of the landing gear.'*

Part 1 of the SB provided instructions for initial and repetitive (100 flight hour) inspections of the trunnion attachment fittings to determine if loosening had occurred. Part 2 provided larger diameter bolts, which strengthened the installation and removed the requirement for the repetitive inspections.

SB 956 Part 2 was embodied on G-JDBC on 11 August 2003, which thus removed the repetitive inspection requirement of Part 1. However, the maintenance organisation for this aircraft stated that they nevertheless continued to check the torque of the trunnion fitting bolts every 100 flight hours. The most recent such check was conducted on 6 June 2008, ie, 24 days before the accident.

The maintenance organisation stated that when the broken remains of the fitting were removed from the aircraft, it was noted that the bolts were "extremely tight". A subsequent inspection of the assembly torque on the attachment bolts on the trunnion fittings on the intact right landing gear showed that seven out of the eight bolts were at 140 lb.ins, with one at 80 lb.ins. (The specified value is 100-140 lb.ins). The torque on the left gear aft fitting attachment bolts could not be measured, as these were removed shortly after the accident.

Discussion

The metallurgical examination of the failed trunnion fitting determined that fretting had occurred, leading to a low cycle fatigue process in the material adjacent to the bolt holes. This culminated in the complete failure of the component, much as predicted in SB 956. In the absence of any additional evidence, it is likely that the fretting occurred due to the bolt torques slackening off in service.

The maintenance requirements remain the same regardless of whether an aircraft is used primarily in an air-taxi operation or, like G-JDBC, in a training role, in which the landing gear is subjected to many more cycles/landings per hour. The maintenance organisation appears to have recognised this, in that they continued to check the torque of the trunnion fitting attachment bolts every 100 flight hours, despite having complied with SB 956. It was not established why the trunnion fitting attachment bolts appeared to have slackened off prior to this failure.

ACCIDENT

Aircraft Type and Registration:	Rans S6-116 Coyote II, G-BUTM	
No & Type of Engines:	1 Rotax 912-UL piston engine	
Year of Manufacture:	1993	
Date & Time (UTC):	7 May 2008 at 1440 hrs	
Location:	Grove Farm (private airstrip) near Gamston, Nottingham	
Type of Flight:	Training	
Persons on Board:	Crew - 2	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Left landing gear strut broken, propeller strike, engine shockloaded, fuselage damage	
Commander's Licence:	Commercial Pilot's Licence	
Commander's Age:	50 years	
Commander's Flying Experience:	2,126 hours (of which 4 were on type) Last 90 days - 67 hours Last 28 days - 30 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot and examination of hardware by the AAIB	

Synopsis

Whilst on an instructional sortie, the student flared too high on landing and the aircraft landed heavily, fracturing the left main landing gear. Some evidence of metal fatigue was noted in the fracture face, but it is not considered to have advanced enough to have had a significant effect on the strut's ultimate strength.

History of the flight

The aircraft was being flown with an instructor to familiarise its owner with tailwheel aircraft. Two sorties had already been flown, involving approaches and go-arounds. On the accident flight, after some upper air work, an approach was made to Grove Farm airstrip with the intention that the owner would attempt his first landing on Runway 09. The approach was stable in a light easterly wind but the handling pilot flared somewhat high – not so high, in the opinion of the instructor, that damage would be expected - and a very heavy landing resulted. The left wing dropped and the aircraft veered to the left, coming to rest upright in a crop. The crew evacuated the aircraft normally after switching off the fuel and magnetos and it was apparent from the ground marks that the left main landing gear strut had broken immediately on touchdown.

Examination

The aircraft was examined prior to commencement of repairs and the fractured strut seemed to contain an element of metal fatigue. The two pieces of the strut were sent to the AAIB for metallurgical examination. The strut is essentially a solid cantilever steel rod tapering toward the wheel end with a hollow, parallel section at the top where it inserts into a fitting attached to the fuselage. The strut had failed at the change in section from tubular to solid and there was indeed evidence of a pre-existing fatigue crack on the inside of the tubular section. Extending around about 25% of the circumference (see Figure 1), the maximum depth was less than a millimetre, so it was not considered that it had significantly affected the ultimate strength of the strut. The strut also had noticeable bending distortion towards the lower end.

The repair organisation believe that the main landing gear struts were original and the aircraft had flown about 400 hours since new. Both struts were found to be 'rattling' in the socket of the fuselage fittings, despite some apparent attempts to shim them. New struts and fittings were ordered and found to require shims to achieve a reasonable fit. The previous owner of the aircraft did, however, state that the struts had been a very tight fit in the fittings when the aircraft had been built and did not require shims.

The Light Aircraft Association (LAA) advised that there did not appear to be a history of fatigue failures with this aircraft model and that it seemed a characteristic that the struts would take on a 'set' over a period of time in service.

The aircraft had experienced a nose-over during a soft-field landing in about 1999. The current repairer noted the contemporary repairs but also noted additional significant damage which had apparently not been spotted at the time. He is cataloguing this damage and will submit a report to the LAA, who have also been advised of the discovery of the fatigue crack in the strut.

