CONTENTS

COMMERCIAL AIR TRANSPORT

FIXED WING

ROTORCRAFT

None

GENERAL AVIATION

FIXED WING

ROTORCRAFT

CONTENTS (Continued)

SPORT AVIATION / BALLOONS

ADDENDA and CORRECTIONS

(ALL TIMES IN THIS BULLETIN ARE UTC)

SERIOUS INCIDENT

Aircraft Type and Registration:	Airbus A330-243, G-OJMC
No & Type of Engines:	2 Rolls-Royce RB211 Trent 772B-60 turbofan engines
Year of Manufacture:	2002
Date & Time (UTC):	28 October 2008 at 0426 hrs
Location:	Sangster International Airport, Montego Bay, Jamaica
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 13 Passengers - 318
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	47 years
Commander's Flying Experience:	14,500 hours (of which 3,000 were on type) Last 90 days - 170 hours Last 28 days - 40 hours
Information Source:	AAIB Field Investigation

Synopsis

Due to an error in the takeoff performance calculations, incorrect takeoff speeds were used on departure. On rotation, the aircraft initially failed to become airborne as expected, causing the commander to select TOGA power. The aircraft then became airborne and climbed away safely. Whilst the investigation could not identify the exact source of the error, deficiencies were revealed in the operator's procedures for calculating performance using their computerised performance tool.

A study of previous takeoff performance events showed that the number and potential severity is sufficient to warrant additional safeguards to be identified by industry and to be required by regulators.

Two Safety Recommendations are made.

History of the flight

The crew reported for duty at 0245 hrs UTC (2145 hrs local) at Sangster International Airport, Jamaica for the flight to the UK. The flight crew consisted of a commander, a co-pilot and a supernumerary pilot, who was an A330 line captain and also a qualified A320/A321 training captain.

During the pre-flight preparation, the flight crew were unable to locate the aircraft's performance manual. As a result, at about 0400 hrs UTC (2300 hrs local in Jamaica, 0400 hrs local in UK), the commander contacted the operator's flight dispatch department in the UK by mobile telephone, requesting that the figures be calculated using the Airbus Flight Operations Versatile Environment (FOVE) computerised system. The dispatcher taking the call in the UK and the commander reported that the telephone reception had been good and that communications had been clear. Information was passed by the commander to the dispatcher in order for the performance figures to be calculated using the FOVE system and these figures were then read back to the commander. The telephone was then handed to the operating co-pilot to repeat this process as a cross-check. The commander and co-pilot stated that they both received the same takeoff performance figures and that these were entered into the Flight Management Guidance System (FMGS).

The remainder of the pre-flight preparation was completed without incident and all three pilots briefed for the departure from Runway 07. The brief included a review of the performance figures entered into the FMGS, none of which the three pilots considered abnormal for the aircraft's planned weight.

Takeoff was commenced at 0426 hrs UTC with the commander acting as handling pilot. The aircraft appeared to accelerate normally and the co-pilot made the standard calls as the aircraft passed through 100 kt and then V_1/V_R. The commander was surprised by how close the calls had followed on from each other. On hearing the co-pilot call 'rotate' he pulled back on his sidestick and pitched the aircraft to about 10° nose up but stated that the aircraft 'did not feel right' and instinctively selected TOGA power. The aircraft then became airborne and climbed away.

Having completed the after-takeoff checks the crew discussed the incident and decided to check the takeoff performance figures by reference to the generic performance data contained in the FCOM 2 Manual carried on the flight deck. This revealed significant differences in the performance data derived from the manual to that used for the takeoff.

The flight continued without further incident and, during the final descent, the aircraft's performance manual was found. It had been incorrectly stowed amongst some navigation charts.

Airport information

The Montego Bay / Sangster International Airport has one runway designated 07/25. Takeoff Run Available (TORA) for Runway 07 is 2,663 m with an Accelerate/ Stop Distance Available (ASDA) of 2,724 m and an upslope of 0.03%.

Reduced thrust takeoff

Certain aircraft can optimise the engine thrust used during takeoff by using less than the maximum thrust available. This reduces engine wear whilst providing sufficient power to achieve takeoff under the prevailing conditions. On Airbus aircraft this is referred to as 'FLEX'. The takeoff power is adjusted by entering an artificial outside air temperature (OAT) into the FMGS. The OAT is calculated from the aircraft configuration and airport weaher conditions, and is referred to as the 'FLEX temperature'. When the throttle levers are advanced to the FLX/MCT (FLEX / Maximum Continuous Thrust) position, the autothrottle system commands the reduced thrust. The higher the FLEX temperature used, the lower the thrust generated.

Operator's FOVE takeoff performance calculation procedure

Each of the operator's Airbus aircraft carried a performance manual containing tabulated data which allowed the crew to determine takeoff performance. Flight crews were also able to contact the operator's dispatch office, based in the UK, to request performance data calculated using the FOVE system. As this gives more accurate performance figures it is generally used on occasions where takeoff performance is more limiting.

Instructions and procedures on the use of the FOVE computer system were contained in the operator's Flight Support Procedures Manual. This manual was intended for use by ground staff only. Flight crews were not provided with a comparable written procedure documenting their role in obtaining FOVE performance figures from their dispatch office.

The FOVE system required the user to input aircraft data, including the takeoff weight, weather conditions and runway information, prior to it computing the relevant performance data. The calculated data produced included the V_1, V_R and V_2 speeds as well as any permitted reduction in takeoff thrust, expressed as the FLEX temperature. It was also capable of calculating the aircraft's Green Dot[1] speed. The aircraft's FMGS also calculates the Green Dot speed independently of the performance figure provided by FOVE, and so this could be used as a gross error check, provided that the same takeoff parameters were input to both systems. The function to calculate the Green Dot speed had, for an unknown reason, been disabled on this operator's FOVE system and they had no procedure requiring the FOVE-generated Green Dot speed to be passed to crews.

In addition the system displayed any specific takeoff emergency procedures required for the departure being used. However, the operator's procedure did not specify the requirement to pass any emergency turn procedures to the crew as part of the performance calculation process as this information should be available to the crew in the onboard performance manual. In this event, the crew of G-OJMC could not find this manual.

The procedure published in the operator's Flight Support Procedures Manual required the dispatcher to obtain the input figures from the crew and enter them into the FOVE computer. Once the performance figures had thus been computed he would then read back the input figures to one of the crew members as a crosscheck, followed by the performance figures. He would then request to speak to the other crew member and would in turn hand the FOVE computer over to the other dispatcher on duty for the whole process to be repeated.

If the dispatcher was on duty on his own he was required to contact the duty pilot, who had his own FOVE computer, to carry out the second calculation. In this way two independent sets of performance figures were generated using two sets of input data. Once the entire procedure was complete the two pilots compared the performance figures they had independently obtained and, provided they were consistent, these were then entered into the FMGS.

The dispatcher logged the input information and performance output on a logsheet, which was retained as a record. However, there was no standard method or requirement for the flight crew to record either the performance figures or the information used to derive it as part of the flight documentation.

The FOVE procedure did not appear in any flight crew documentation. A flight crew air safety report, raised in August 2008, questioned the procedure for cross-checking performance data, because the procedure was alleged to be open to interpretation. The report was passed to the relevant department for comment but none had been received at the time of this incident.

Footnote

[1] The single engine target speed in the clean configuration, being approximately the best lift to drag ratio speed.

FOVE performance calculation

The telephone conversations were not recorded and it has not been possible to determine exactly what information was passed between the crew and dispatcher. Two dispatchers were on duty at the time, but only one was in the dispatch office when the call was made and only he processed the data. He did however speak with both pilots and confirmed the input data and performance data with each.

The data recorded by the dispatcher in the FOVE performance log are shown in Table 1.

As noted above a takeoff mass (TOM) of 120,800 kg was recorded on the performance log, although the true TOM recorded on the aircraft's loadsheet was 210,183 kg. When recalculated using the correct TOM, this gave the following output conditions shown in Table 2.

Input Conditions		Output Conditions	
Date	28 October	Flex	63°
A/C reg	G-OJMC	V1	114 kt
Runway	07	VR	114 kt
Wind	0 kt	V2	125 kt
OAT	27°C	Config	2
QNH	1015	Perf limit wt	236,893 kg
TOM	120,800 kg		
Config	Optimal		
Air Conditioning	Off		
Anti ice	Off		
Rwy cond	Dry		
Thrust option	TOGA		

Table 1

Flex	50°
V_1	136kt
V_R	140kt
V_2	147kt
Config	2
Perf limit wt	236,893kg

Table 2

Duty periods

Flight crew

The commander had ended an eight-day period of leave on 24 October during which he had been attending to a sick family member. He was at home on standby on 25 October, but was not called.

The operating co-pilot had returned from a long-haul trip on 22 October. He then had three days off.

The supernumerary pilot had been off on 22-23 October. The following day he had attended a two hour office meeting at his home base and was at home on standby on 25 October, but was not called.

All three crew members had flown out to Jamaica on the 26 October. The flight had departed the UK at 0938 hrs UTC (0938 hrs local) and had arrived at 1945 hrs UTC (1445 hrs local). The commander and co-pilot operated the flight and the training captain had positioned on the same aircraft as a passenger.

The return flight was due to depart at 0005 hrs UTC (1905 hrs local) on 28 October but, due to the delayed arrival of the inbound flight, the departure was rescheduled for 0400 hrs UTC (2300 hrs local). The crew was notified of this change at about 1530 hrs UTC (1030 hrs local).

Dispatcher

The dispatcher had been off sick from 22-24 October. He had then worked from 0700 hrs UTC to about 1730 hrs UTC on 25 October. He next reported for duty at 1850 hrs UTC on 27 October for a planned 12 hour shift. From a subsequent interview it was apparent that he had not fully recovered from his period of sickness when he returned to work.

Electronic flight bags (EFBs)

With the advent of 'less paper' and 'paperless' cockpits came a variety of devices which allow flight crews to access documentation and information electronically. In 2003, the JAA issued Technical Guidance Leaflet (TGL) 36[2] which provides guidelines to cover airworthiness and operational criteria for the approval of EFBs.

An EFB is defined in TGL 36 as:

> *'An electronic display system intended primarily for flight deck or cabin use. EFB devices can display a variety of aviation data or perform basic calculations (e.g. performance data, fuel calculations etc.)'*

Under these guidelines, the operator's FOVE system was classified as a Class 1 hardware and Type B software EFB. Such a configuration does not require airworthiness approval but TGL 36 outlines an operational approval process to ensure the fidelity and reliability of the system, which should be undertaken with the appropriate airworthiness authority. Included in this operational approval process are details of the flight crew training required, and procedures for crosschecking of data entry.

Work is in progress to supersede TGL 36 with an EASA Acceptable Means of Compliance (AMC 20-25). As of July 2009, this was still in draft form and the Notice of Proposed Amendment (NPA) action under the EASA rulemaking procedures is pending.

Footnote

[2] JAA Temporary Guidance Leaflet No 36 – *Approval of Electronic Flight Bags (EFBs)*.

Recorded Information

Due to the length of the flight between Montego Bay and the UK, the Cockpit Voice Recorder (CVR) had been overwritten. However, the Flight Data Recorder (FDR) had recorded over 53 hours of operation and captured the incident flight.

The recording started with the aircraft taxiing to Runway 07, arriving at the threshold at around 04:26:25 hrs. Just prior to takeoff, the FDR recorded a gross weight of 210,338 kg, CG position of 30% Mean Aerodynamic Chord (MAC) and a FLEX temperature of 63°C. The slats and flaps were extended in CONF 2 and the air conditioning packs were selected to OFF for takeoff.

Takeoff commenced after the aircraft was lined up, with the thrust levers advanced to the FLX/MCT position and the commander's side stick pushed forward to around 4 degrees (maximum travel is ±16 degrees) to command a slight nose-down pitch. Both engines increased to 82% N_1 and the aircraft began accelerating, achieving a longitudinal acceleration of around 0.16g.

Data presented in Figure 1 shows recorded aircraft parameters plotted with respect to the G-OJMC's estimated position on the runway. As the aircraft latitude and longitude was only recorded every four seconds, position on the runway was established by integrating the longitudinal acceleration and assuming that the aircraft started rolling at the runway threshold.

As the aircraft accelerated through an airspeed of 116 kt, over a two second period, the commander pulled back on the sidestick to -14.8° to command the aircraft to pitch up. Figure 1 shows this command was then reduced to -10.6° and then back up to -15.5° over the next second. The nose gear left the ground three and a half seconds after the pitch up command began, at an airspeed of 125 kt. The commander then reduced the sidestick position to around -9° pitch up command but the aircraft pitch attitude continued to increase.

Ten and a half seconds after the initial pitch up command, as the aircraft accelerated through 138 kt, the main landing gear was still on ground and the commander applied a further pitch up command by pulling fully back on the sidestick to -16.3°. Two seconds later as pitch attitude increased further, the main landing gear squat switches registered that the main gear had extended. The pitch attitude at this time was 10.2°, airspeed 143 kt and the approximate runway distance covered was 2,086 m. Maximum aircraft pitch attitude on the ground with the main gear compressed was recorded as 9.5° nose-up.

As the aircraft became airborne, the thrust levers were advanced to the TOGA position and the recorded engine N_1 increased to 91%. Aircraft pitch attitude continued to increase until, at a radio altitude of 40 feet and 13.4° pitch up, the commander pushed the sidestick forward to 5.6°. By 50 feet radio altitude, the aircraft had covered an estimated distance of approximately 2,500 m since the start of the takeoff roll.

Aircraft performance

With the lower aircraft acceleration provided by a lower thrust from the engines, the aircraft will require more runway length to achieve a given speed than if the engines were producing full thrust. With more runway used up, the distance available in the event of a rejected takeoff is then reduced.

Using a 63° FLEX temperature and takeoff weight of 210.4 tonnes, the aircraft manufacturer calculated that in the event of a rejected takeoff at V_1 with all engines operative, the required Accelerate-Stop Distance (ASD)

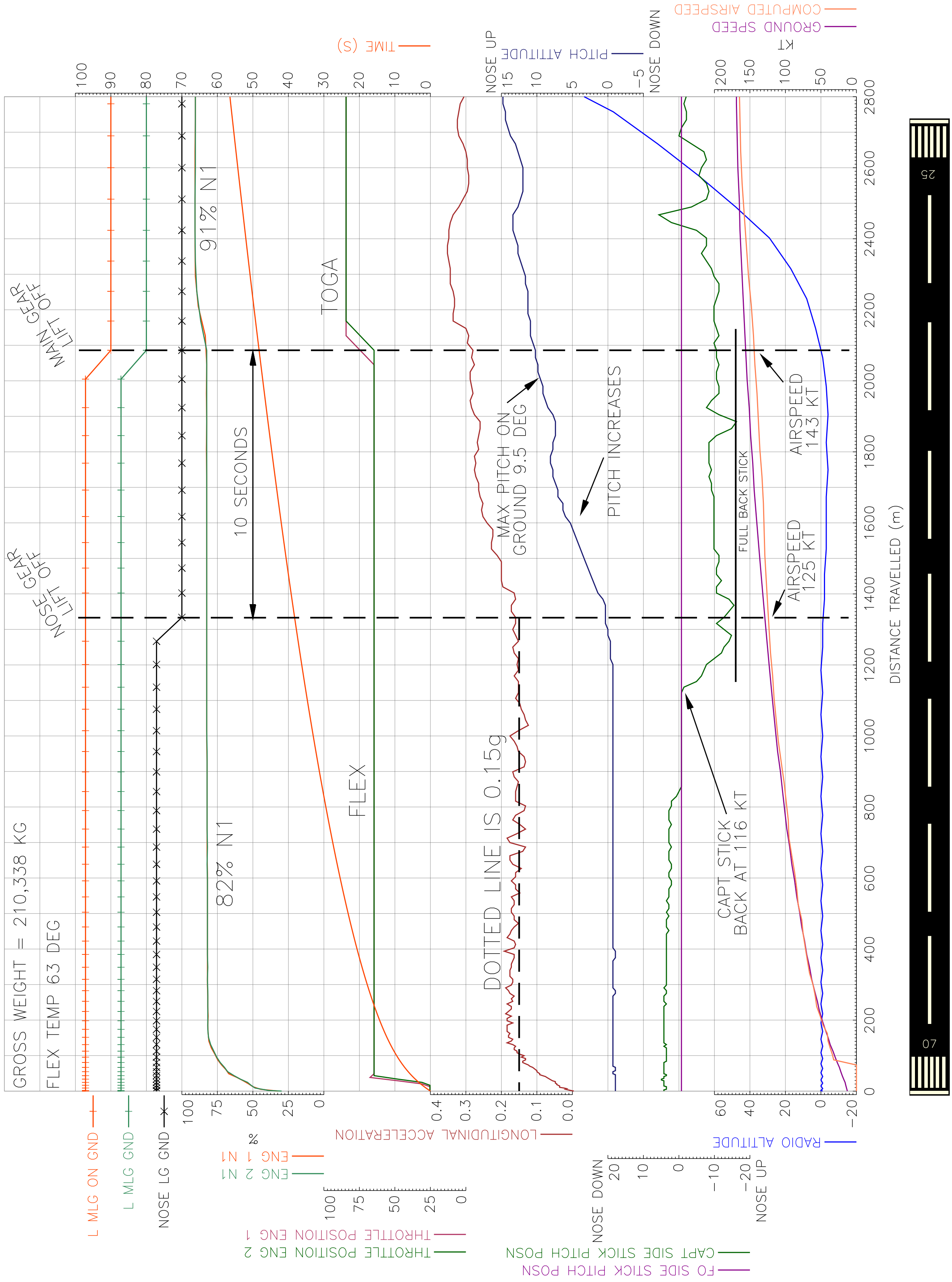

Figure 1

Relevant G-OJMC FDR Parameters

would have been 1,828 m. In wet conditions this would have increased to 2,082 m.