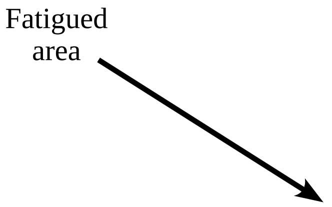

Figure 1

ACCIDENT

Aircraft Type and Registration:	Reims Cessna F172M Skyhawk, G-BFPM
No & Type of Engines:	1 Lycoming O-320-E2D piston engine
Year of Manufacture:	1975
Date & Time (UTC):	9 August 2008 at 1036 hrs
Location:	The Old Airfield, Strubby, Alford, Lincolnshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 3
Injuries:	Crew - None Passengers - 2 (Serious) 1 (Minor)
Nature of Damage:	Moderate
Commander's Licence:	Private Pilot's Licence
Commander's Age:	44 years
Commander's Flying Experience:	582 hours (of which 105 were on type) Last 90 days - 10 hours Last 28 days - 3 hours
Information Source:	AAIB Field Investigation

Synopsis

Following a flight in the local area, the aircraft was landing back at Strubby, where there was a significant crosswind from the left. The initial touchdown was followed by a bounce, following which the left wing lifted and the aircraft turned to the right. The pilot applied full power with the intention of conducting a go-around, but the aircraft stalled into a standing crop to the right of the runway and turned over onto its back. The pilot was uninjured but an elderly passenger suffered a heart attack on the following day. The remaining passengers required on-going hospital treatment.

History of the flight

The flight was planned as a surprise 80th birthday present for a local man and had been arranged approximately one month beforehand when a member of his family approached an acquaintance, who was a pilot and who owned a Cessna 172 aircraft based at Strubby. However, a few days before the agreed date, the pilot realised he had a domestic commitment that would prevent him from fulfilling the task; he therefore asked a friend, who also owned a Cessna 172, if he could conduct the flight. The friend agreed to do this as a favour, although he had not met the family.

An approaching weather system threatened to postpone the flight, which was intended to be approximately one hour's duration in the local area. However, on the day before the flight, the pilot checked the forecast and decided that conditions would be satisfactory for the following morning, although the approaching weather front would cause conditions to deteriorate later on. Accordingly he contacted the family, asking them to be at the airfield at 1030 hrs, although, having re-checked the forecast early on the day of the flight, he made a further telephone call, asking the passengers to attend the airfield one hour earlier, at approximately 0930 hrs.

In the event, the family arrived at Strubby somewhat later, although the exact time is unclear. The pilot, who had been checking the aircraft, ensured everyone was strapped in and took off at around 1030 hrs. The 80-year old passenger and his wife were in the rear of the aircraft, with their adult granddaughter in the front passenger seat. She had brought along a camcorder with which she subsequently filmed much of the flight, including the landing.

The flight proceeded normally, with the video footage confirming that although overcast, the visibility was good. There was some turbulence however, and the pilot became concerned on several occasions that his male passenger was feeling unwell. After flying over the passengers' home village, the granddaughter requested that they return to the airfield. The pilot interpreted this as an indication of concern for her grandfather, and decided to save time by conducting a 'straight in' approach, rather than flying a conventional circuit pattern. A wind turbine farm some 1.5 miles from the airfield and which was close to the approach path for Runway 26, provided an indication of the wind direction, and it became apparent that there was a significant crosswind component; a remark made by the pilot to this effect could be heard on the video recording.

The pilot selected the flaps, in stages, until he had full flap (40°) set by short final approach. The video recording showed that the aircraft nose was off-set to the left in order to maintain the runway centreline. Just before touchdown the pilot used the rudder to align the aircraft with the runway and made an apparently normal landing. However, a bounce ensued, following which the aircraft suddenly rolled and turned to the right. The pilot immediately applied full power and the aircraft flew a few feet above the surface on a track approximately 35° to the right of the runway heading. The stall warning horn was sounding continuously and, after several seconds, the nose dropped suddenly into a standing crop some 30 metres to the right of the runway and the aircraft turned over onto its back. Another member of the passengers' family who had been waiting at the airfield, telephoned the emergency services and assisted the occupants in vacating the aircraft. The pilot turned off the electrics and later returned to the aircraft to turn off the fuel. There was no fire, although a small quantity of fuel leaked from the tank vents.

The pilot was uninjured but the front seat passenger was heli-lifted to hospital. The rear seat occupants were taken by ambulance to hospital, where the grandfather suffered a heart attack on the evening of the following day. As a result of this, he underwent surgery approximately two weeks later.

Crosswind issues

An aftercast provided by the Met Office indicated that at around the time of the accident, an active warm front was lying approximately north-south over the east of England. Ahead (to the east) of the front, which had not yet reached the accident site, was a strengthening south-westerly wind. The 1050 hrs (local) wind observation at RAF Coningsby, some 30 miles to the southwest, was 210º/14 kt. Half an hour later, the Humberside Airport readings were similar, at 210º/17 kt. Other nearby surface reports, together with isobaric analysis, were used to estimate the surface wind speed and direction at Strubby. These were 210º/15 kt, with gusts to 26 kt. These would have given crosswind components for Runway 26 of 11.5 kt and 20 kt respectively.

The Flight Manual for G-BFPM contained the following note on crosswind landings:

> *'When landing in a strong crosswind, use the minimum flap setting required for the field length. Use a wing low, crab, or a combination method of drift correction and land in a nearly level attitude……..'*

Later models of Cessna 172 aircraft have maximum flap settings of 30º, compared with 40º available on G-BFPM. A Flight Manual for one such aircraft contained essentially the same advice as that given above, but noted that:

> *'If flap settings greater than 20º are used in sideslips with full rudder deflection, some elevator oscillation may be felt at normal approach speeds. However, this does not affect control of the airplane.'*

With regard to drift correction, it additionally stated that:

> *'…the wing low method gives the best control….'*

There was also a note stating that operation of this type of aircraft in direct crosswinds of 15 kt has been demonstrated.

Discussion

The meteorological aftercast indicated that, during the period between when the aircraft took off and its return to the airfield, the wind strength may have increased. Although the initial touchdown appeared normal, it is likely a gust caused the aircraft to roll to the right. Should the pilot have maintained the right rudder input he had applied to align the aircraft with the runway just before touchdown, then this may have been responsible for the turn to the right. In any event, when the pilot committed to a go-around, the aircraft was pointing significantly to the right of the runway heading, which may have eliminated any headwind component. This, together with the aircraft weight and the drag associated with the selection of 40° of flap, is likely to have prevented the aircraft from attaining flying speed.

ACCIDENT

Aircraft Type and Registration:	Staaken Z-21 Flitzer, G-FLIZ	
No & Type of Engines:	1 Volkswagen 1834 piston engine	
Year of Manufacture:	1999	
Date & Time (UTC):	22 August 2008 at 0925 hrs	
Location:	RAF Lossiemouth	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Propeller broken, engine shock-loaded, upper wing skin (Ceconite) scuffed over ribs, upper quarter rudder and fin crushed, right main wheel buckled	
Commander's Licence:	National Private Pilot's Licence	
Commander's Age:	55 years	
Commander's Flying Experience:	589 hours (of which 125 were on type) Last 90 days - 7 hours Last 28 days - 1 hour	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Synopsis

G-FLIZ made an approach to land with a crosswind from the left and touched down left main wheel first. As the right wing and tail lowered, the left wing rose rapidly accompanied by a swing to the right. The pilot was unable to control the ensuing motion and the wingtip and propeller struck the ground. This caused the aircraft to pitch forward and it came to rest inverted.

History of the flight

G-FLIZ made an approach to land on Runway 05 and the pilot believed from looking at the windsock, that the surface wind was 340°/10-12 kt. This implied a crosswind from the left of approximately 11 kt. He made his approach with the left wing low and with 5 kt added to the normal approach speed. The left wheel touched down and the pilot closed the throttle and maintained left aileron to slow the rate at which the right wing lowered. He also kept some right rudder applied to keep the aircraft straight. As the right wing and tail lowered to the ground, he centralised the rudder but the left wing rose rapidly, accompanied by a marked swing to the right. The tail also began to rise. Despite the application of full left aileron and rudder, the aircraft continued to turn right and the pilot applied some power to regain rudder authority. The aircraft began to swing to the left and the right wing tip hit the ground.

After about 80° of turn, the aircraft pitched forward, the propeller struck the runway and the aircraft became inverted. The pilot undid his harness and climbed out of the open cockpit.

Analysis

The pilot had some right rudder applied after touchdown to counteract the left aileron. He considered it possible that the position of his left leg with right rudder applied prevented him from applying full left aileron. It seems likely that a gust of wind lifted the left wing at a rate that was beyond the roll authority available. Although full left rudder input physically allowed the application of full left aileron, the pilot was unable to control the subsequent motion of the aircraft.

ACCIDENT

Aircraft Type and Registration:	Streak Shadow SA, G-TTOY	
No & Type of Engines:	1 Rotax 618 piston engine	
Year of Manufacture:	1996	
Date & Time (UTC):	20 July 2008 at 1220 hrs	
Location:	Brimpton Airfeld, Berkshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Tail boom failed, nose leg collapsed, rear hanger bars bent	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	47 years	
Commander's Flying Experience:	133 hours (of which 21 were on type) Last 90 days - 0 hours Last 28 days - 0 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Synopsis

The aircraft descended rapidly from about 100 feet during the approach to land, striking the ground hard, short of the runway. The pilot considered that a lack of recent fying practice may have contributed to him not recognising the potential for low level wind shear, which the aircraft then encountered.

Circumstances of the accident

This was the frst fight of the year for the pilot, who had planned a short fight from Popham Airfeld, near Basingstoke, to Brimpton Airfeld, about 11 nm to the north. The weather conditions were good, with a gusty wind giving some light turbulence on departure from Popham. The pilot made contact with the Air/Ground radio station at Brimpton, who advised him that Runway 25 was in use and that the surface wind was from 310º(M) at 10 kt. Runway 07/25 had a grass surface and was 635 metres long, with the Runway 25 threshold being displaced by 100 metres beyond the start of the strip.

The pilot discontinued two approaches to the runway, the frst because of other traffc and the second when he recognised that his aircraft was positioned too high on the fnal approach. The third approach was fown at about 60 kt with fap 15, with the actual wind appearing to match that reported.