Previous occurrences and studies

Transportation Safety Board (TSB) of Canada, 9G-MKJ investigation

On 14 October 2004, an aircraft registered 9G-MKJ attempted to take off from Runway 24 at the Halifax International Airport. The aircraft overran the end of the runway for a distance of 825 feet, became airborne for 325 feet, and then struck an earth bank, killing all on board. The accident was investigated by the Transportation Safety Board (TSB) of Canada whose report[3] included in its conclusions that it was likely that an incorrect aircraft weight was used to generate takeoff performance data. This resulted in incorrectly calculated takeoff speeds and a thrust setting which was too low to enable the aircraft to takeoff safely for the actual aircraft weight.

The report also stated that:

> *'Once the take-off began, the flight crew did not recognize that the aircraft's performance was significantly less than the scheduled performance until they were beyond the point where the take-off could be safely conducted or safely abandoned.'*

As a consequence of this accident, TSB Canada issued a number of recommendations including recommendation A06-07:

> *'the Board recommends that:*
>
> *The Department of Transport, in conjunction with the International Civil Aviation Organization, the Federal Aviation Administration, the European Aviation Safety Agency, and other regulatory organizations, establish a requirement for transport category aircraft to be equipped with a take-off performance monitoring system that would provide flight crews with an accurate and timely indication of inadequate take-off performance.'*

The Canadian Department of Transport (Transport Canada) was the only organisation required to respond to this recommendation from the TSB. Their response was:

> *'It is agreed that if a Take-off Performance Monitoring System could be designed to function as intended, it could provide a significant safety benefit, however in order for Civil Aviation Authorities to establish a requirement for aircraft to be equipped with a take-off performance monitoring system, an acceptable system would have to exist. Transport Canada is not aware of any certified system that is available at this time to meet this recommendation.'*

Transport Canada also cautioned that such a system may create a greater hazard through spurious warnings resulting in unnecessary high-speed rejected takeoffs and stated that such a system would have to demonstrate a high reliability.

Since the initial response, work has progressed between Transport Canada and the TSB with Transport Canada forming a cross-disciplinary project team. Objectives of

Footnote

3 Transportation Safety Board of Canada Aviation Investigation Report No A04H004,

this team include establishing what remains to be done before a certifiable Takeoff Performance Monitoring System (TPMS) could be made available, consulting with industry to gauge their interest in a TPMS solution, and working with industry to bring about a certifiable system. By April 2009, none of these objectives had been achieved and progress was limited.

In response to the 9G-MKJ accident report, the JAA issued a Safety Information Circular (SIC)[4] highlighting the importance of crosschecking EFB output, independent calculation and gross error checks. It also detailed suggested improvement to EFBs to prevent incorrect data from previous flights being used.

AAIB G-OOAN investigation[5]

During takeoff out of Manchester Airport on the 13 December 2008 a Boeing 767, registration G-OOAN, suffered a tailstrike. After dumping fuel, the aircraft safely returned to Manchester. Takeoff speeds had been calculated using a computer-based tool, into which the crew had inadvertently entered the Zero Fuel Weight instead of the aircraft takeoff weight, a difference of 54.4 tonnes. Subsequent takeoff speeds were in the order of 20 kt lower than they should have been.

During the takeoff, the commander delayed the V_1 call by 10-15 kt due to a "sluggish" acceleration which he felt was due to the aircraft being heavier than calculated.

Australian Transportation Safety Board (ATSB) A6-ERG investigation

On the 20 March 2009, during takeoff from Melbourne Airport in Australia an A340-500, registration A6-ERG, suffered substantial tailstrike damage. It also damaged some lights and the instrument landing system at the airport. The preliminary report[6] issued by the ATSB detailed that a takeoff weight 100 tonnes lower than the actual aircraft takeoff weight was inadvertently used by the flight crew during takeoff performance calculations. The result was the use of a thrust setting and takeoff speeds lower than that required for the actual aircraft weight and a tailstrike occurred during rotation.

CAA Mandatory Occurrence Report (MOR) data

A search of the CAA MOR database for performance related incidents during takeoff covering the ten-year period prior to this incident revealed 26 relevant events.

- Eight cases related to the aircraft being significantly heavier than the loadsheet figure used to calculate the performance.
- Four cases involved aircraft performance being calculated remotely from the aircraft, the incorrect figure then being passed to the crew prior to departure via ACARS. These cases did not involve a system of crosschecking between the crews and those carrying out the calculations.
- Four cases involved deficiencies in performance and airfield charts intended for use in calculating aircraft performance. These were all identified prior to takeoff, although it is not known whether they were used to produce erroneous data during previous flights.
- Three cases identified failings in the design of the Flight Management Computer (FMC) on one aircraft type which allowed the commander's and co-pilot's FMCs to display

Footnote

4 JAA SIC No 7, 15 August 2006.
5 AAIB Report EW/G2008/12/05, July 2009 Bulletin.

Footnote

6 ATSB report AO-2009-012, Issued 30th April 2009.

different figures. This was discovered when a weight change was programmed into one FMC which was not then reflected in the other.

- Three cases were due to engine problems resulting in reduced thrust being available, but which were not necessarily reflected in specific warnings to the crew.
- Two cases resulted from ice accretion causing degraded performance.
- One case was due to the crew misinterpreting Minimum Equipment List (MEL) performance requirements as a result of a technical failure.
- One case was due to the crew entering incorrect data into the FMC.

Study into performance errors at takeoff

In 2008, the BEA[7] issued a report titled '*Use of Erroneous Parameters at Takeoff*'[8] which was instigated after two serious incidents in France involving early rotation and a subsequent tailstrike on takeoff. Both events were caused by use of incorrect aircraft weight at takeoff with consequential incorrect calculations of thrust and takeoff speeds. The effect in each case was that the aircraft attempted to take off using incorrect performance parameters.

The report included analyses of the accident involving 9G-MKJ and of a further 11 incidents involving tailstrikes or crew perceptions of a reduced performance on takeoff.

Footnote

[7] Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile, the French equivalent of the AAIB.

[8] Use of Erroneous Parameters at Takeoff, DOC AA 556/2008, May 2008, available on the BEA website.

Conclusions of this report included the fact that errors relating to takeoff data are frequent and that the use of the appropriate aircraft weight is a key factor in calculation of the correct takeoff parameters. Time pressure and interruptions as the departure time approached were cited as common factors in contributing to errors. In several of the cases, crews perceived abnormal aircraft behaviour during the takeoff and took action.

Takeoff performance monitoring systems

Once the takeoff data has been calculated and programmed into an aircraft's flight management system, no additional takeoff performance monitoring is undertaken by the aircraft while accelerating down the runway. In the case of G-OJMC and in a number studied in the BEA report, the flight crew suspected that the takeoff performance was abnormal and took action.

The concept of TPMS has been the subject of a number of studies. The systems operate on the principle of monitoring aircraft acceleration and comparing it against the expected acceleration for the given aircraft configuration and airfield conditions. Beyond this, dynamic systems, using aircraft position and the remaining runway available, can continuously calculate whether sufficient runway remains available for safe takeoff or for a safe rejected takeoff. Such a system could help flight crews decide if the takeoff performance is somehow abnormal.

Concerns have been raised with such systems that spurious warnings may lead to unnecessary high-speed rejected takeoffs with their associated risks. However, the benefits of such a system are the ability to provide a timely alert in the event of unexpected takeoff performance and that its calculations could be made independent of data entered by flight crews.

Airbus developments

The aircraft manufacturer confirmed that, as part of ongoing system improvements, studies are underway looking at improvements to the FMGS to help prevent flight crews entering erroneous takeoff data. These improvements include identifying out-of-range weight entries and takeoff speeds, and are designed to capture incorrect crew entries prior to takeoff. The manufacturer has recently certified a system known as 'Brake to Vacate' (BTV) on the A380. The primary function of this system is to be able to stop the aircraft next to a pilot-selectable runway exit after landing. This system also includes a function which monitors aircraft performance during deceleration with respect to runway position. If insufficient runway remains using a calculated deceleration profile, the flight crew are advised and the system will automatically apply maximum braking. Currently the BTV function is available only during rollout following a landing and not during a rejected takeoff.

EASA activities

As part of this investigation, the EASA was contacted to obtain its views and current thinking on the topic of TPMS. Their response was that no direct work into such systems was underway. However, they were extremely forthcoming about future developments in EFB standards, recognising the continued improvements in sophistication and increased use of such devices. Also recognised were the safety implications of erroneous takeoff parameter input and the need for robustness in both EFBs and operational procedures.

Separately, as part of the EASA Rulemaking programme[9], work is underway into ascertaining the 'real' weight and balance of aircraft with a view to reducing the number of accidents and incidents involving incorrect load data and loading.

Footnote

[9] EASA 4-year Rulemaking Programme 2009-2012 items OPS.036 (a) and (b).

Analysis

Operational factors

Whilst it has been determined that the crew used incorrect performance speeds and thrust setting for the takeoff, it has not been possible to determine the exact cause of the error. It is apparent that the operator's procedures were not followed in full, and that the operator's FOVE system had been set up in such a way that an important crosscheck designed into the system was not available to those using it.

The crew were all able to describe the normal range of takeoff speeds and FLEX temperatures they would expect to see for such a takeoff, the figures actually used falling some way outside this range. The crew were, in theory, well-rested although there had been disruption to the flight's departure time. It is likely that the mental performance of all those involved would have been affected by being at a low point in their circadian rhythm at the time of making the performance calculations. However, these circumstances are not exceptional for crews, especially on long-haul flights where time differences will be a factor.

The crew were unable to explain why they did not recognise that the figures they used were outside the expected range, and it is considered possible that other crews, especially those less experienced or less rested, might be expected to make a similar oversight.

As a result of this incident the operator has reconfigured its FOVE system to incorporate the Green Dot calculation function. They have revised the ground staff instructions to include this function and to ensure pilots are passed any emergency turn information. A notice has also been issued to flight crews notifying them of the FOVE procedure to be used, including the need to crosscheck the Green Dot speed calculated by FOVE with that calculated by the aircraft's FMGS.

Aircraft performance

With an incorrect aircraft weight entered into FOVE, the calculated V_1 and V_R speeds were too low for the takeoff at Montego Bay. In terms of available runway length, the effect of using an incorrect FLEX temperature was less significant as calculation demonstrated that, in this instance, sufficient runway was available for takeoff even at the lower thrust setting. In addition, despite taking longer to accelerate, the lower V_1 speed would have allowed sufficient runway remaining should a rejected takeoff have been necessary.

The FDR shows a rotation speed of 116 kt which, for this aircraft configuration, meant that insufficient lift was available to allow the aircraft to lift off and accounted for the sluggish aircraft rotation recognised by the commander. As the main landing gear left the runway, the aircraft was accelerating through 138 kt towards the correct V_R of 140 kt and the selection of TOGA thrust increased that acceleration.

A tailstrike was avoided in this event as aircraft pitch attitude reached a maximum of 9.5° whilst the main landing gear shock absorbers were compressed; 11.5° of pitch would have been required for the tail to contact the runway.

Takeoff performance monitoring

Throughout the course of this investigation, numerous other takeoff incidents, similar to G-OJMC, were identified. These incidents occurred despite having procedural safeguards in place, such as independent crosschecking. The number of incidents of this type has been recognised by the aircraft manufacturer and the EASA who have embarked on projects to reduce the likelihood of incorrect takeoff parameters being used.

All current improvement work focuses on EFB procedural robustness and reducing the probability of incorrect data being input into flight management systems before takeoff. However, once this takeoff data has been input, no additional independent analysis is performed on-board to establish whether that data is consistent with the aircraft configuration and airfield conditions.

In a number of the cases, flight crews successfully identified some kind of performance abnormality during takeoff. However, this may not always be the case due to a number of factors including high crew workload, the range of aircraft operating conditions and subtle margins of under-performance. This was the case during the 9G-MKJ incident in Canada which ended up in fatal injuries being sustained by all on board.

A system which actively monitors takeoff performance can add an additional safety net, independent of data input by flight crews. However, despite being identified as having a positive impact, little or no progress has been made in the development of takeoff performance monitoring systems in recent years. Such a system would require a high level of maturity before being introduced to avoid unnecessary and potentially unsafe crew actions.

As a consequence, the following recommendations are made:

Safety Recommendation 2009-080

It is recommended that the European Aviation Safety Agency develop a specification for an aircraft takeoff performance monitoring system which provides a timely alert to flight crews when achieved takeoff performance is inadequate for given aircraft configurations and airfield conditions.

Safety Recommendation 2009-081

It is recommended that the European Aviation Safety Agency establish a requirement for transport category aircraft to be equipped with a takeoff performance monitoring system which provides a timely alert to flight crews when achieved takeoff performance is inadequate for given aircraft configurations and airfield conditions.

INCIDENT

Aircraft Type and Registration:	Airbus A330-323X, N270AY
No & Type of Engines:	2 Pratt & Whitney PW4000 SER turbofan engines
Year of Manufacture:	2000
Date & Time (UTC):	29 May 2008 at 1025 hrs
Location:	Manchester Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 12 Passengers - 250
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to main landing gear and brake pack; debris recovered from runway
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	60 years
Commander's Flying Experience:	14,650 hours (of which 2,390 were on type) Last 90 days - 58 hours Last 28 days –26 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft suffered a loss of Engine Pressure Ratio (EPR) information for the left engine during the takeoff roll. The takeoff was rejected at about 120 kt. During the deceleration the brake reaction rod on the left main rear (No 5) wheel was released from its mounting, the brake pack rotated and caused damage to the brake hydraulic lines. The aircraft was decelerated to taxi speed and taxied clear of the runway to a parking area. During taxi two tyres deflated and most of the contents of the Green hydraulic system were lost.

The investigation found that the pin attaching the brake reaction rod to the brake unit had suffered an overload failure; evidence suggested that it was in a weakened condition following an earlier, unidentified event. The EPR problem was the result of a failure in a pressure-sensing tube that supplied the FADEC on the No 1 engine.

History of the flight

The aircraft was scheduled to carry out a flight from Manchester, UK, to Philadelphia, USA. There were three pilots operating the flight; the commander was the Pilot Not Flying (PNF) and was seated in the left hand seat. The co-pilot was a company-qualified captain acting as Pilot Flying (PF) in the right hand seat. The first officer was on the jump seat acting as third pilot.

The weather conditions were fine: the surface wind was calm and the temperature was 16ºC. The aircraft taxied uneventfully to holding position T1 for Runway 23L. It was cleared for takeoff from Runway 23L at 1013 hrs and the takeoff roll commenced shortly afterwards.

The PF selected the thrust levers to the FLX (flex) position; a reduced takeoff thrust temperature of 45ºC had previously been entered in the Flight Management Guidance System (FMGS). As the aircraft started to accelerate an ECAM (Electronic Centralised Aircraft Monitoring) caution was generated. The crew later recollected it to have been either AUTO FLT A/THR LIMITED or ENG THR LEVERS NOT SET. The PF, thinking that perhaps one or both thrust levers was not exactly in its detent, selected TOGA thrust on both engines. An ECAM caution ENG 1 EPR MODE FAULT, was then observed. There was some discussion between the pilots after which the commander decided to reject the takeoff and he assumed control, in accordance with the airline's Standard Operating Procedures (SOPs). A rejected takeoff (RTO) from a groundspeed of around 120 kt was carried out; the aircraft reached a groundspeed of 130 kt before the speed decreased. The aircraft slowed to taxi speed and was turned off the runway at the next available exit ('W1') and onto Taxiway 'Y' where it was brought to a stop.