At an estimated height of 100 to 120 feet, the aircraft pitched down rapidly. The pilot attempted to correct this with power, and the pitch attitude increased initially before the aircraft again pitched down. There was insufficient height to make a further recovery and the aircraft hit the ground very hard, short of the runway, accompanied by a loud bang. As it continued along the ground towards the runway there was a second bang as the nose landing gear separated; the tail boom had failed in the initial contact so the pilot had been unable to keep the aircraft's nose raised.

The aircraft skidded to a stop with the engine still running. The pilot, who was wearing a full harness and suffered only minor bruising, shut the engine down and extricated himself from the aircraft, assisted by local flying club members who were quickly on the scene. When the pilot inspected the site, it was clear that the aircraft had touched down heavily at two points in the 100 metre undershoot area, and that the nose landing gear had separated at about the start of the runway itself.

The pilot reported learning that trees in the vicinity sometimes gave rise to unusual wind effects when the wind was from certain directions. As it was his first flight of the season, he felt he may have been better avoiding a situation that required a crosswind landing. He also thought that his lack of recent experience may have led him to fail to recognise the potential for low level wind shear posed by the trees adjacent to the runway.

ACCIDENT

Aircraft Type and Registration:	Vans RV-6A, G-RVSA
No & Type of Engines:	1 Lycoming O-360-A4M piston engine
Year of Manufacture:	2004
Date & Time (UTC):	30 August 2008 at 1349 hrs
Location:	Fishburn Airstrip, Co. Durham
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Serious) Passengers - 1 (Minor)
Nature of Damage:	Damage to nosewheel, propeller, canopy and tail
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	74 years
Commander's Flying Experience:	185 hours (of which 86 were on type) Last 90 days - 10 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft touched down on Runway 26 at Fishburn and bounced twice before the nose landing gear made firm contact with the soft, grass surface of the runway. The nose landing gear then appeared to become partially embedded in the ground and the aircraft nosed over onto its back.

History of the flight

Following an uneventful flight from North Weald to Fishburn, the aircraft made an approach to land on Runway 26. This runway is approximately 600 metres in length, and has a mown grass surface with a slight uphill slope. The weather was good with the wind at 2,000 ft noted by the pilot to be from 270° at 10 kt. The visibility was estimated at 15 km and there was scattered cloud at 2,500 ft.

The aircraft was initially slightly high on the approach but the pilot considered it satisfactory and corrected by reducing power. The initial touchdown was followed by a low bounce, probably caused by an undulation in the runway surface. A second low bounce followed, although at this stage the landing still appeared to be normal. After the third contact with the runway, the aircraft pitched nose up to a height of approximately four feet before falling back onto the runway on the main landing gear. The aircraft pitched forward and began to decelerate sharply. The deceleration continued until the ground speed was about 10 kt, when the aircraft nosed over onto its back. From examination of the damage to the runway surface, it appears that following the firm nose wheel contact it dug into the soft grass causing the aircraft to nose over.

Both occupants were able to exit the cockpit through the canopy and received assistance from the Airfeld Rescue and Fire Fighting Service. The air ambulance attended the scene to provide treatment for the injuries.

Conclusions

The pilot's assessment of the cause of the accident was a frm touchdown on the nose landing gear, causing the aircraft to pitch forward onto its back.

ACCIDENT

Aircraft Type and Registration:	Pegasus Quantum 15-912, G-CCWN
No & Type of Engines:	1 Rotax 912-UL piston engine
Year of Manufacture:	2004
Date & Time (UTC):	16 September 2008 at 1715 hrs
Location:	Sutton Meadows, Cambridgeshire
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	27 years
Commander's Flying Experience:	3,200 hours (of which 620 were on type) Last 90 days - 145 hours Last 28 days - 54 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The fight was planned as a trial lesson and was the student's frst fight in a microlight. The Pegasus Quantum is a fex-wing microlight with a tandem seating arrangement in which the student occupied the front seat. Durng the fight, the instructor progressively allowed the student to take control, with the student eventually fying a circuit followed by an approach to land. The instructor described the student as fying "very well". At around 100 ft on approach, the microlight began to drift to the right of the runway centreline and the instructor said "I have control". However, the student pulled the control bar fully back and froze. The instructor immediately applied full power and attempted to push the bar forward. Despite repeated vocal commands the student did not release the control bar and the microlight struck the ground at around 80 mph. It bounced back into the air before touching down again and coming to rest around 40 m from the intial impact point. There were no injuries.

ACCIDENT

Aircraft Type and Registration:	Pegasus XL-Q, G-MTYE
No & Type of Engines:	1 Rotax 462 piston engine
Year of Manufacture:	1988
Date & Time (UTC):	17 August 2008 at 1230 hrs
Location:	Enstone Microlight Club, Oxon
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to trike pylon and wing hang strap
Commander's Licence:	Private Pilot's Licence
Commander's Age:	Not given
Commander's Flying Experience:	3,882 hours (of which 20 were on type) Last 90 days - 48 hours Last 28 days - 12 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The f ex-wing microlight aircraft was holding short of the runway in use. The surface wind was estimated at 8 to 10 kt and blowing from the aircraft's 7 o'clock position. As the pilot reached for the radio, he inadvertently pulled back on the control bar. This allowed a gust of wind under the wing trailing edge, which tipped the aircraft forward onto its port leading edge. The engine was shut down and the aircraft was lifted back onto its main wheels with the assistance of helpers. Damage was later found to the trike pylon and the wing hang strap.