After reviewing the aircraft's status the commander decided to return to the parking area and seek maintenance assistance. They requested taxi instructions from ATC on the tower frequency and the aircraft was taxied back along the runway and vacated at 'VD'. While on the runway ATC advised the crew that there was some smoke around the left main landing gear and asked if assistance was required. The crew replied that they would continue and that the brakes were warm.

A runway inspection was carried out during which debris was found; ATC were informed by the inspection vehicle on the tower frequency. The aircraft continued to taxi back towards the terminal area; as it did so the crew noted a very high indication for the No 1 brake temperature. They then saw indications of a loss of hydraulic fluid from the Green system and loss of pressure from one tyre. They decided not to continue to the terminal area but requested directions to a brake cooling area where the aircraft could be checked by the Airfield Fire and Rescue Service (AFRS). ATC instructed the aircraft to wait on the taxiway initially, and then directed it to taxi ahead to hold at A6. The commander, aware that a slow taxi with one wheel deflated was allowed, accepted the clearance and moved ahead slowly. The aircraft was brought to a stop near A6, next to an engine test bay area.

The AFRS attended, checked the aircraft and communicated with the crew on the dedicated frequency of 121.6 MHz. The passengers remained on board the aircraft until it was considered safe to bring the steps and start the disembarkation.

Aircraft information

The aircraft mass at takeoff was calculated at 469,472 lbs; the maximum takeoff mass allowed was 508,400 lbs. Flaps 1 was selected for takeoff, the calculated V_1 speed was 148 kt IAS. Autobrake setting MAX was selected before takeoff.

A dedicated FADEC controls the thrust for each engine; thrust setting is normally made through control of the Engine Pressure Ratio (EPR). If no EPR is available (either sensed or computed) the FADEC automatically reverts to N1 (fan speed) mode. In this case the ENG EPR MODE FAULT ECAM caution is generated to indicate that the FADEC has reverted to N1 mode and autothrust is no longer available. This caution is inhibited during the takeoff when the groundspeed is greater than 80 kt until after the aircraft is airborne.

The autobrake system is armed for takeoff by selecting the MAX push-button. If the autobrake is armed, braking will be commanded automatically if an RTO is initiated above a groundspeed of 72 kt. If an RTO is initiated when the groundspeed is below 72 kt, the pilot must apply braking manually.

The Flight Crew Operations Manual (FCOM) offers guidance to pilots regarding when the decision to reject or continue a takeoff should be made. The decision-making process is assisted by the use of a recommended speed of 100 kt as an interim decision point. Below 100 kt the advice provided is:

> *'the captain should seriously consider discontinuing the take-off if any ECAM warning/caution is activated.'*

Above 100 kt the advice is:

> *'the captain should be go-minded and very few situations should lead to the decision to reject the take-off.'*

There are a number of examples of situations listed that should lead to a rejected takeoff, including:

> *'any amber ECAM caution of the ENG system.'*

Description of brakes and main landing gear

The Airbus A330 main landing gear is of a conventional design, with a bogie beam attached to each landing gear leg and a brake pack for each wheel.

The brakes are of the carbon multi-disc type and are operated by one of two independent hydraulic systems: the 'Normal' brakes are supplied from the Green hydraulic system, with the 'Alternate' brakes using the Blue system. Anti-skid and autobrake functions are also provided. Each brake unit consists of a housing, which contains the hydraulically-operated pistons, and a heat pack containing the rotor and stator discs. The housing and heat pack are mounted on a torque tube that surrounds the wheel axle. The stator discs are keyed onto the torque tube and hence do not rotate, while the rotors engage with the inside of the wheel and thus rotate with the wheel.

During brake operation, hydraulic pressure causes the pistons within the housing to apply axial pressure to the rotors and stators between thrust plates at either end of the heat pack. This results in a torque on the brake unit that is reacted by a steel rod attached, by means of a pin, to the brake housing at one end and a lug in the centre of the bogie beam at the other. The arrangement of these components can be seen in the diagram at Figure 1 and in the photographs of the aircraft at Figure 2, taken shortly after the incident.

The brake rod attachment pin, or torque pin, is inserted through the brake rod from the bogie beam side and passes through the brake housing. It is retained by an end cap, which is itself retained by a cross-bolt, nut and split pin.

The brake reaction rod can be fitted at any wheel

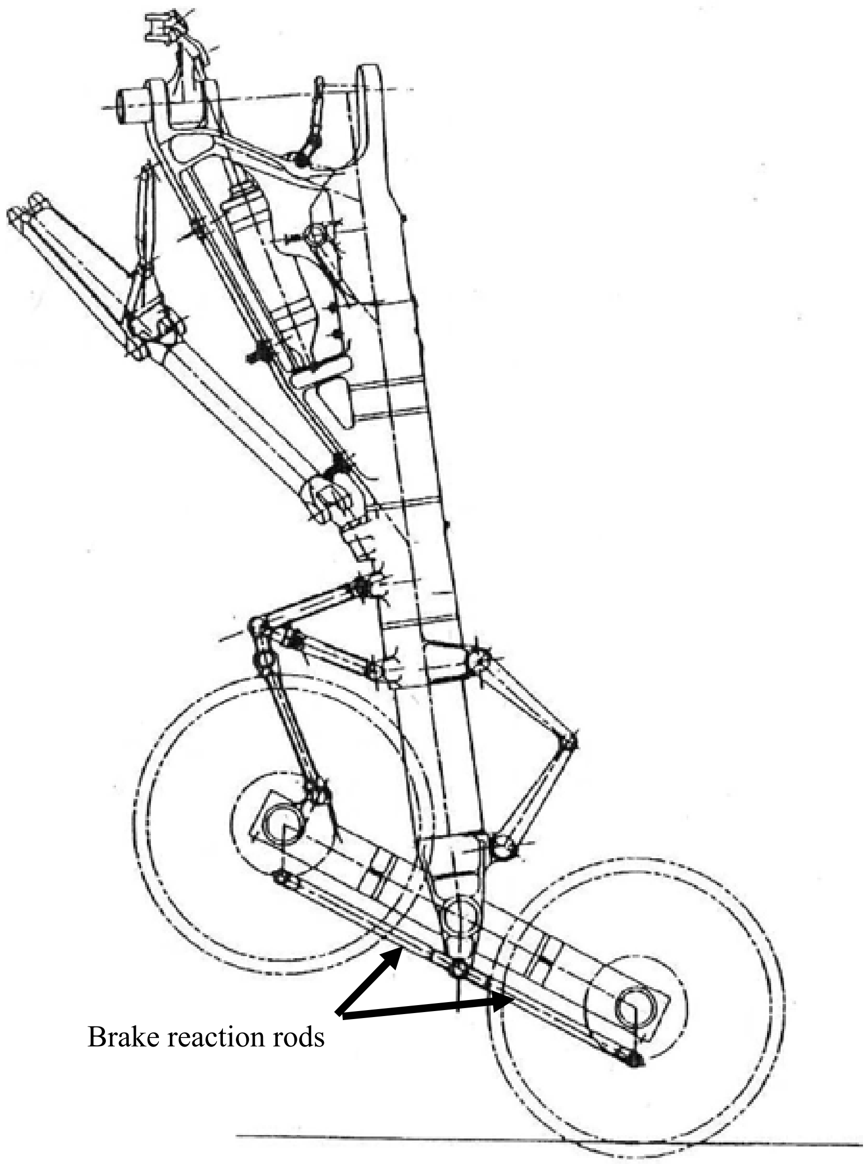

Figure 1

Main landing gear shown in 'flying attitude'

position. It will be appreciated, from a consideration of the geometry, that the rear axle brake rods are subjected to a tensile load during brake operation, while those at the front are placed in compression. The pin is loaded in single shear. The brake rods in each pair are linked together by a lanyard, which consists of a steel cable connected at either end to a clamp on each brake rod. This is a modification introduced by the landing gear manufacturer following an event in which an incorrectly installed pin, of a previous design standard, became detached during takeoff. The lanyard is designed to restrict movement of the brake rods in the event of a pin failure.

Figure 3 shows a photograph of the unaffected right landing gear of N270AY, showing the layout of the components described above.

Figure 2

Views of the left landing gear. Note hydraulic fluid spillage

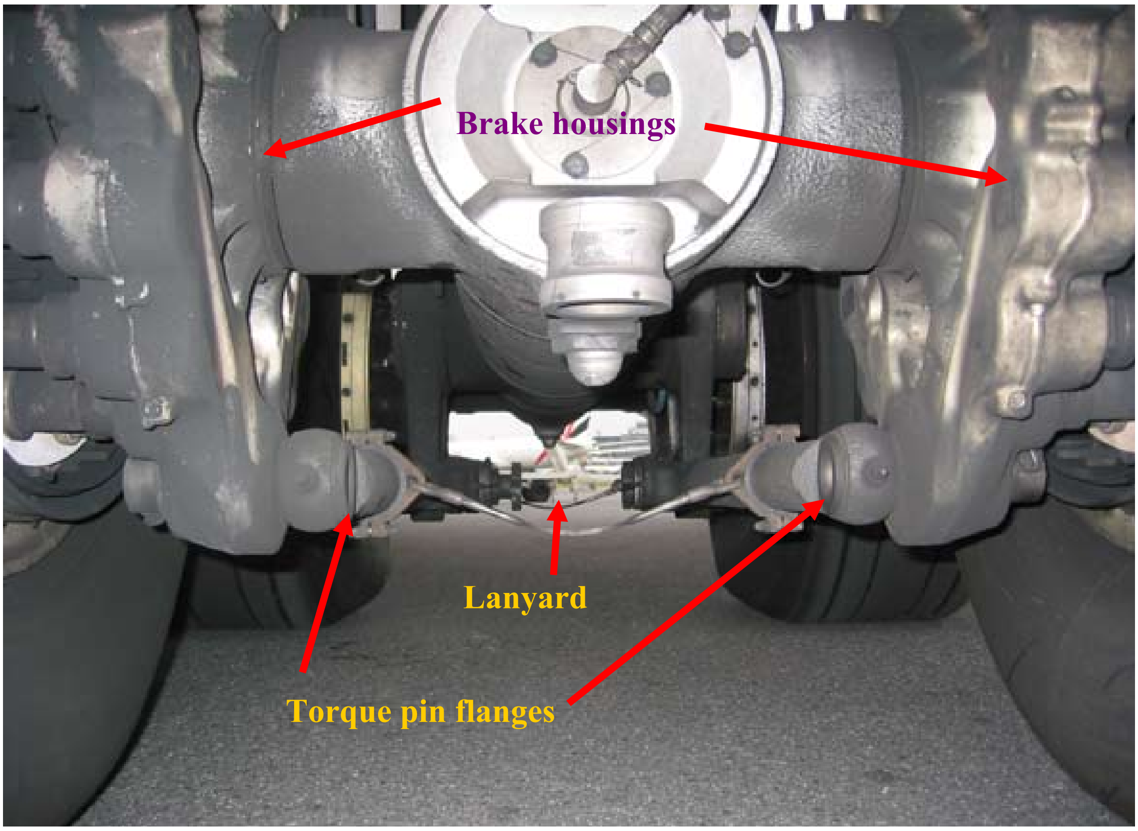

Figure 3

View looking forward on intact right landing gear, showing layout of components

Airport information

Runway 23 was inspected immediately after the event by the airport operator and some debris was found between consecutive turn-offs 'VC' and 'VD'. The aircraft had turned round at the end of the runway and backtracked before turning off at 'VD'; it did not backtrack the area between 'VC' and 'VD', thus confirming that the debris on the runway was shed from the aircraft during the RTO, as opposed to taxiing back. At the time of the runway inspection the origin of the debris was not certain, but the information that some had been found was broadcast on the tower frequency. This would have enabled the pilots of N270AY to hear the information.

Recorded information

The aircraft was fitted with a Flight Data Recorder (FDR) capable of recording a range of flight parameters into solid state memory. A Cockpit Voice Recorder (CVR) recorded crew speech and cockpit area microphone (CAM) inputs, also into solid state memory; this consisted of 120 minutes of combined crew speech recording, and area microphone, together with 30 minutes of separate channel, higher quality recordings. Both recorders were downloaded at the AAIB and data and audio recordings were recovered for the incident.

An extract from the CVR transcript is shown in Table 1.

ELAPSED TIME FROM TAKEOFF CLEARANCE (seconds) & SOURCE	INTRA-COCKPIT COMMUNICATION CONTENT
30.0 PF (HOT MIC)	FLEX
32.0 PNF (CAM)	SET
33.0 CAM	[sound of ECAM Caution]
35.0 PF (HOT MIC)	ERR LET'S GO TO MAX
39.0 PF (HOT MIC)	EPR MODE * FAULT LET'S CONTINUE CONTINUE CONTINUE
43.0 PNF (CAM)	WE'VE GOT NO WE'VE GOT NO EPR
46.0 PF (HOT MIC)	ERR WHAT DO YOU THINK
47.0 PNF (CAM)	* * * REJECT
48.0 PF (HOT MIC)	OK YOUR AEROPLANE
49.0 PNF (CAM)	MY AIRCRAFT
50.0 PNF (CAM)	REJECT

Unintelligible words are denoted by * and [ ] contains an editorial insertion.

Table 1

Extract from the CVR transcript

The FDR data show that prior to the aborted takeoff run, the aircraft was configured with Flaps 8°, a flex temperature of 45°C was selected, and Max Braking Mode was armed.

The brakes were released[1] ten seconds after the aircraft was cleared for takeoff, the thrust levers were advanced and the aircraft began accelerating along the runway. Both thrust levers reached the FLX position after 17 seconds with no recorded asymmetry, with an indicated EPR of 1.43 on each engine. Two seconds later, both the commanded and actual EPR parameters for the No 1 Engine showed NCD (Non Computed Data), indicating no available data. The aircraft's groundspeed at this point was about 45 kt. Shortly thereafter, the crew became aware of a problem, made the decision to select maximum thrust and advanced the thrust levers to the TOGA position. The aircraft's groundspeed at the time was about 70 kt.

Three seconds later, as the aircraft accelerated through 84 kt, the crew identified an "EPR MODE FAULT" and made the decision to "CONTINUE", before realising they had "NO EPR", subsequently electing to "REJECT" the takeoff. Over the nine seconds between identifying the EPR fault and rejecting the takeoff, the aircraft accelerated a further 40 kt to 124 kt ground speed, travelling about 900 m along the runway from the point of brake release.

Footnote

1 The FDR records two brake pressures each second: one from each undercarriage bogie. There are four brakes per bogie so the brake pressure for an individual brake is sampled every four seconds. The recorded resolution is 32 psi. The brakes are numbered 1-8 starting from the front-left wheel of the left bogie through to the front-right wheel of the right bogie (ie brakes 1-4), then left to right similarly for the back row of wheels (ie brakes 5-8).

Maximum braking was then applied for about three seconds during which the Max Braking Mode disarmed as the crew applied brake pedal pressure. The maximum brake pressure is not clear given the low brake pressure sample rate but is evident from the longitudinal deceleration. However, no increase in the brake pressure (from a nominal zero) was recorded for the No 5 brake. Coincident with the application of maximum braking, both thrust levers were brought back to idle, and into reverse five seconds later. A recorded maximum groundspeed of 130 kt was reached during the aborted takeoff.

As the aircraft decelerated, the commanded EPR for the No 2 Engine showed NCD for 12 seconds, during which the actual EPR for the No 1 Engine became available again.

After turning around at the end of the runway, the aircraft spent the next 16 minutes taxiing back towards the terminal, before a low pressure warning activated for the Green hydraulic system. Zero brake pressure was recorded for the No 5 brake throughout the taxi.

Examination of the aircraft

Post Flight Report

The Aircraft Condition Monitoring System (ACMS) monitors the aircraft systems and records any faults. These include ECAM messages and can be logged in the form of pre-programmed reports that can be printed out on the flight deck. In addition, the system can be interrogated on the ground for the purpose of generating Maintenance Reports. In this case the Post Flight Report (PFR) listed the 'ENG THR LEVERS NOT SET' message, together with the EPR mode fault for the No 1 engine. The maintenance pages had additionally logged a message: 'SENSE LINE P5 TO EEC', which referred to a sensing tube that supplied a reference pressure, used in calculating the EPR, to the Electronic Engine Control, or FADEC (see the next section of this report). There were also messages concerning the No 5 brake (normal system) servo valve and its associated brake temperature sensor. However, there were no messages that reflected the Green system hydraulic low-level warning.

Engine examination

On removing the No 1 engine cowlings, it was apparent that the sensing tube that fed the 'P4.95' pressure to the FADEC, thus allowing the EPR to be calculated, had failed. The failure had resulted in the complete separation of the tube immediately adjacent to a clamp that attached the tube to the engine casing. The failure appeared to be the result of fatigue in the unsupported length of tube between two clamps. The loss of pressure resulting from the tube failure accounted for the EPR Mode Fault that occurred during the takeoff roll.

Landing gear

The aircraft was initially examined by the AAIB on the evening of the day of the incident. It had not been moved from the position on the taxiway where the flight crew had brought it to a halt.

Upon examination it was immediately apparent that the brake unit on the No 5 wheel (ie rear left wheel on the left landing gear bogie) had become disconnected from its associated brake reaction rod as a result of the failure of the attaching torque pin. As a result, the brake unit had been free to rotate with the wheel, causing the consequent failures of the hydraulic hoses and electrical harness that were attached to it; these failures were responsible for generating the PFR and Maintenance Reports. The tension in the hoses had in turn caused the failure of a bracket/cable guide assembly that was mounted on the bogie beam. It was clear that these components had acted as a flail, causing marks on the side of the bogie beam and damage to a plastic, cruciform-shaped bearing retaining device at the central pivot on the bogie beam that attached front and rear left hand brake rods. The security of the bearing had not been compromised however. The detached part of the retainer was among the debris found on the runway. Other debris included pieces of the brake pin flange, two lengths of braided hose, the broken-off piece of bracket/cable guide and a bushing from the brake rod.

The No 1 tyre (ie the one ahead of the No 5 wheel) had deflated following the RTO as a result of the heat generated during the heavy braking, thereby causing the activation of the fusible plug in the wheel. It was subsequently noted that the No 6 tyre was showing only 65 psi, as opposed to the normal pressure of around 215 psi. It was found that the core within the fusible plug had melted but had resolidified before the tyre had become completely deflated. Otherwise, none of the tyres displayed any evidence of damage, such as skid-induced flats or cuts, that could have been attributable to the incident.

The operator dispatched a maintenance team to Manchester to repair the aircraft and prepare it for a ferry-flight to its maintenance base in the USA.

The first task was to remove the No 5 wheel and brake unit. As the wheel was removed from the axle, it was apparent that the two outermost stator discs had disintegrated. It was subsequently found impossible to remove the brake pack from the axle sleeve as a result of heat-induced distortion, with the heat being generated by brake-unit rotation on the sleeve following the torque pin failure. However, the sleeve had not rotated relative to the axle. The axle sleeve and brake unit were therefore removed as a complete item and subsequently taken for examination at the brake manufacturer's UK facility.

The brake rod attachment pin had migrated in an outboard direction within the brake housing to the extent that the end of the pin had been in contact with the wheel rim as it rotated; some swarf had been generated as a result. The pin had been able to move axially in the bore in the brake housing due to the fracture of the flange at the head end. The pin was removed by driving it out of the housing, following which it was subjected to specialist metallurgical examination.

It was found that the lanyard linking the two rear brake reaction rods (ie on wheel Nos 5 and 6) had broken, which had allowed the No 5 brake rod aft end to trail on the ground. A flat area had been ground away on the rod end as a result of contact with the runway/taxiway. It was unclear how the brake rod had been able to move the necessary distance to generate a significant tension in the lanyard, since upward and outboard movement is constrained by the close proximities of the axle housing and brake housing respectively. The only other visible damage to the brake rod was the inboard half-bushing at the aft end was missing; this was among the items recovered from the runway. The bushing and brake rod were subsequently returned to the landing gear manufacturer for additional investigation.

Examination of the brake unit

The examination of the brake unit at the manufacturer's UK facility was conducted in the presence of representatives from Airbus UK and the AAIB. The fragments from the broken stator discs were examined, with a lack of oxidation on the fracture faces indicating that they were recent and thus had probably broken during the RTO, as opposed to having been in that state for a number of landings.

The operator's records indicated that this brake pack was installed on the aircraft on 15 June 2006 and had achieved 1,260 landings at the time of the incident. The brake manufacturer stated that the average brake life for this operator for the fourth quarter of 2006 was 1,330 landings; thus the subject brake unit had achieved approximately 95% of this figure. During service, the disc thickness reduces as material is worn away in braking operation. The thickness of the broken discs was found to be in the range 0.496 to 0.510 in. The disc thickness of another brake unit, which had been returned to the overhaul facility, having reached the end of its service life, averaged 0.545 in.

The brake manufacturer noted that there had been previous occurrences of broken stator discs, but that these had invariably been associated with brake units that were nearing the end of their overhaul lives. As discs become thinner, they are less able to withstand the pressures associated with heavy braking. A modification is available to address the issue of stator disc strength; details are provided in manufacturer's service bulletin VSB 2-1577-32-10, issued in January 2007. This modification had not been implemented on N270AY.

The only other feature worthy of comment was the heat damage to the brake housing, with a small crack being visible at the inboard end of the bore where it fitted over the axle sleeve. In addition there was a small amount of what appeared to be solidified molten phosphor bronze emanating from the region of the bush between the housing and the axle sleeve. It was considered that this was the result of the friction that would have been generated as the housing rotated relative to the axle sleeve (and the bush) following the detachment of the brake pin.

It was concluded that the stator discs failed as a result of a combination of their worn condition and the stresses associated with maximum braking effort with a heavy aircraft. However, a brake pin failure is not an inevitable consequence of brake disc disintegration and it was unclear how the two failures could be connected.

Finally, the location on the runway of the debris indicated that the brake pin failed during the time the brakes were applied for the RTO. It is likely that the brake disc failure occurred either at the same time or shortly before, since, following the pin failure, the brake pack would have been rotating with the wheel and therefore unstressed.

Examination of the brake rod attachment pin (torque pin)

The brake pin was designed and manufactured by the brake manufacturer and was examined briefly at the brake manufacturer's facility prior to being subjected to a metallurgical examination by a specialist company. It was subsequently examined by the manufacturer in the USA.

The runway debris included fragments of the flange, from the head of the pin, amounting to about 50% of the circumference. The remainder was not recovered. Photographs of the pin and flange fragments in their 'as received' condition are shown at Figure 4.

Batch markings on the recovered portion of the flange indicated that the pin was among those potentially susceptible to hydrogen embrittlement and machining irregularities, and which had, according to the manufacturer, led to previous cases of in-service flange failure. This had resulted in changes to the pin manufacturing processes and the issue of related service

Figure 4

No 5 torque pin together with flange fragments that were found on the runway bulletins VSB 2-1577-32-7, issued in August 2004 and VSB 2-1577-32-8, issued in May 2005. However the metallurgical examination revealed no evidence of material or manufacturing defects, so the flange failure was due entirely to overload. However, part of the fracture face on the pin was found to be corroded (Figure 5), leading to the conclusion that the associated part of the flange had failed at an earlier date. Although it was not possible to estimate when this was likely to have occurred, it was noted that there had been minimal accumulation, on the fracture face, of the brake dust that had liberally coated adjacent components, suggesting a relatively recent event. Significantly, none of the recovered pieces of the flange were from the corroded area of the pin. This in turn suggested that the pin flange had failed in overload during the RTO, having been weakened in a previous event in which part of the flange had become detached. There was no evidence to indicate the nature of any previous event, although it was speculated that the failure of the lanyard that connected the two rear brake rods together might have been associated with that event.

Two axial cracks were evident in the pin at the fracture end and it was additionally noted that the pin was bent. It was considered that the pin was subjected to a bending action during the process of the flange failure, with the axial cracks opening up as a consequence of a crushing force applied across the diameter, imposed by the bores of the brake rod and/or housing.

The pin was manufactured from 300M steel, heat treated to 275-300 KSI (the ultimate strength, in thousands of pounds per square inch). The material was found to comply with this specification.

The brake manufacturer's metallurgical investigation of the pin essentially concurred with the above findings.

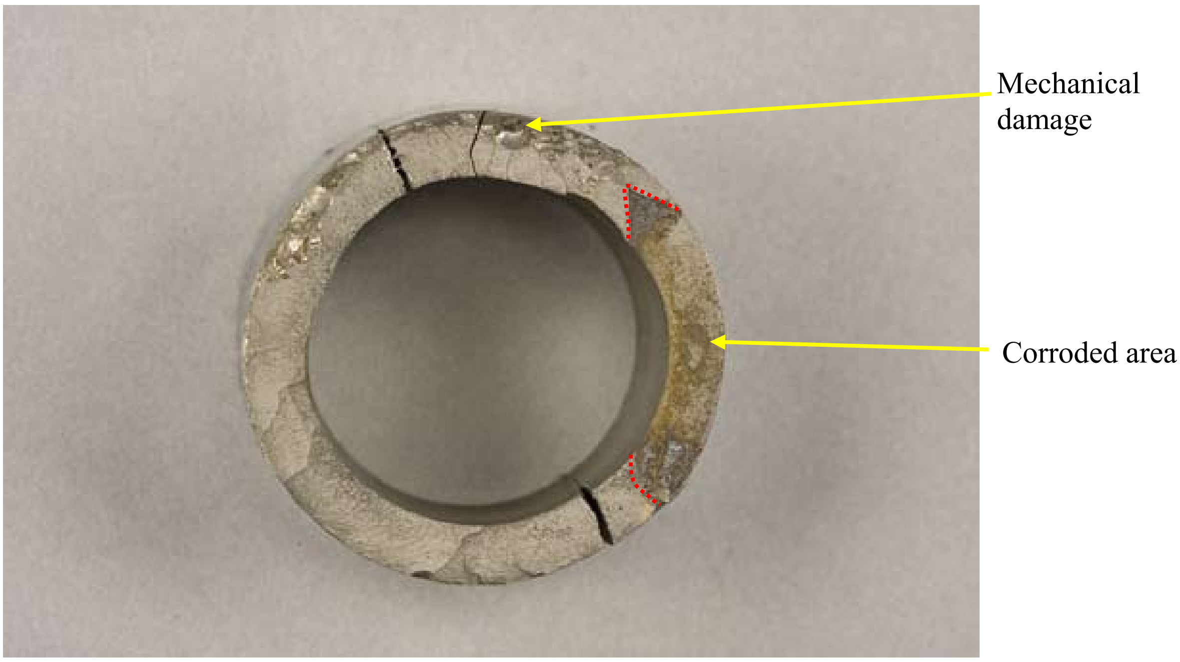

Figure 5

View of torque pin fracture face

The possibility of a previous event having been responsible for a partial failure of the flange prompted questions to the operator regarding any recent heavy or 'crabbed' landings, pivot turns during ground manoeuvring, or operation with tyres in a deflated condition. The operator stated that there were no records of any such occurrences, although the No 5 tyre was changed, due to being worn to limits, on 24 May, five days before this incident.

Examination of the brake reaction rod

As noted earlier, there was little visible damage to the brake rod; this included the removal of a half-bushing and the damage arising from the runway contact. The rod surface was protected by a thick layer of anti-chip paint, and some scuffing was observed on the rear outboard region. The paint was removed during the examination at the manufacturers, which revealed that the surface underneath was undamaged. A dimensional check revealed that apart from some damage in the bore at the rear of the rod, which was associated with the bush removal, there had been no significant plastic deformation of the component.

The cable that formed the principal component of the lanyard that had joined the two rear brake rods together was found to have failed in overload. The landing gear manufacturer stated that the tensile failure load of the cable was approximately 4,000 lb force, but could not explain how the rod could have moved a sufficient distance to have generated any significant tension, especially in the absence of significant deformation of the rod. Also, the cable was outside the plane of rotation of the flailing items, such as the brake hoses and metal guide, and so they could not have been responsible for the failure. It was confirmed that the brake rod would not contact the ground after the pin failure, so long as the lanyard remained intact.

The landing gear manufacturer calculated that an aft load applied to the lanyard would, at the point of cable failure, apply an axial load of approximately 2,750 lb force to the brake pin. The force required to fail the pin flange would, however, be an order of magnitude more.

Prior to removing the paint from the surface of the rod, it was observed that the clamp that anchored the lanyard had a small build-up of partially removed paint against its aft face. This feature was consistent with a load on the lanyard in an aft direction such that it resulted in a tendency for the lower edge of the clamp to peel back the layer of paint that abutted it. Such a load might have arisen from, for example, the bogie running over an obstruction, which fouled the lanyard: however, the aircraft did not leave the paved surface during the incident, thus limiting the scope for encountering such an obstruction. Furthermore any obstruction might reasonably be expected to break the front brake rod lanyard also, since it is at the same height above the ground. Finally, a microscopic examination of the individual strands of the failed cable did not reveal the presence of any foreign material that might have originated from an object brought into violent contact with the lanyard. However, it was observed that the bundle of fractured wires on each half of the lanyard was bent, as though they had been caught around an object prior to failure.

It was considered that an event that resulted in the snagging of only the rear lanyard could conceivably have occurred with the gear bogie in its 'flying' attitude. This would necessarily have happened in the landing or takeoff phase, and would probably in itself have constituted a reportable occurrence. No evidence of such an incident came to light during the investigation, but it was nevertheless considered potentially useful to examine the No 6 brake rod attachment pin (ie opposite the No 5 pin) for evidence of distress. Unfortunately, following a request to retrieve this component, it went missing in transit.

Landing gear tests

The final part of the landing gear investigation consisted of a test at Airbus UK's landing gear test facility using representative components. This involved removing the brake rod torque pin and disconnecting the hydraulic hoses and electrical harnesses before rotating the brake unit in order to examine the possibility of various components coming into conflict. This revealed that a stainless hose guide mounted on the front of the brake housing had been installed back to front on the incident aircraft. The only immediate consequence of this was that the guide jutted in a forward, as opposed to aft direction, which, with the bogie in its flying attitude, caused its associated hydraulic hose to be somewhat taut. However, following the removal of the brake pin and consequent rotation of the brake unit, it was found the guide contacted the brake reaction rod in the manner shown in Figure 6, where it can be seen that the profiles of the guide edge and the aft flank of the rod closely match. (Note: the landing gear was fixed in the flying attitude for the duration of the test, although contact between the guide and brake rod would still have occurred on the ground.) The guide had been rotated into the as-shown position by the tension generated in the hydraulic hose, which had sheared one of the two attaching bolts. The contact accounted for the marks on the anti-chip pain. It

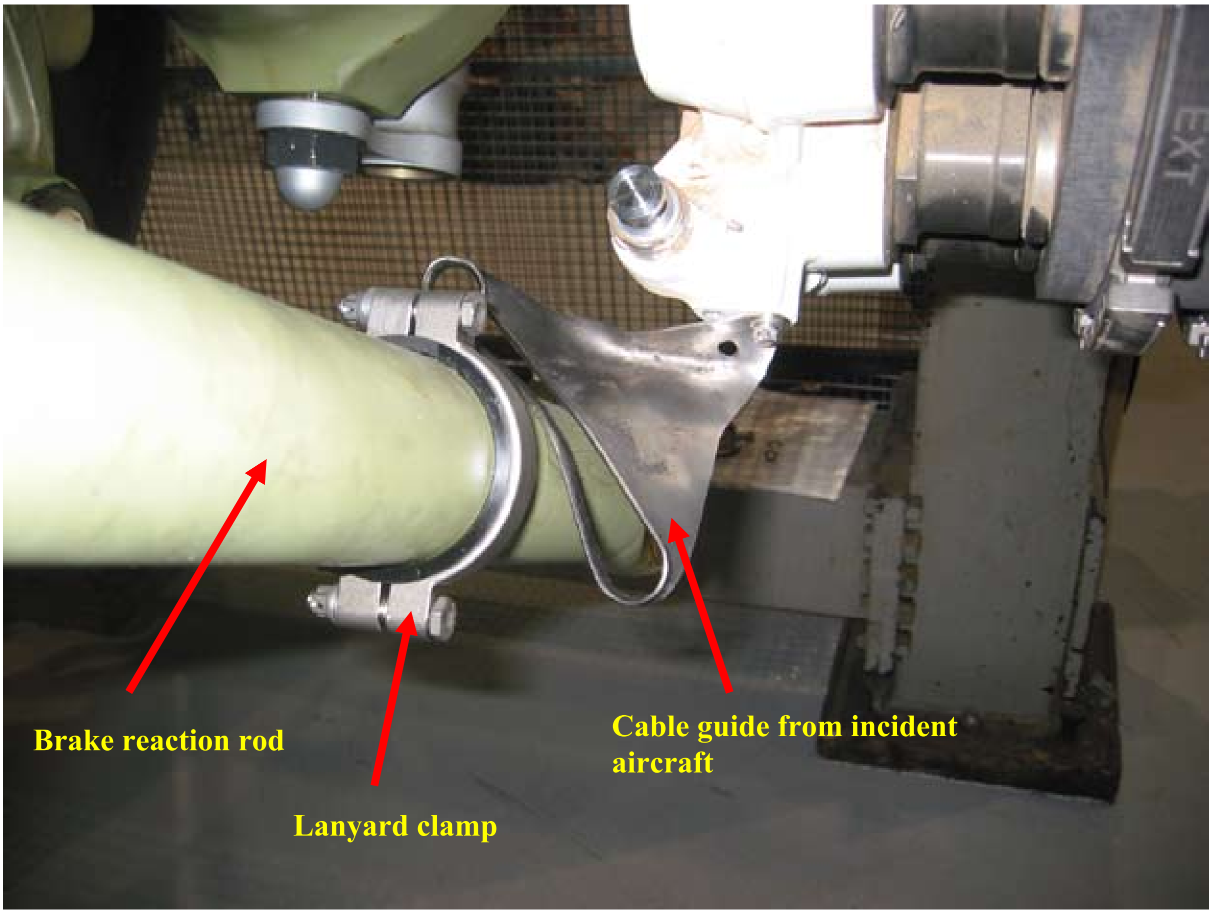

Figure 6

View of test showing how cable guide on brake housing may have contacted the brake reaction rod was also noted that the downward component of the force on the rod, generated during the process of distorting the guide, imparted a tension in the lanyard, thus providing a potential mechanism for failing the lanyard cable.