BULLETIN RE-ISSUED

In its August 2008 Bulletin, the AAIB published a report into a serious incident to an Airbus A319.

The report identified an element of training given to the co-pilot which appeared to conflict with the normal duties expected of a handling pilot in the right seat during a rejected takeoff. A Safety Recommendation (2008-027) was made in the report which recommended that the operator '*review their flight crew simulator training to ensure that it reflects their current Standard Operating Procedures (SOPs).*' After completion of the consultation period (Regulation 12.1) for the final report and just before publication, the operator advised the AAIB that, under '*Flight Crew Incapacitation*', their Operations Manual contained an SOP which required a right seat handling pilot to carry out those duties usually assigned to the commander of an aircraft under some circumstances. As a consequence, the operator stated that there was no conflict between their SOPs and the training provided to their pilots. Given this new information the AAIB has accepted these observations and has withdrawn Safety Recommendation 2008-027.

In addition, following publication, a review of the report was requested under Regulation 15(1) of the Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 1996.

Consequently, the Chief Inspector decided that, following review, the report should be updated and re-issued in full to incorporate new and revised information.

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.

One Safety Recommendation is 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 7.4km 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 350° at 7 kt. G-DBCI commenced a rolling takeoff at 0944:20 hrs at a weight of 58,124 kg. At that weight, V_1 and V_R were both 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. He stated that, at approximately 130 kt, 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 at an airspeed 5 kt below V_1. 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.

The commander commented that, during the takeoff roll, he 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 remarked that the takeoff had been normal up to the point the aircraft started to yaw, with small movements of 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 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 stopped on the taxiway. The aircraft 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 and the skid marks were confirmed. It was reported to the crew of G-DBCI that the aircraft's right main landing gear may have become 'blocked'. This information, which had been passed to the crew during the flight, had been interpreted by the commander 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 184°/004°M. 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 325° and 005°, 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 285° and 330°, 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 325°/5 kt and 320°/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 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).