Green hydraulic system

After the RTO the crew reported a Low Level indication for the Green hydraulic system, which was repeated on the Hydraulic System ECAM page when electrical power was restored on the aircraft during the investigation. Despite this, the PFR had logged no record of this warning. Confirmation from the DFDR was not possible, as there was no hydraulic system Low Level warning discrete. During the examination of the aircraft, considerable fluid spillage was observed, which led to an assumption that the Green reservoir had emptied following the rupture of the No 5 brake hoses. The reservoir had a capacity of up to 52 litres, with the Low Level warning set at 8 litres. For such a potentially large volume of fluid to have escaped suggested that the hydraulic fuse in the brake line downstream of the servo-valve, which should have limited the flow, had failed. However, during the time the aircraft was being prepared for the ferry flight to the USA, the fuse was not replaced and although there was anecdotal evidence that less than three litres were required to top up the system, this was not confirmed by any written record. The issue was thus not resolved, meaning that either there was a substantial fluid loss, together with an unexplained lack of a PFR report, or the loss of fluid was limited by the hydraulic fuse, accompanied by an erroneous Low Level flight deck indication. Given the extent of fluid deposited on the ground around the aircraft after it had halted, which would have been in addition to that which is likely to have been lost in the braking and taxiing operations, the first of the two scenarios seems the more probable. In addition, Airbus indicated that the system pressure must be in excess of approximately 0.5 bar in order to keep the fuse closed.

Previous events

EPR sensing tube

Airbus was aware of one other incident involving the P4.95 sensing tube, which occurred on another A330 in October 2007 and which also resulted in a rejected takeoff. In that case the tube did not fail completely, but developed a leak which, although causing a low EPR indication, was insufficient to trigger a reversion to N1 control mode; this resulted in an N1 overspeed warning.

The engine manufacturer noted that they had received 38 reports of tube fractures on the various P4.95 sensing manifold assemblies on PW4000-100 engines: these had resulted in air turnbacks and a diversion and had additionally prevented aircraft dispatches under ETOPS operation. The failures were identified as having occurred as a result of low-cycle fatigue, due to differential thermal expansion between the manifold assemblies and the turbine exhaust casing.

Torque pin failure

The aircraft manufacturer stated that there had been very few previous failures of a torque pin flange, although there were four cases of cracks being found in the flange radius due to the hydrogen embrittlement and machining irregularities that were discussed earlier.

Analysis

The crew noticed a fault with the thrust setting at a fairly early stage of the takeoff roll. The attempted corrective action of setting TOGA thrust was unsuccessful, and a further ECAM caution, EPR MODE FAULT, was observed. As this caution is inhibited above 80 kt, it must have occurred below this speed. There was a delay of a few seconds before the decision to reject the takeoff was made, during which time the aircraft reached a maximum groundspeed of 130 kt. This delay made the RTO a relatively high-energy event. The delay occurred because the initial decision by the PF to continue the takeoff after receiving the EPR MODE FAULT caution was reconsidered by both pilots and reversed. Time to analyse what was happening was short and, in accordance with the SOPs, the commander had to take control and carry out the rejected takeoff. Had the takeoff been continued, the FADEC would have continued to operate in N1 mode, although autothrust would not have been available for the remainder of the flight.

The crew remained unaware of the damage sustained by the aircraft until they had taxied some distance and the loss of hydraulic fluid and high brake temperature became apparent. The message from the runway inspection about debris having been found could have alerted them, but either they did not hear it or thought that the debris was not from their aircraft. When they realised the brake temperatures were very high they asked to go to a brake cooling area where the aircraft could wait until it was safe to be approached. However, once one tyre had deflated, their ability to move the aircraft was limited.

Three factors featured in the landing gear investigation: the disintegration of the two brake stator discs, the torque pin flange failure and the failure of the lanyard that connected the rear brake reaction rods.

Whilst the discs, which had achieved approximately 95% of the average brake life, most probably failed as a result of the torque spike associated with the use of MAX autobrake, the pin failed simultaneously due to being in a weakened state following an earlier and therefore unrelated incident. No evidence came to light that indicated the nature or even the existence of such an incident, although it was speculated that it might have been associated with the failure of the lanyard cable. If the cable did fail during the RTO, a potential cause was identified in the form of contact between a wrongly-installed hose guide, which had become displaced when the brake unit started to rotate, and the brake reaction rod. However, the glancing nature of this contact was unconvincing; moreover, it did not account for the observed rearward movement of the lanyard clamp, or the bent ends of the fractured strands of the cable, which together tended to favour the possibility of snagging an obstruction. On the other hand, such an event would also have left the failed cable ends potentially visible during pre-flight inspections.

Calculations indicated that the pin would sustain an axial load on the flange an order of magnitude higher than the failure load of the cable. However, a sharp pull, in an aft direction, on the cable would tend to draw the rear ends of the pair of brake rods together, which in turn could preferentially load the rear arcs of the flanges, as opposed to imparting a uniform load around the flange circumference.

Safety action

Following the investigation, Airbus UK indicated that they would revise the Aircraft Maintenance Manual (AMM), to provide sufficient information to ensure the correct installation of the cable guide.

Although it is likely that the torque pin failed under the action of peak brake torque during the RTO, it did so having lost part of its flange in an earlier event. Since the nature of this event was not apparent, it was not possible for either the airframe or the landing gear manufacturer to propose any appropriate safety action.

As noted earlier, the engine manufacturer had identified the P4.95 sensing tube failures as being the result of low-cycle fatigue, arising from differential thermal expansion between the manifold assemblies and the turbine exhaust casing. It was also determined that the assemblies and their associated mounting brackets were too rigid. These problems were addressed by Service Bulletin PW4G-100-77-12, which was issued on 2 May 2007. This introduced sensing manifold assemblies having a different tube material and wall thickness, together with redesigned contours to reduce stress concentrations.

The operator of N270AY stated that SB PW4G-100-77-12 was in the process of being embodied across the fleet at each engine shop visit. The failed tube was of a pre-modification standard.

SERIOUS INCIDENT

Aircraft Type and Registration:	Airbus A340-313, G-VAIR
No & Type of Engines:	4 CFM56-5C4 turbofan engines
Year of Manufacture:	1997
Date & Time (UTC):	27 April 2008 at 0218 hrs
Location:	Nairobi Airport, Kenya
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 14 Passengers - 108
Injuries:	Crew - None Passengers - None
Nature of Damage:	Minor scratches to left aft lower fuselage
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	49 years
Commander's Flying Experience:	14,250 hours (of which 9,667 were on type) Last 90 days - 108 hours Last 28 days - 41 hours
Information Source:	AAIB Field Investigation

Synopsis

During the final stages of landing at Nairobi (NBO) the flight crew lost visual references, during which time the pilot flying made a left rudder pedal input. A go-around was initiated. However, the aircraft touched down and the left main landing gear ran off the paved runway for a distance of 180 m. No significant damage occurred. The Ministry of Transport (Air Accident Investigation Department) of Kenya delegated the entire investigation to the UK AAIB and appointed an Accredited Representative to assist with the subsequent enquiries.

At an early stage of the investigation the AAIB issued a Special Bulletin to publicise factual information available at that time. Due to the inability to obtain pertinent information related to a number of areas of inquiry, the Chief Inspector of Air Accidents has ordered that this report be completed as a Bulletin rather than an Inspector's Investigation.

Five Safety Recommendations are made.

History of the flight

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

The 0100 GMT ATIS obtained by the crew for NBO before the top of descent reported the wind to be from 040° at 3 kt with 7 km visibility, broken cloud at 1,600 ft, temperature and dewpoint 15°C and QNH 1020. The crew carried out an area navigation (RNAV) standard arrival procedure to join the ILS for Runway 06. All navigation aids at NBO were reported to be serviceable. The ATIS weather was confirmed with Approach Control at 0153 hrs during the early part of the RNAV arrival. At 0210:03 hrs Approach passed information to G-VAIR that an aircraft ahead had reported the landing visibility as 3,000 m with a cloudbase of 300 ft agl. Approach then transferred the aircraft to Tower.

At 0210:43 hrs G-VAIR was cleared to land by NBO Tower and the controller advised: "THE VISIBILITY REPORTED AS 3000 M LAND AT YOUR OWN DISCRETION WIND 050 AT 05 KT". The First Officer, who was pilot flying (PF), re-briefed the go-around actions and the approach was continued with the autopilot and autothrottle engaged. The crew stated that they became visual with the runway at a height of between 300 and 200 ft. At the decision height of 200 ft, both pilots had more than the minimum visual reference required and could see "all the approach lights and a good section of runway lights". The autopilot was disconnected at 100 ft radio altitude and the PF began to flare the aircraft between 75 and 50 ft radio altitude. The aircraft floated at around 20 ft for a few seconds before it entered an area of fog and the PF lost sight of the right side of the runway and the runway lights. The commander also lost sight of the right side of the runway.

The aircraft touched down in a normal attitude but on the main gear only; the body and nose gear did not contact the ground throughout the event. The PF was not aware that the aircraft was moving laterally on the runway, but the commander became aware of the left runway edge lights moving rapidly closer to him before he lost the lights completely and was only aware of their position by the glow of the lights illuminating the fog. The commander called "go-around" and the PF immediately advanced the thrust levers from idle to full thrust. G-VAIR became airborne after a period of just under five seconds on the ground. The gear retracted normally and the crew continued with the go-around, climbing to an altitude of 9,000 ft to enter the hold. During the ground roll the crew had heard and felt a rumbling and suspected that the aircraft might have departed the left side of the declared runway although they did not believe that the aircraft had left the paved surface. The aircraft entered the hold while the crew considered their options. Having decided to divert to Mombasa the commander informed ATC that they may have run off the runway side and that they wished to divert to Mombasa. The First Officer remained as PF for the diversion, which was followed by a normal, day VMC landing.

Ground marks

Having been advised of the possibility that the aircraft had run off the runway an inspection by Nairobi Airport staff confirmed the presence of a set of landing gear tracks running off to the left of the paved surface. They believed these had been made by the main gear of G-VAIR. The marks started 800 m from the threshold of Runway 06 and continued towards the edge of the runway for 160 m. From that point the marks from the left main gear passed over a runway light (which had been destroyed) before continuing off the paved surface and then curving right to run approximately parallel with the runway for 180 m. The set of marks from the right main gear did not quite leave the paved surface (stopping 5 cm from the edge of the paved shoulder) although they were off the declared runway surface. The airport staff provided a diagram depicting the ground marks and this is shown in Figure 1. Photographs of the ground marks were also taken at six hours and 14 days after the event. These are shown in Figures 2 and 3 respectively.

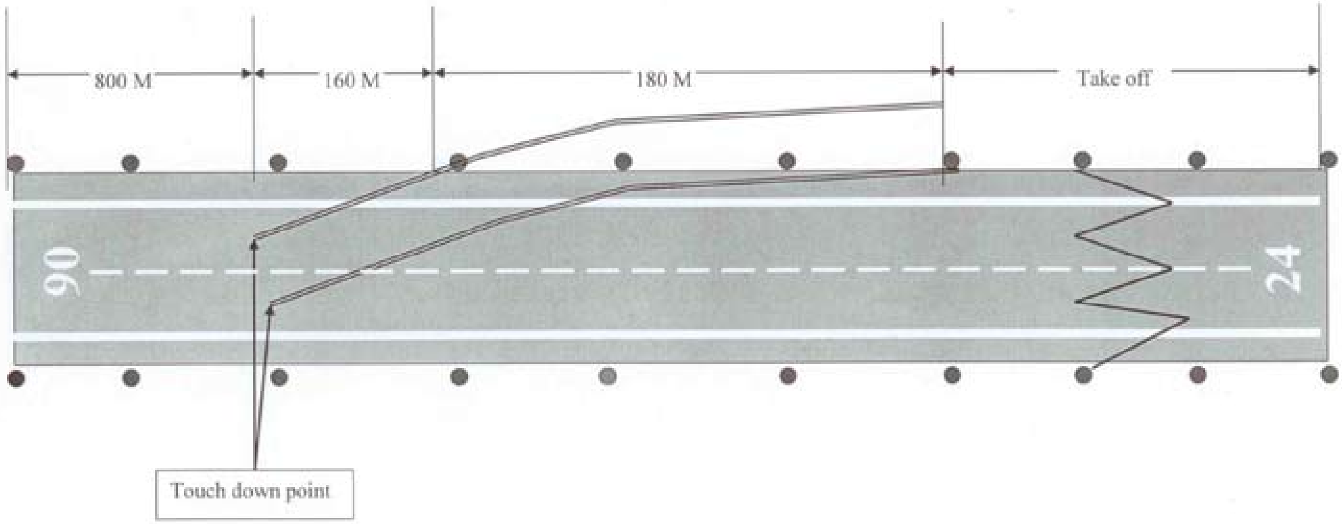

Figure 1

Diagram depicting ground marks

Figure 2

View towards the touchdown point

Figure 3

Left hand runway edge markings for Runway 06 with G-VAIR left main gear tyre tracks visible

Damage to aircraft and infrastructure

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

Flight recorders

The aircraft was fitted with a solid-state Cockpit Voice Recorder (CVR) which recorded the last two hours of flight crew speech and cockpit area microphone (CAM) sounds, a solid-state Flight Data Recorder (FDR) with a capacity for recording over 25 hours of data, and a Quick Access Recorder (QAR) that recorded data onto a removable optical disk.

Following the incident, the operator requested that the CVR, FDR and QAR optical disk be removed from the aircraft. However, due to a lack of replacement units at Mombasa, it was decided to conduct a non-revenue flight back to Heathrow with the recorders installed, but with the circuit breakers for the CVR pulled to preserve the two-hour recording. The FDR and QAR were allowed to record during the flight in the knowledge that the recordings of the incident would not be overwritten during the flight back to Heathrow, given the duration of the flight and the recording capacity of the recorders.

Although the CVR circuit breakers (CBs) had been 'pulled and collared' at Mombassa as requested, the recording was inadvertently overwritten at Heathrow during subsequent attempts made by the operator to download the FDR, and during which the circuit breaker had been reset.

Data from the QAR, normally used to support the operator's Flight Data Monitoring (FDM) programme, was replayed by the operator and problems were found with a number of recorded parameters that were essential to this investigation. However, these parameters had been recorded correctly on the FDR.

The FDR recorded information from a large number of flight data and discrete parameters, including relevant air data, engine, control surface and cockpit controls.

Relevant recorded information

A time history of the relevant flight parameters during the approach and aborted landing at Nairobi is shown at Figure 4. The data presented starts at 02:17:40 UTC, 42 seconds before touchdown, with G-VAIR at approximately 450 ft agl, autopilots 1 & 2 engaged and automatic throttle system (ATS) engaged and active in SPEED mode, on the ILS approach to Runway 06. At this point, the aircraft's descent rate was about 800 ft/min, the computed airspeed was a nominal 135 kt, flaps and slats extended (32º and 24º respectively) and the landing gear was down (not shown).

The aircraft continued descending on the ILS with minor variations in heading of ±2º to the runway heading. At approximately 90 ft agl, wings level and 4º nose-up pitch attitude, both autopilots were disengaged (Point A) with multiple FO sidestick inputs and some left rudder following. The ATS remained engaged and active.

Between 40 and 50 ft agl, the PF initiated the flare by briefly pulling back on the side stick (see Point B).

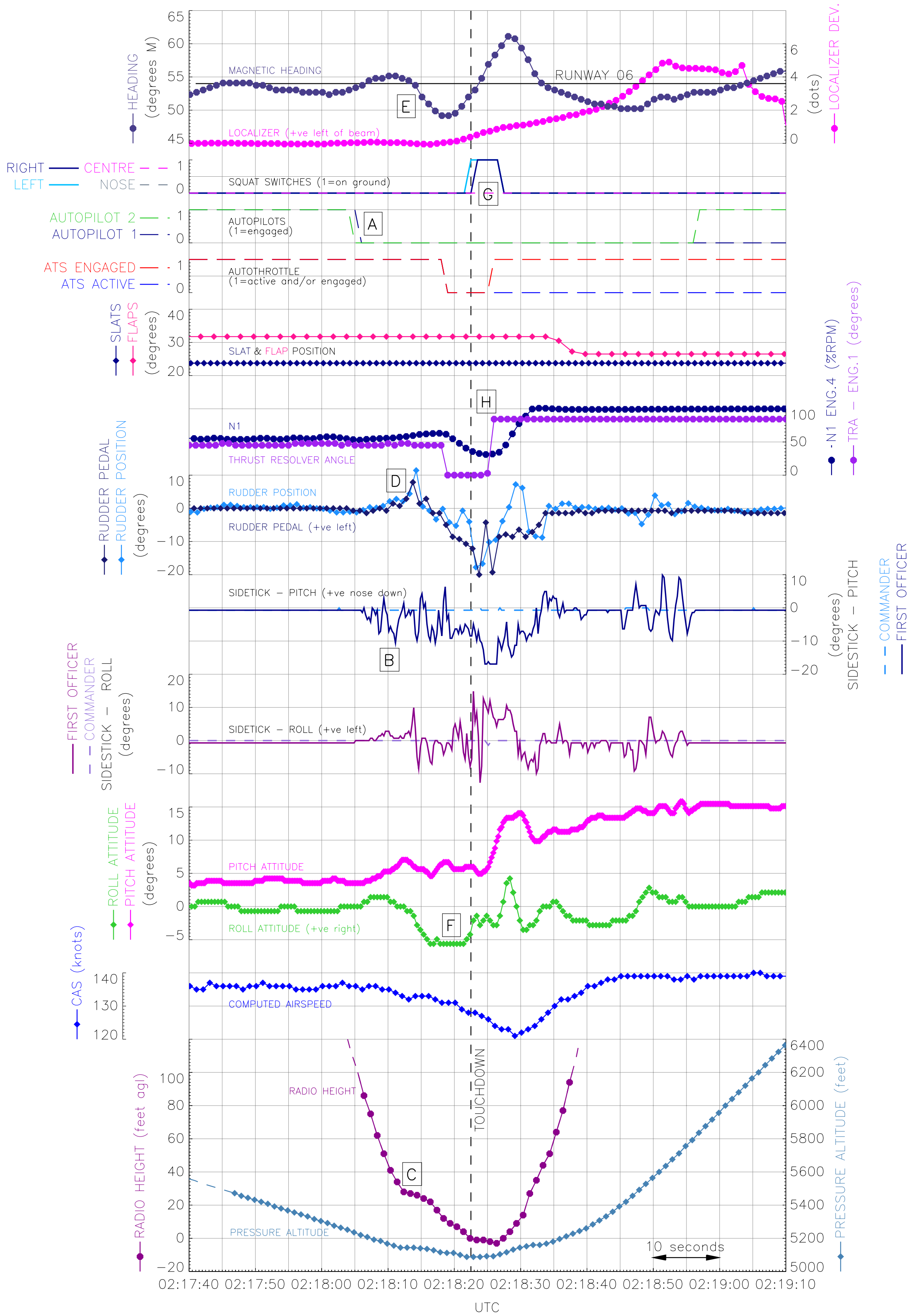

Figure 4

Salient FDR Parameters
(Serious Incident to G-VAIR on 27 April 2008)

This momentarily pitched the aircraft to 7º nose up, and reduced the rate of descent to about 60 feet/minute as the aircraft passed through 30 ft agl (Point C). The FO then put in a 10º left side-stick[1] input followed by an 8º right input, during which the FDR recorded an 8º left rudder pedal[2] input being made (Point D), causing G-VAIR to roll left and drift to the left of the runway centreline (Point E).

The PF continued to make further pitch and roll stick inputs and, as the aircraft passed through 17 ft agl, all engines were throttled back to idle, causing the ATS to drop out automatically. Right rudder inputs were also made that slowed the drift to the left; however, the aircraft remained left wing down till touchdown (Point F).

Touchdown occurred 10 seconds after the flare was initiated, still left of the runway centreline with only the main gear making contact with the ground and the left gear touching down first (Point G). The airspeed at touchdown was 128 kt, with a recorded vertical acceleration of 1.1g (not shown).

The main gear remained on the ground for about five seconds during which TOGA thrust was selected (Point H). A pitch attitude of 13.5º was recorded as the aircraft rotated. The subsequent climb, diversion to and landing at Mombasa were uneventful.

Loss of CVR recordings

The earliest recordings on the two-hour CVR started 35 minutes after the incident. The flight time from Nairobi to Mombasa was only 80 minutes, including five minutes of taxiing at Mombasa; therefore, only the last 45 minutes of the 80-minute flight had been recorded, followed by 75 minutes of recordings while the aircraft was on the ground at Mombasa, and then Heathrow with electrical power on.

In accordance with the operator's procedure to preserve recordings made by flight recorders following an incident, the CBs for the CVR were pulled when the aircraft was on the ground at Mombasa. However, this was done the following day once the aircraft had been put in 'Airworthiness Hold' and ground checks, including engine idle runs, were being carried out prior to its flight back to Heathrow. The aircraft was powered for a total of 40 minutes, during which the CVR was recording, before the CVR CBs were pulled ready for the flight back to Heathrow.

The remaining 35 minutes of the recording was made while the aircraft was on the ground at Heathrow. A request was made for the CVR and FDR to be removed from the aircraft; however, the engineers were unable to get access to the CVR, which was located in the rear bulk hold, because of baggage being unloaded. In the meantime, rather than immediately remove the FDR, the engineers decided to follow their normal maintenance procedure following an incident, of downloading the recorder data onto a flash memory card, with the FDR still on the aircraft. These downloads were done in accordance with Airbus AMM 31-33-00-710-807 which required electrical power on the aircraft and both of the CVR CBs to be pulled and collared. However, problems were experienced with the download so the engineer in charge decided to reset the CVR CBs. The problems continued for a further 35 minutes until the data was finally downloaded, throughout which the CVR was recording. The aircraft was then powered-down and the FDR and CVR subsequently removed.

Since this incident, the operator has taken a number of actions, including changes in procedures, for the

Footnote

1 The maximum side-stick input is ±20.5º.
2 The maximum rudder pedal input is ±30º.

preservation of recorded data following a serious incident or accident. These are:

1. Notice to Aircrew, Reference 52/9 Issue 1, issued 13 May 2009 through 13 November 2009, entitled '*Preservation of data following a serious incident or accident*' – issued to advise all aircrew of their responsibilities to preserve recorded data in the event of a serious incident or accident, particularly with respect to the CVR. It also details the requirement to make a technical log entry for the removal of the recorders. The intention is for this procedure to be replaced by a permanent procedure in the next revision of their Operations Manual.

2. Quality Notice, QN/GEN/142, issued 6 May 2009, entitled '*Preservation of data following a serious incident or accident*' – issued to remind all engineers of their responsibility to preserve data in the event of a serious incident or accident, particularly with respect to CVR recordings. This also details the requirement to make a technical log entry for the removal of the recorders.

3. The aircraft hold procedure detailed in the Quality Notice, QN/GEN/117 (issued 24 August 2007), has been modified to include the requirement to pull and collar the CVR CBs and the making of a technical log entry. This procedure is to be made a permanent procedure (EDP 1.77) by inclusion in the next revision (due July 2009) of their Engineering Department Procedures (EDP). In the meantime the modified procedure has been issued as an Airworthiness Department Temporary Local Operating Instruction.

4. Also to be included in the next revision of the EDP is Issue 6 of EDP 4.39 entitled '*Retention of aircraft parts/documents which are subject of an MOR or ASR*'. This will include all of the new information included in QN/GEN/142.

QAR parameter recording issue

Once the aircraft had returned to Heathrow, the optical disk from the QAR was removed and downloaded by the operator. On examination of the data it became apparent that the commander's and FO's side-stick pitch input parameters, essential parameters for the investigation, were not being recorded correctly.

This problem, however, was already known to Airbus who first became aware of it in April 2006 following complaints from an operator. The problem was traced back to the Data Management Unit (DMU) by Honeywell, the unit's manufacturer, and an interim fix was developed and made available to any operator who contacted them reporting the same problem.

A final fix was developed by Honeywell and published in Honeywell Service Bulletin (SB) No. 967-051X-002-31-15, which detailed the update and installation of the DMU software. The Honeywell SB was then incorporated into the Airbus SB No. A340-31-4104 entitled '*Indicating/Recording Systems – Install Acms Enhanced Dmu Software Step 5.0 For A340 With Cfmi Engines'*, dated November 2007.

The operator of G-VAIR was unaware of the QAR problem until it received the Airbus SB in November 2007, which was subsequently embodied fleet-wide on 13 January 2009.

Go-around training

In March 2008, one month before the G-VAIR event, the UK CAA issued a Flight Operations Communication (FODCOM 11/2008)[3]. A CAA review of Operational Flight Data Monitoring (OFDM) information had shown that there was a '*significant*' trend developing in go-around incidents which was not being adequately covered by pilot training. This FODCOM recognised that routine recurrence training for pilots focused on the go-around from instrument minima usually with one engine inoperative. In order to provide more varied scenarios for go-arounds during operators' training programmes the FODCOM recommended that:

> *'The practice of go-arounds with all engines operating from other than at Decision Altitude should be carried out regularly. As a minimum, this should be included in the operator's three-year training programme but should not be too prescriptive in detail. Unplanned go-arounds should be included to verify pilot understanding of Standard Operating Procedures (SOPs). This would enable operators to vary the training in order that it encompass a variety of circumstances including:*
>
> *a) above Decision Altitude and above the platform altitude in the Missed Approach Procedure;*
>
> *b) between Decision Altitude and touchdown; and*
>
> *c) after touchdown.'*

As the FODCOM had only been issued one month prior to the G-VAIR event the PF had not yet received this additional training. His last recurrent training had been in December 2007, before the FODCOM was issued, and as such he would expect to complete his next set of recurrent training (which would include the additional training identified) in June 2008. He also commented that late go-arounds are not unusual at the operator's home base, however these would not be from such a low height. The operator's Flight Crew Training Manual defines a rejected landing as a go-around manoeuvre initiated below the minima. Training for rejected landings was conducted as part of Category 2/3 operations, but these approaches would always be flown by the commander with the use of automatics.

Following the overrun of an Embraer ERJ-170, the National Transportation Safety Board (NTSB) recommended, in their report published on 15 April 2008, that the Federal Aviation Administration (FAA) improve the training of pilots for rejected landings below 50 ft following rapid reduction in visual cues. It recommended that the FAA:

> *'Require 14 Code of Federal Regulations Part 121, 135, and Part 91 subpart K operators to include, in their initial, upgrade, transition, and recurrent simulator training for turbojet airplanes, (1) decision-making for rejected landings below 50 feet along with a rapid reduction in visual cues and (2) practice in executing this maneuver. (A-08-16)'*

Operator assessment for Nairobi

Before commencing operations to NBO in 2007 the operator conducted an audit of the airfield and its infrastructure. During the audit under '*conditions of surfaces and lighting'* the auditor commented that:

Footnote

3 http://www.caa.co.uk/docs/33/FOD200811.pdf.

'Very Heavy rubber deposits on the 06 thresholds. KAA have removal machine but they have only been successful with cleaning more recent rubber deposits. They say that the older deposits have somehow bonded with the runway surface and are resistant to removal. It may ultimately require local resurfacing.

Runway centreline markings – SATIS'

The operator's audit did not identify the runway lighting position or ATC low visibility procedures as being an issue. In the airfield charts provided for Nairobi the operator included the advice:

'The weather can include morning fog (especially Nov-Mar) at our planned arrival time…. Additionally the ATIS has been reported as unreliable, and so crews should note that conditions may not be as they expect.'

'Potential Safety Hazards – Fog and thunderstorms possibly unannounced.'

Airfield information

Runway surface

Runway 06 at Nairobi is declared as 4,117 m long by 45 m wide. It consists of a grooved asphalt surface with 7.5 m asphalt shoulders either side to give a total paved width of 60 m. Two weeks after the incident to G-VAIR, an AAIB Inspector, in conjunction with the Kenyan Accredited Representative, conducted a visual inspection of the runway condition. The touchdown zone area of Runway 06 appeared heavily contaminated with rubber deposits which partially obscured the runway centreline markings. A photograph of this area is shown in Figure 5.

Figure 5

Contamination in touchdown zone area of Runway 06

As part of the inspection it was intended to assess the friction levels of the runway surface, in particular those areas which appeared to be heavily contaminated. However, no calibrated grip testing equipment was available at that time.

Section 7.9 of ICAO Annex 14, Volume I requires that States specify two friction levels as follows:

> *'a) a maintenance friction level below which corrective maintenance action should be initiated; and*
>
> *b) a minimum friction level below which information that a runway may be slippery when wet should be made available.'*

Although requested, no evidence was provided to the investigation that friction tests had ever been conducted. On 18 September 2008, in response to questions from the Kenyan Accredited Representative, the KAA responded that they were "*setting up a procedure for testing the grip levels on the runway and will be updating you on the progress*." By 1 July 2009 no further information had been received on this subject.

Runway lighting

The Runway 06 edge lighting consisted of raised lamps set at the edge of the paved area, a distance of 7.5 m from the edge of the 45 m declared runway strip. This appeared to be at variance with the ICAO Annex 14 Standard which stipulates a maximum distance of 3m from the edge of the runway for edge lighting. The runway had no centreline lighting, nor was it required by ICAO Annex 14. Once it became apparent during the investigation that the position of the runway edge lights was not in accordance with ICAO Annex 14, the operator amended their Company Brief for NBO to draw attention to this fact and to emphasise that:

> *'the absence of centreline lights in combination with the position of the runway edge lights can cause confusing visual clues at DA.'*

The runway lighting was observed by an AAIB inspector during a night arrival two weeks after the incident. During a good-visibility arrival, turning from base leg to final, the runway lighting had a ragged appearance. A UK CAA expert from Aerodrome Standards was of the opinion that this ragged appearance may have been caused by the rotational alignment of individual lights not being uniform.

Photographs of the edge lighting were shown to an expert in runway lighting systems. He commented that, in the photograph shown in Figure 6 below, the glass on the lamp appeared "frosted" which would diffuse the light adversely affecting its output. He also commented that, in one photograph he was shown (Figure 7), the lamp appeared to be misaligned and also that he would have expected to see reference markings to the runway centre line and a unique identifier for each lamp neither of which was visible in the photographs.

The AAIB has offered to conduct a photometric survey of the runway lighting at NBO, but, to date, this offer has not been taken up.

Weather reporting

An Automated Weather Observation System (AWOS) was installed at Nairobi. This system was certified as operational by the manufacturer and accepted into service on 31 October 2006. In addition to sending data to the meteorological office on the airfield it had the capability to provide instantaneous Runway Visual Range (RVR) to the ATC tower as well as other weather information. The display for this system was positioned next to the tower controller's communications desk, as shown in Figure 8.