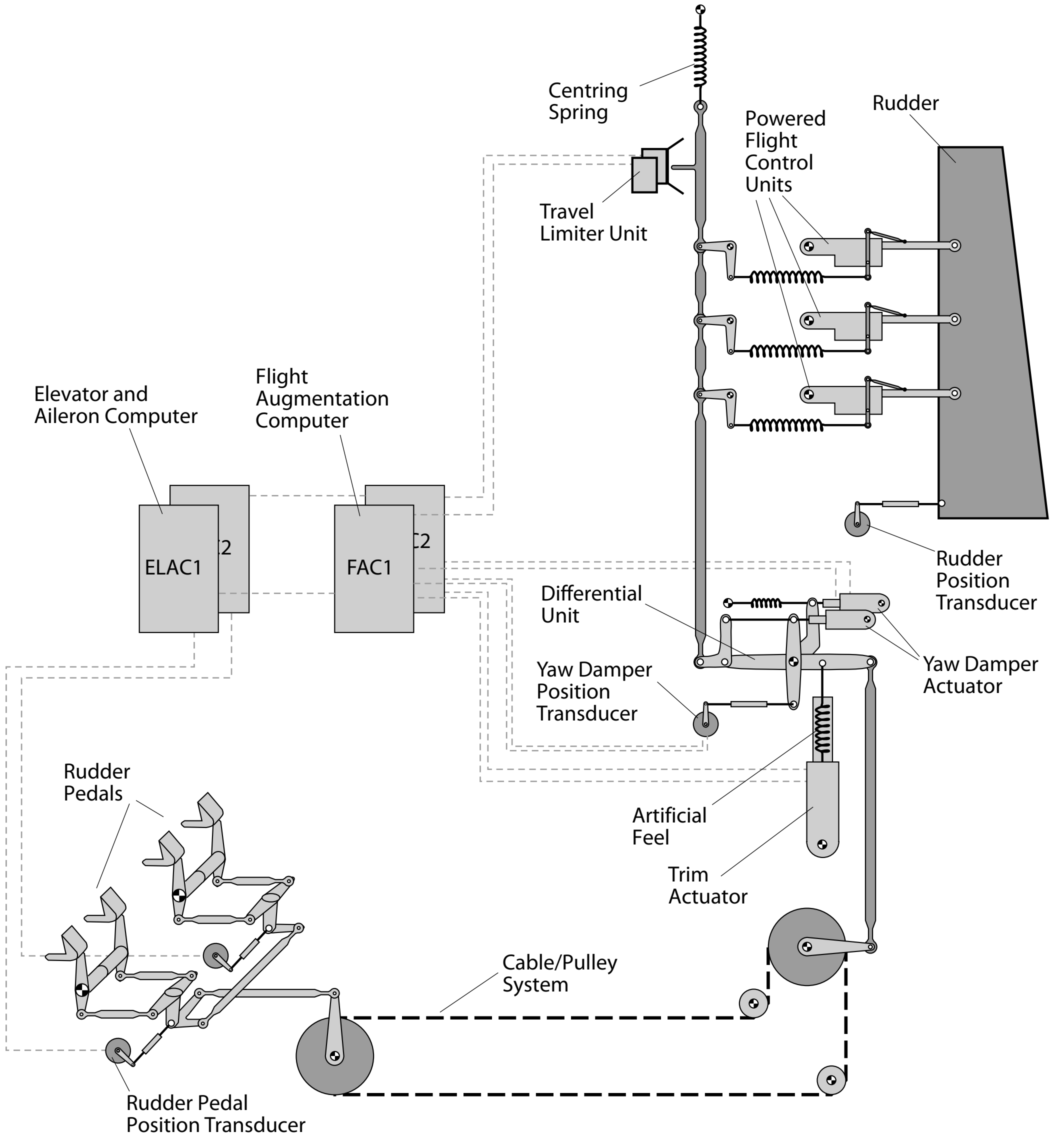

Figure 1

A319 Rudder Control System Schematic

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 ±30° 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.

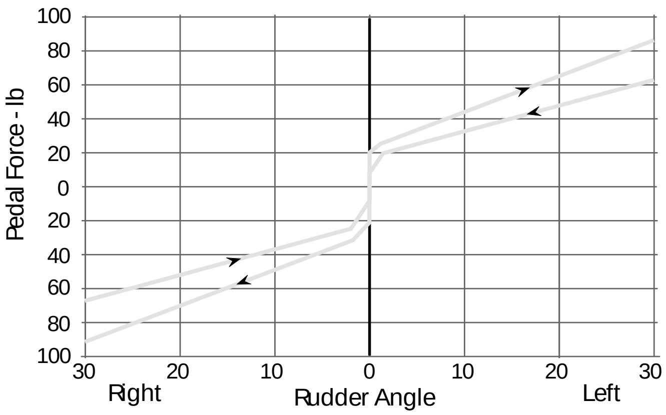

Figure 2

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 and 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 ±20° rudder deflection; trim rate is 1.2°/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 ±5° rudder deflection, at a maximum rate of 40°/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 32°) resulted in a maximum pedal displacement of 15°, 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, 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 approximately 1640 hrs on 19 April 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 the rudder operated normally in response to both pedal and trim inputs. 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 1 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.