Figure 6

"Frosted" edge light

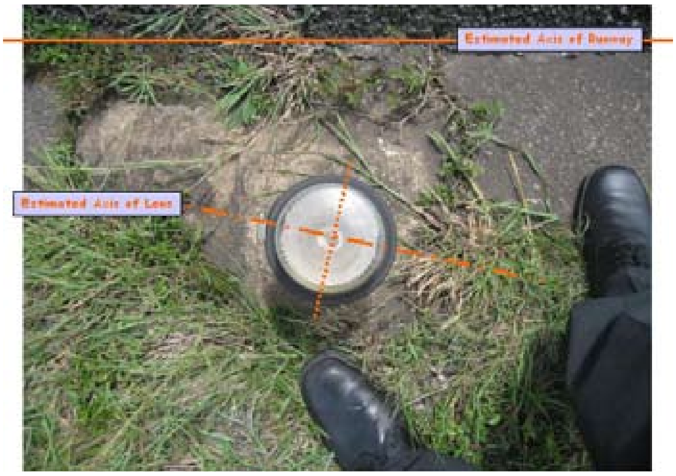

Figure 7

Example of edge light misalignment

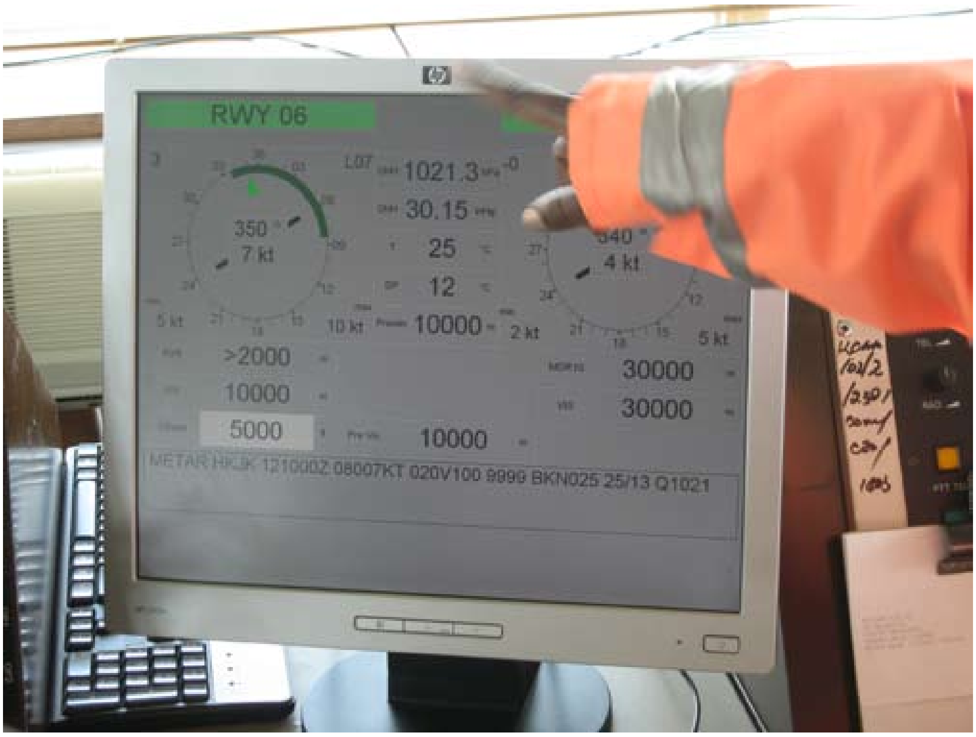

Figure 8

AWOS display in the tower

The RVR sensing system comprised a LT31 transmissometer with a LM21 background luminescence meter positioned near the touchdown zone of Runway 06. According to the system manufacturer the architecture of the AWOS was such that the data recorded in the system memory would have been the same as that displayed on the controller's monitor. There was no direct connection between the AWOS and the control for runway lighting intensity. During its installation, the AWOS was set up to calculate RVR based on a lighting intensity of 100%, in accordance with ICAO Standards. However, should a reduced lighting intensity be selected by ATC, ICAO requires an adjustment to be made in the way that RVR is calculated. In the absence of an automatic system, this would have had to have been done manually by ATC.

Following this event, the memory of the AWOS was downloaded and the manufacturer provided assistance to interpret the recorded information. The AWOS recorded both a Meteorological Optical Range (MOR) and RVR at one minute intervals, with each reading being calculated as an average over the preceding minute. An extract of the recording is shown in Table 1. Note that the times recorded by the AWOS are not synchronised to, but are accurate to within approximately one minute of, UTC. At 0210 hrs the system recorded an RVR of 2100 m (2300 m MOR). For the next three minutes the RVR varied around 1600 m before reducing to 800 m (200 m MOR) at 0214 hrs. The RVR reduced further to 550 m (150 m MOR) at 0216 hrs. The system recorded, and therefore should have displayed, a minimum RVR of 600 m around the time of G-VAIR's attempted landing.

Time	RVR_1A	MOR_1A
27/04/2008 02:08	2100	2400
27/04/2008 02:09	2100	2300
27/04/2008 02:10	2100	2300
27/04/2008 02:11	1600	500
27/04/2008 02:12	1700	550
27/04/2008 02:13	1600	500
27/04/2008 02:14	800	200
27/04/2008 02:15	650	150
27/04/2008 02:16	550	150
27/04/2008 02:17	600	150
27/04/2008 02:18	600	150
27/04/2008 02:19	600	150
27/04/2008 02:20	600	150
27/04/2008 02:21	600	150
27/04/2008 02:22	700	150
27/04/2008 02:23	1000	250
27/04/2008 02:24	1300	400
27/04/2008 02:25	1000	250
27/04/2008 02:26	1000	250
27/04/2008 02:27	1000	300
27/04/2008 02:28	800	200

Table 1

Extract from AWOS recording

The UK Met Office, in relation to the rapid change in visibility shown on the AWOS data, commented that:

> "such changes in visibility (the rapidity of the change in RVR) should be considered realistic in that patches of mist and particularly fog can quickly envelope sensors as the mist/fog is moved with the wind."

The recorded surface winds for ten minutes either side of the incident were between 4 kt and 7 kt from between 040° and 096° (approximately 20 degrees left to 35 degrees right of runway track).

Regarding the RVR capability of the AWOS, the Kenyan Accredited Representative advised that his

> "understanding of the situation is that the automatic system had been installed in the Tower but the controllers had not been trained on it. It is, therefore, possible that the duty controller did not make any reference to it during this incident. This issue is being addressed between ATC and Met".

He further advised that ATC relied on receiving pilot reports and half hourly METARs in order to pass on weather information to flight crews.

It is understood that, as part of the installation contract, the system manufacturer provided maintenance and operation training to the Met personnel at NBO, but not to the Tower controllers.

Runway visual range (RVR)

RVR is defined in ICAO Annex 3 Chapter 1 as

> *'the range over which the pilot of an aircraft on the centre line of a runway can see the runway surface markings or the lights delineating the runway or identifying its centre line.'*

The ICAO Manual of RVR Reporting also states that

> *'the reported RVR value is intended to represent how far a pilot can see down a runway.'*

RVR is not a measurement of one specific parameter, but is an assessment based on calculations that take into account various factors and utilise a number of constants. Should the actual conditions vary from those allowed for in the constants then the calculation of RVR will be erroneous. One parameter which may vary from that predicted is lighting intensity, and the ICAO Visual Aids Panel (1970) suggests an allowance of 20% be made due to contamination and ageing of runway edge lights.

One technique used to determine RVR uses a transmissometer to measure the transmittance of the atmosphere. RVR is then calculated by taking into account the measured value of transmittance, the characteristics of the runway lights and the expected detection sensitivity of the pilot's eye under the prevailing conditions of background luminance. This was the method being used at Nairobi on 27 April 2008.

Runway lighting - ICAO requirements

Standards for airfield ground lighting are defined by ICAO Annex 14. In relation to runway and approach lighting it states in Section 10.4 that:

'A light shall be deemed to be unserviceable when the main beam average intensity is less than 50 % of the value specified in the appropriate figure.

A system of preventive maintenance of visual aids shall be employed to ensure lighting and marking system reliability.

The system of preventive maintenance employed for a precision approach category 1 shall have as its objective that, during any period of category 1 (CAT 1) operations, all approach and runway lights are serviceable, and that in any event at least 85 per cent of the lights are serviceable….'

Sections 10.4.3-10.4.9 discuss category two (CAT2) and category three (CAT3) operations. These sections recommend:

'in-field measurement of intensity, beam spread and orientation of lights included in approach and runway lighting systems…. Should be undertaken by measuring all lights, as far as practicable, to ensure conformance with the applicable specification…'

ICAO Annex 14 specifies characteristics of each type of runway light in terms of isocandela diagrams (Figure 9 refers) which define the required beam shape and intensity. Annex 14 also specifies required colour and setting angles of the emitted light and maintenance performance levels for individual fittings and overall serviceability of a lighting system. Any individual light fitting is deemed unserviceable when the light intensity is less than 50% of specification.

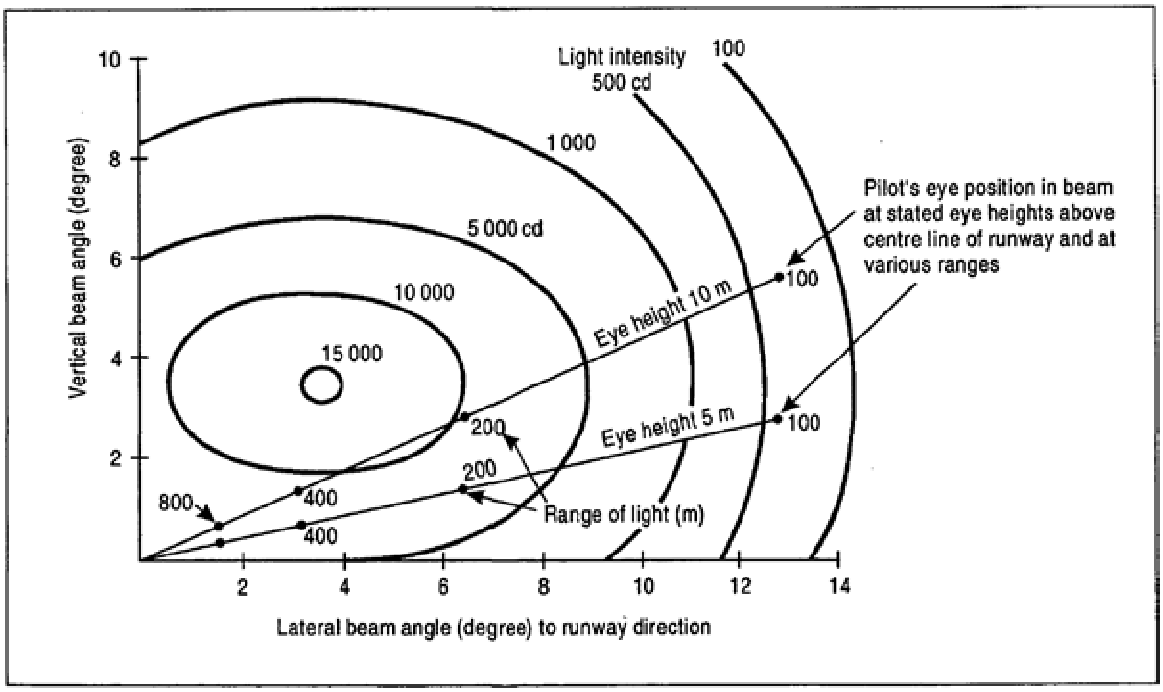

Figure 9

Isocandela diagram for a runway edge light taken from ICAO Manual of Runway Visual Range Observing and Reporting Practices, Third Edition 2005. (Doc 9328 AN/908)

As can be seen from the diagram there is a very narrow field where the light focuses its maximum beam intensity. Small variations in orientation result in disproportionately large decrements in light output.

Runway lighting maintenance

The UK CAA, in conjunction with other UK government agencies, sponsored a research programme during the 1990s into the maintenance and quality of Aeronautical Ground Lighting (AGL). Prior to this study, the UK accepted practices for the maintenance of lighting were a combination of block (or bulk) change, where a batch of lamps is replaced or light housings refurbished after a set period of time, and spot replacement where an individual lamp is changed when it is observed that it has failed completely.

Block change maintenance is a technique which remains an ICAO accepted practice at CAT 1 airfields. It assumes that all light fittings and lamps deteriorate uniformly with time whereas spot replacement assumes that the lighting quality remains essentially constant up until the time that the lamp fails and is extinguished.

The initial target of the research programme was to develop a mobile photometric measurement system. This system was specifically designed to measure accurately and rapidly the performance of aerodrome lighting systems against the ICAO Annex 14 standards for beam intensity and orientation by using an array of light sensors either fixed in a hand-held frame or, in later models, towed behind a vehicle.

This system was tested at a number of UK airports. The study showed that at one airfield, following total refurbishment, 20% of the fittings were below ICAO standards, and that after six months 50% of the fittings were considered unserviceable. In addition it was found that lamps can run with very low output for a considerable time before finally failing and hence there is a risk of operating below ICAO serviceability levels for extended periods.

Differential maintenance

Following the UK CAA research study the technique of differential maintenance was developed. This involves conducting routine photometric surveys of the airfield lighting and changing lamps and light fittings when certain trigger values are reached. As a consequence, the lighting quality never falls below ICAO standards for extended periods and maintenance costs can be reduced as serviceable fittings or lamps are not replaced needlessly.

The UK CAA report identified a number of electrical, optical and physical reasons for variation in lighting quality;

a) High-intensity lighting is powered from constant current sources in order to provide stable light output. Light output is very sensitive to changes in operating current and a 6% reduction in current can result in a 25% reduction in light output.

b) Airfield lighting is designed to produce a narrow high intensity beam. The required beam characteristics are achieved by means of a compact optical system in which the lamp filament is located at the focal point of a lens system. Any movement of the filament from the focal point will alter the beam orientation and probably the spread. Movement of the lamp in its holder or filament sag have been found to produce azimuth and elevation variations of up to 5°. Dirt and contamination were found to cause up to a 40% loss in output, surface pitting from jet blast up to 45% and the lens mounting up to 30% (not all losses were found in a single unit).

c) Azimuth errors in excess of 3.5° were found during the study.

d) Lamp life itself was not considered in tests; however, filament sag was expected to increase as lamps age which would change beam orientation.

The UK CAA provides guidance on lighting maintenance to licence holders in document CAP 168 - Licensing of Aerodromes:

> *'12.1.5 The conventional AGL maintenance strategies of block change, or change on failure, have been shown to be inadequate with many of the lamps failing to meet the required standard either immediately or shortly after the maintenance activity (see paragraph 12.3.8). Lamps and associated equipment do not age at a uniform rate and consequently only limited benefit is achieved from a routine block change. On the other hand, if the performance of individual lights is allowed to decay until lamp failure occurs, then each light will be operating below the required standard for a substantial percentage of its life. Both strategies result in the possibility of entering LVPs with the installation operating below the required serviceability levels. Routine and regular targeted maintenance procedures are essential if this scenario is to be avoided.*
>
> *12.1.6 The performance of lights can change rapidly, especially at large aerodromes with high movement rates. Therefore, it is important to assess performance accurately on a regular basis and act upon the information collected. The frequency with which such assessments should be undertaken is dependent upon the type and age of the installation, maintenance policy adopted, movement rates and prevailing weather conditions. Typically, a weekly survey, with associated maintenance, has been found to be adequate for a major aerodrome.'*

The UK CAA does not differentiate between airfield categorisation regarding the type of maintenance activity required. CAP 168 details the standards required and allows airfields to develop their own strategies for ensuring compliance:

> *'12.2.2 The objectives…specifically target precision instrument approach runways and operations in low visibility. For precision instrument approach runways the CAA expects the aerodrome authority to provide evidence that the performance of the associated AGL meets the requirements for all weather operations… One method of providing such evidence is to carry out regular measurements of the photometric performance (i.e. the luminous intensity, beam coverage and alignment) of the AGL when in service.'*

Lighting at Nairobi

The Kenya Airports Authority (KAA) reported that the plan for management of lighting at NBO relied on twice-daily inspections of the general airfield lighting and bulk replacement of lamps to ensure uniform lighting. They advised that maintenance personnel were required to check light orientation on a routine basis. The AAIB have been unable to obtain copies of these maintenance procedures or records of any recent inspections carried out.

Previous incident

In January 2007 a Dutch registered MD-11 landed on NBO Runway 06 at night in heavy rain. The aircraft departed from the left side of the runway in a similar position to G-VAIR. The MD-11 crew regained the runway brought the aircraft to a halt and no serious damage occurred. The report into this incident was conducted by the operator of the aircraft with oversight from the Dutch Safety Board. The report produced on 5 October 2007 made the following recommendations:

> ‘1- *Inform the Kenyan Authorities about the (in) visibility of the center line in the touch down zone of runway 06 in NBO as a result of rubber deposits. Request the Authorities to have the center line cleaned.*
>
> 2 - *Inform the Kenyan Authorities that the absence of center line lights in combination with the position of the runway edge lights of runway 06/24 in NBO, caused visual illusion of the flight crew which is considered a contributing factor to this incident. Recommend to install center line lights on the runway.*
>
> 3 - *Inform the Kenyan authorities that the position of the runway edge lights of the runway is not according ICAO standard. Recommend to have the runway edge lights repositioned.’*

The Dutch operator commented that they visited the Kenya CAA and Kenya Airport Authority on 29 February and 1 March 2008 to discuss the report with them. However, since then they have received no further communication on the matter.