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

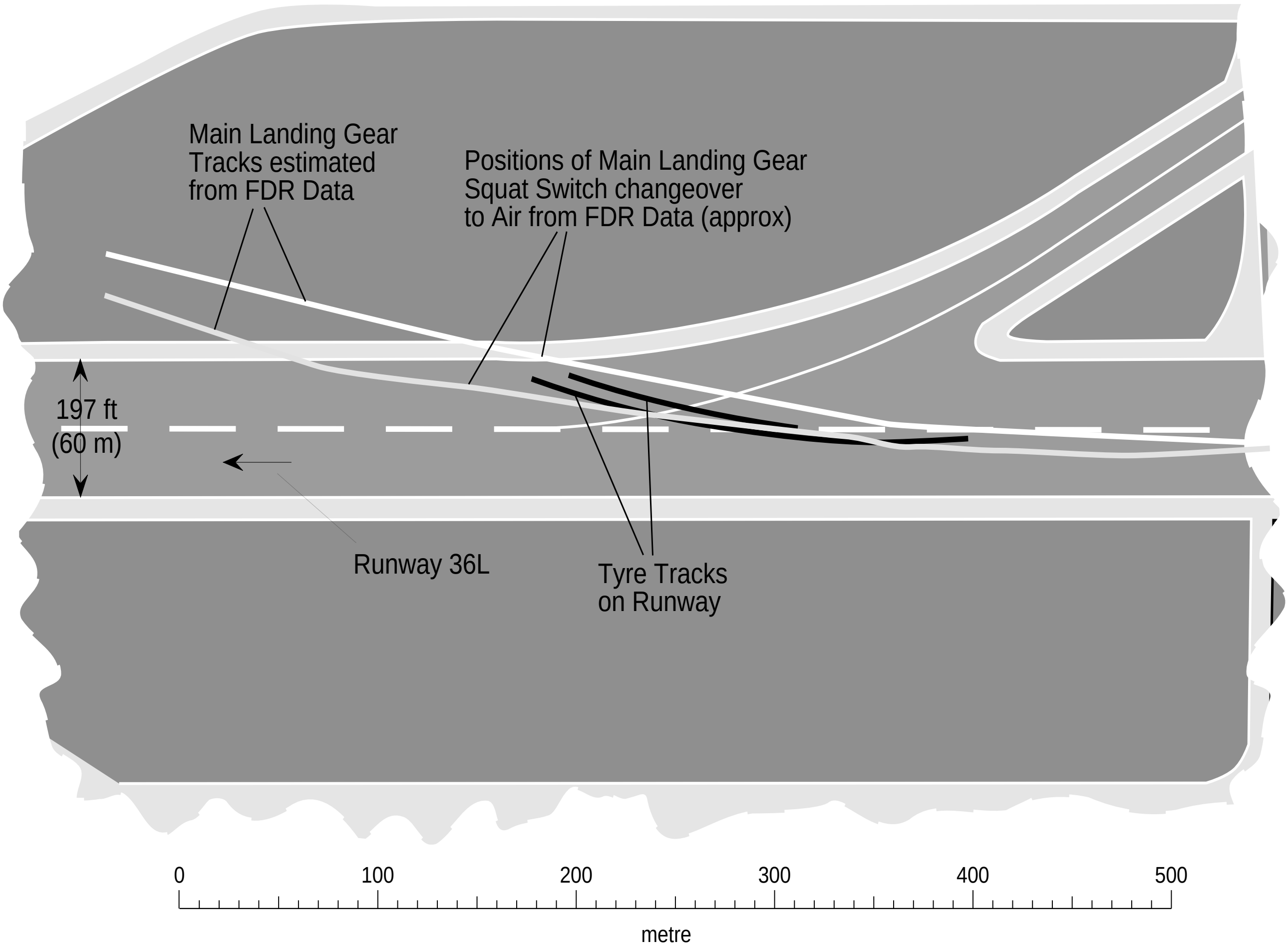

Figure 3

Plan View of Runway Tyre Marks and Main Landing Gear Tracks estimated from FDR Data

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; 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.

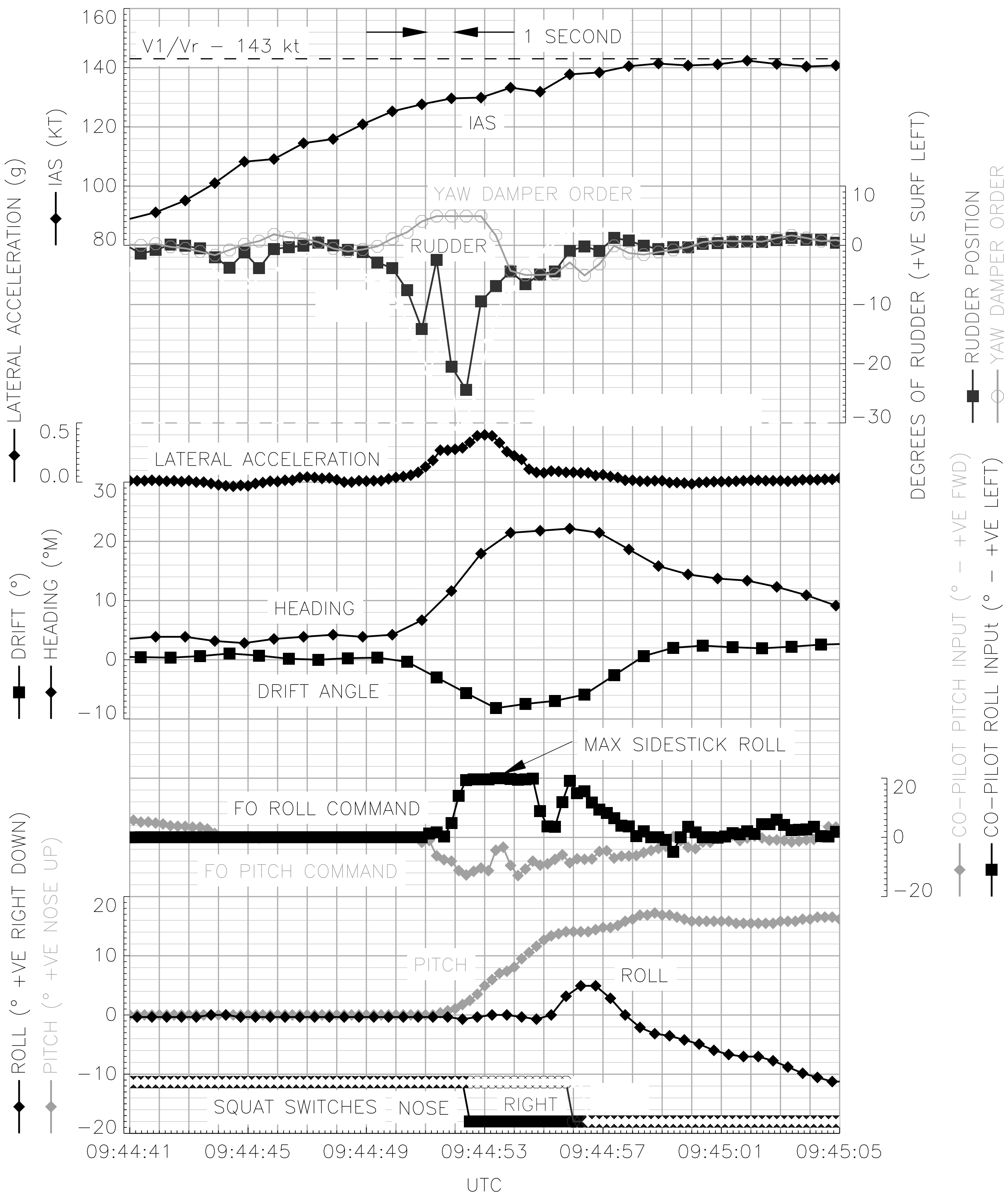

Figure 4

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. A further 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 - 13 kt.

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

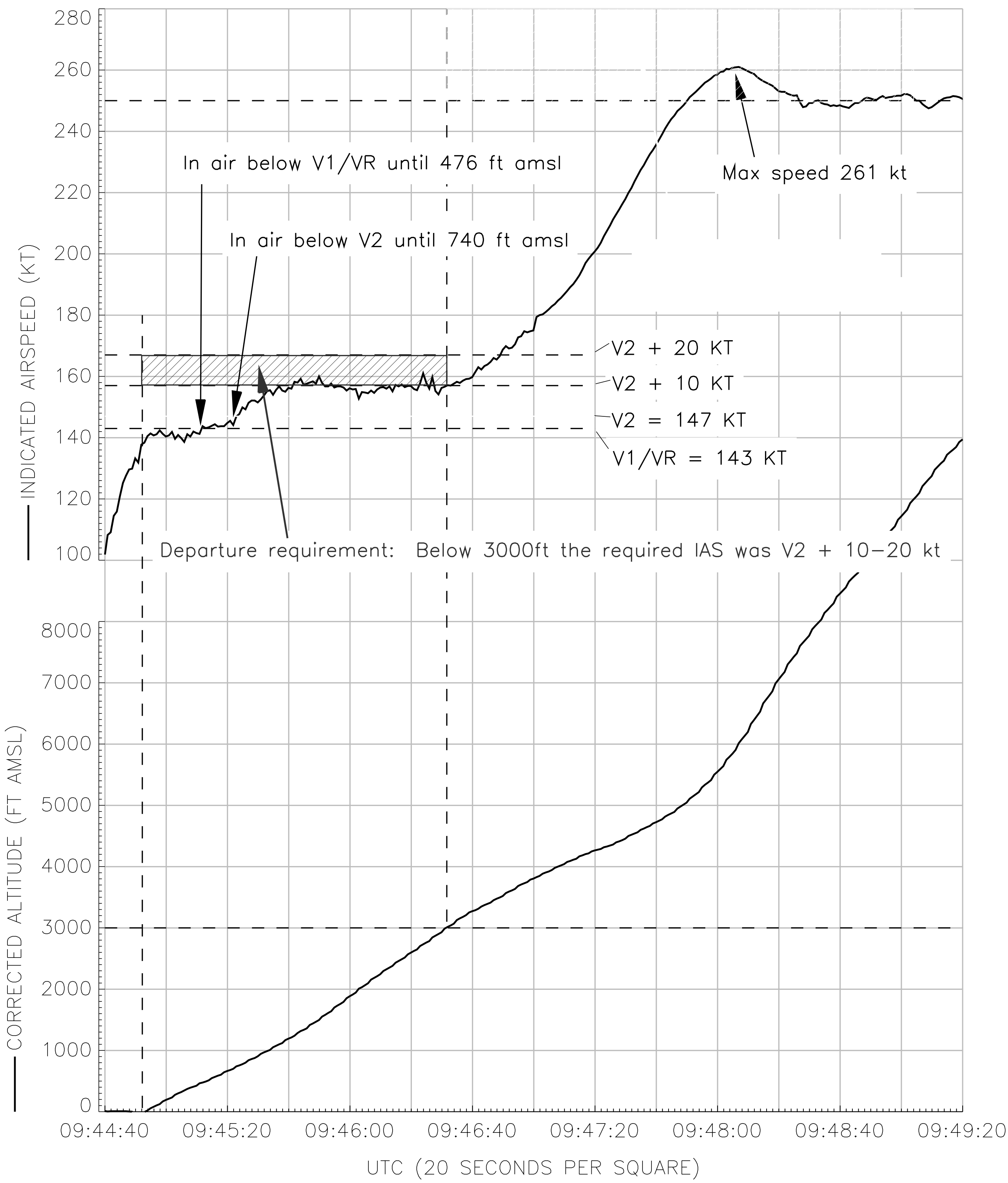

Figure 5

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

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…'*

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 3°. This contrasts with the G-DBCI event where the commander reported a heading change of approximately 30° (later confirmed by the FDR to have been 18°).

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 an assessment of the reasons why G-DBCI 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 having seen 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 changed radio frequency 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 unfyable. 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 direct the aircraft along a path in the vertical plane at a speed defned by the SRS guidance law. In SRS mode, the aircraft maintains a speed target equal to V_2 + 10 knots in normal engine confguration. 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 knots. 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 fight 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 fight 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 fying 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.'

The Operations Manual provides advice and guidance on the procedure to follow in the event of *Flight Crew Incapacitation.* Under *Chain of Command,* it states:

'The fit pilot must assume control and return the aeroplane to a safe flight path.'

The operator stated that, should incapacitation of the commander be detected by PF in the right seat during takeoff, PF should assume command and make the decision to continue or abort the takeoff, as appropriate. As part of their recurrent training programme, the operator provides all their flight crew, whether LHS or RHS, with the facility to exercise this decision making process in the simulator every three years.

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.

The Takeoff Safety Programme involved engine failures, mainly at V_1-5 kt with one carried out at V_1-20 kt, and 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.

Following the incident in Amsterdam, the commander received refresher training in the simulator, which included the guarding of the flying controls as PNF and the taking over of control in the event of mishandling by PF during takeoffs and landings. This was supplemented with supervised line flying operations before the commander was returned to full line flying duties. The commander's performance during this period was assessed as being '*all to a good standard*.'

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 rudder or the pedals were 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 was countered by a brief rapid reversal of the rudder pedals. 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

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