ATC personnel

At the time of the incident a trainee Air Traffic Control Officer (ATCO) was on duty under the supervision of a qualified ATCO. Having rested for 18 hours, both had reported for duty at 1600 hrs and thus were about 10.5 hours into a 12 hour shift when the event occurred. A review of the ATC tapes in conjunction with the ATC unit manager confirmed that the trainee complied with unit standard operating procedures.

Action taken by the Kenya Airport Authority

During July 2008 the runway edge and centrelines were repainted. In October 2008 the KAA informed the investigation that, previously, they had been periodically removing rubber deposits from the runway touchdown area using a chemical process. However, the chemical stock at NBO had run out and an order for a restock had not been completed. The KAA stated that they were in the process of inviting tenders for a new supply of chemical as a short-term measure. They also stated their intention to resurface the runway in order to rehabilitate the grip levels in the touchdown area and that, during that work, the runway lighting would be repositioned in order to comply with ICAO Annex 14.

Discussion

The loss of visual references during the flare is a complex event. Sudden changes in RVR can occur due to the natural variability in the density of fog. The phenomenon of rapidly-forming drifting fog during the wet season at Nairobi is not fully understood. In addition, although advisories to pilots caution about such phenomena for certain times of the year it can occur outside those periods, depending on the climatic conditions. A modern instrumented RVR system capable of immediately displaying changing visibility was installed at NBO 18 months before this incident. However, its value was limited as, due to the absence of appropriate training on the AWOS, information from that system was not passed to flight crews and pilot-assessed visibility from several minutes earlier was routinely relayed instead. Therefore the following Safety Recommendation is made:

Safety Recommendation 2009-069

It is recommended that the Air Traffic Controllers at Nairobi International Airport are provided with appropriate training in the use of the Runway Visual Range measuring equipment which is a function of the Automated Weather Observation System installed at the airport.

Despite offers for a photometric survey to be carried out by the UK AAIB, the quality of the lighting at Nairobi could not be scientifically assessed. However, as a subjective observation, the lighting units seen during the AAIB visit appeared to have variable brilliance and their positioning was not in compliance with ICAO Standards. Therefore the following Safety Recommendations are made:

Safety Recommendation 2009-070

It is recommended that the Kenya Airports Authority review their maintenance programme for runway lighting at Nairobi International Airport to ensure that runway lighting quality complies with ICAO Standards.

Safety Recommendation 2009-071

It is recommended that the Kenya Airports Authority take action to ensure that the positioning of the runway edge lights at Nairobi International Airport complies with ICAO Standards.

The Kenya Airports Authority has already indicated its intention to reposition the runway edge lighting as part of broader runway rehabilitation work. In the meantime, until the runway edge lights have been relocated, it would seem prudent to alert operators using NBO of the non-standard positioning of the edge lights. Therefore the following Safety Recommendation is made:

Safety Recommendation 2009-072

It is recommended that the Kenya Airports Authority notify all aircraft operators using Nairobi International Airport of the fact that the runway edge lights are positioned 7.5 m away from the edges of the declared runway surface rather than the maximum of 3 m specified by ICAO.

In this incident, had the deteriorating RVR figures been passed to the crew it is unlikely that they would have made a significant change in their approach strategy as the recorded RVR remained above CAT1 limits. The decision to continue the approach was made at decision height with the required visual references and the autopilot was disconnected for a manual landing. Instances of loss of visual references during the landing phase are relatively rare, but not unknown, and occur due to a variety of causes. In the case of this aircraft it could not be determined whether the loss of visual reference was due to a localised area of denser fog, a localised reduction in the quality of runway lighting, or a combination of both.

Two seconds before touchdown the aircraft was on the ILS centreline with a heading 3° right of the runway heading. Two seconds after the aircraft touched down it had begun to deviate to the left of the localiser, tracking 3° left of runway heading and the thrust levers had been advanced fully. Within this four second period the crew had to recognise that the aircraft was drifting from the centreline, decide whether to go-around and then execute that decision. Although speed of reactions are variable, in the time available, the fact that the commander called for the go-around which then had to be carried out by the PF, makes it likely that the go-around decision was made just before the aircraft touched down. The aircraft continued to deviate to the left of the centreline while the engines spooled up to go-around thrust and the aircraft was brought broadly parallel with runway heading through the application of right rudder pedal.

Go-around training

The UK CAA FODCOM highlights areas which would enhance pilot training. As this FODCOM had only been issued one month before the G-VAIR event, the PF had not had the opportunity to receive the additional training suggested. As such the efficacy of this training in relation to this event cannot be assessed. The FODCOM training does not require a change in visual conditions during the go-around. However, operators who have access to high-fidelity simulation may wish to consider adding this factor into their training programmes as the area of difficulty for this crew, and for the crew involved in the NTSB report referred to earlier, was the loss of visual references almost at the point of touchdown. This could occur due to either changing meteorological conditions or a simple failure of runway lighting. This incident also reinforces the generic advice that crews should remain 'go-around minded' throughout the landing phase.

Runway surface

Of limited consequence to this investigation, the level of contamination seen on the surface of Runway 06 and the lack of any evidence that grip testing had been conducted was of concern. It was considered that the quantity of rubber deposition may reduce the available friction and braking action for landing aircraft on Runway 06, whilst aircraft conducting a rejected takeoff on the reciprocal runway (Runway 24) in wet conditions could suffer a significant loss of braking effectiveness. In the absence of routine grip testing it is unlikely that an airport authority can determine the condition of the runway with regard to either "slippery when wet" or maintenance planning levels. Therefore the following Safety Recommendation is made:

Safety Recommendation 2009-073

It is recommended that the Kenya Airports Authority initiates routine testing to monitor runway friction levels at Nairobi International Airport in order to ensure compliance with the standards required by ICAO.

Conclusions

The aircraft departed the left side of the runway as a result of the PF's rudder pedal inputs during the flare which were made during a period when the crew reported that they lost their visual references. In such cases, at this critical phase of flight, it is important that flight crews can recognise and react in a timely manner to unexpected events. The crew recognised the deviation and carried out the initial actions of the go-around within two seconds of the aircraft touching down. This suggests that the decision to go-around had been made before the aircraft actually touched down. The reason for the loss of visual references could not be conclusively proven, but it was considered that local changes in fog density together with variability of runway lighting quality were a factor. The excursion was contained and damage was limited by the timely application of corrective rudder combined with the decision to go-around. However, the aircraft's left main landing gear did run off the side of the runway for 180 metres.

Training for rejected landings is now routinely carried out by UK carriers both during type conversion and recurrent training and, as such, no further safety recommendations were considered necessary.

ACCIDENT

Aircraft Type and Registration:	ATR 72-202, G-BWDB
No & Type of Engines:	2 Pratt & Whitney PW124B turboprop engines
Year of Manufacture:	1995
Date & Time (UTC):	25 June 2009 at 0925 hrs
Location:	London Gatwick Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 4 Passengers - 36
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to right rear nose landing gear bay door, door actuating linkages and hinges, tow bar shear pin failed
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	59 years
Commander's Flying Experience:	7,437 hours (of which 3,500 were on type) Last 90 days - 109 hours Last 28 days - 62 hours
Information Source:	Aircraft Accident Report Form submitted by the commander, airfield safety reports and further enquiries by the AAIB

Synopsis

During pushback from its parking stand, prior to the aircraft taxiing for departure, a modified bracket on the towbar struck and damaged the rear right door of the nose landing gear bay.

History of the flight

The aircraft was being operated on a scheduled passenger service from Gatwick Airport to Guernsey. ATC cleared the aircraft to pushback from Stand 9, instructing the crew that the aircraft be positioned far enough back on Taxiway M to be able to turn right into Taxiway Z. The commander passed this information to the ground crew headset operator. However, there was a misunderstanding and the tug manoeuvred the aircraft in accordance with a standard pushback, positioning it tail first into Taxiway Z. Realising what was happening, the commander instructed the ground crew to stop the pushback. When the aircraft was stationary, the commander instructed the ground crew to tow the aircraft forward onto Taxiway M, facing south, so that it could be pushed back beyond Taxiway Z, thereby complying with the original ATC instruction. While the aircraft was being repositioned, the tow bar came into contact with the one of the nose gear bay doors and a shear-pin failed on the towbar. The tow was stopped and the headset operator reported the aircraft damage. The commander shut the engines down . The passengers and baggage were returned to the terminal while engineering assistance was sought. Aircraft damage was limited to the nose landing gear right rear door assembly which was removed to allow the aircraft to be flown empty to its base for rectification.

Operator's safety investigation

Investigation by the aircraft operator and ground handling agent determined that an undocumented modification to the tow bar had occurred, probably during the previous evening. The release cable guide bracket, which was located on the top of the towbar, had been bent from the vertical through an angle of about 45°. In its correct configuration this bracket sits between the nose landing gear bay doors, regardless of towing angle. The modified configuration resulted in the bracket striking the right rear door as the towbar was turned through an angle of about 40°-50° from the centreline of the aircraft. As the tow angle increased, the bracket exerted pressure on the nose bay door, which failed along its hinge line, followed by the tow bar's shear-pin.

SERIOUS INCIDENT

Aircraft Type and Registration:	Boeing 747-436, G-CIVK
No & type of Engines:	4 Rolls-Royce RB211-524G2-19 turbofan engines
Year of Manufacture:	1997
Date & Time (UTC):	23 August 2008 at 2120 hrs
Location:	Heathrow Airport, London
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 19 Passengers - 293
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to No 7 wheel bearing, hub and axle
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	50 years
Commander's Flying Experience:	8,500 hours (of which 6,000 were on type) Last 90 days - 185 hours Last 28 days - 36 hours
Information Source:	AAIB Field Investigation

Synopsis

During taxi to Runway 27R, a wheel fire on the incident aircraft was seen by the crew of another aircraft who reported it to ATC. The commander of the incident aircraft brought it to a stop and requested the assistance of the fire service. When the fire service arrived, they saw smoke emanating from the No 7 wheel but no fire. The wheel was removed and the aircraft towed to a stand where the passengers were disembarked.

The cause of the fire was attributed to a failure of the outer bearing in the wheel; this resulted in a loss of support and caused the rotating wheel hub to rub against the axle. The cause of the bearing failure could not be conclusively established, but improper wheel installation, or an inadequate bearing inspection during the last tyre change, were possible factors.

History of the flight

The aircraft was pushed back from stand 407 at 2105 hrs for a flight to Bangkok. The aircraft's weight was 370,200 kg, which was 27,000 kg below the aircraft's 396,893 kg maximum takeoff weight. After engine start, the aircraft taxied on a heading of 045° and then made a left turn to 270° onto Link 44. This was followed by a right turn back to 045° onto Link 43, in order to cross Runway 27L for a departure from Runway 27R. After crossing runway 27L at N4E, and taxiing along Link 29, a pilot from a nearby aircraft reported to the ground controller that a Boeing 747 on his right had a wheel fire.

The commander of G-CIVK established that this report was referring to his aircraft so he immediately requested the airfield fire service to attend and inspect the aircraft. The commander brought the aircraft to a stop at Link 23, about 0.7 miles north-east of the N4E Runway 27L intersection, at 2121 hrs. There were no warnings or cautions notifying the crew of a problem but, when the commander examined the EICAS[1] 'gear' synoptic page, he noticed that there was no tyre pressure reading for the No. 7 wheel and that the brake temperature for the wheel was slightly elevated; indicating level '2', where '0' is cold and '9' is hottest. All the other wheels were indicating normal tyre pressures and a brake temperature of level '0'. The cabin crew were briefed for a possible evacuation.

When the fire service arrived at the aircraft, they saw smoke emanating from the rear outboard wheel of the left body landing gear (the No. 7 wheel) but no fire. The wheel was left to cool while one fire-vehicle remained to monitor the situation. Engineers from the operator arrived at the scene and discovered that the No 7 wheel bearings were missing and that there was extensive damage to the wheel hub and axle. The left body landing gear was jacked up and the damaged wheel removed; the aircraft was then towed to a new stand where the passengers disembarked.

A ground surface inspection by the airport operator revealed that the wheel's hub cap and some bearing rollers were located just north of the N4E Runway 27 intersection, with additional roller bearings and swarf being found further along taxiway Link 29, Figure 1. These parts were collected and passed to the aircraft operator. No debris was reportedly found on Runway 27, although a sweeper was used to clean the area and the taxiways after the incident and any debris collected was lost. Approximately six aircraft landed on Runway 27 between the time that it was crossed by G-CIVK and the time that the runway was closed for inspection.

Wheel installation

The main wheels on the Boeing 747-400 are mounted on the axle as shown in Figure 2. The Tyre Pressure Indication Sensor (TPIS) and hub cap are omitted from this diagram. When the wheel is delivered to the operator the bearings, grease seals and retaining rings are already installed inside the wheel. The operator slides the wheel onto the axle and then adds the washer and tightens the axle nut. Both the inner and outer bearings are tapered roller bearings and the outer race or 'cup' of each bearing is a press-fit inside the wheel hub and remains inside the hub when the tyre is replaced by a wheel maintenance organisation. The inner race and roller bearing cage or 'cone' of each bearing is removed during each tyre change, inspected and, if deemed serviceable, re-greased and re-installed in the wheel.

The Aircraft Maintenance Manual (AMM) for the wheel installation specifies that an initial axle nut 'seating torque' of 450 to 525 lb.ft is to be applied with the axle washer properly seated against the axle shoulder, in order to seat the bearing cups and cones into their respective abutments and seats. The wheel should be rotated by hand when applying the seating torque, then stopped and the nut loosened to 10 to 100 lb.ft, before being rotated again while applying the final 'flying nut torque' of 150 to 250 lb.ft. Two lockbolts are then inserted to prevent loosening of the nut and, if necessary, the nut can be tightened to a maximum of 250 lb.ft in order to align the lockbolt holes.

Footnote

[1] Engine Indication and Crew Alerting System (EICAS) is a digital multi-function display.

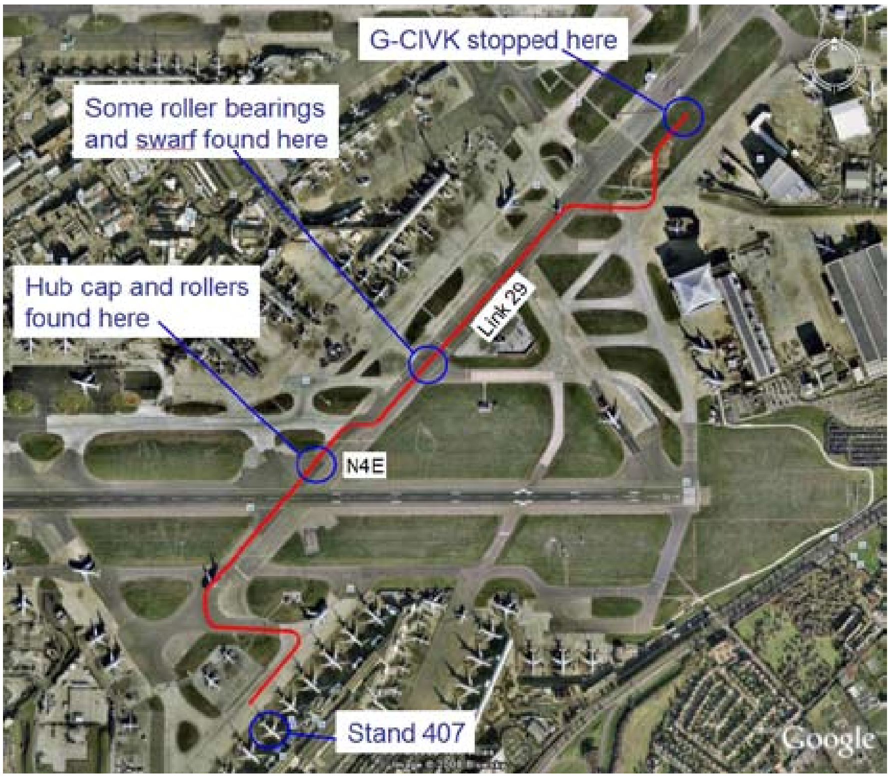

Figure 1

Estimated aircraft ground track based on starting position, the Flight Data Recorder heading parameter and eyewitness reports. The radii of turns are not representative. (Grass is depicted in the area that G-CIVK stopped, but a new taxiway now exists in this area.)

Google Earth™ mapping service / © 2008 TerraMetrics / © 2008 Infoterra Ltd & Bluesky

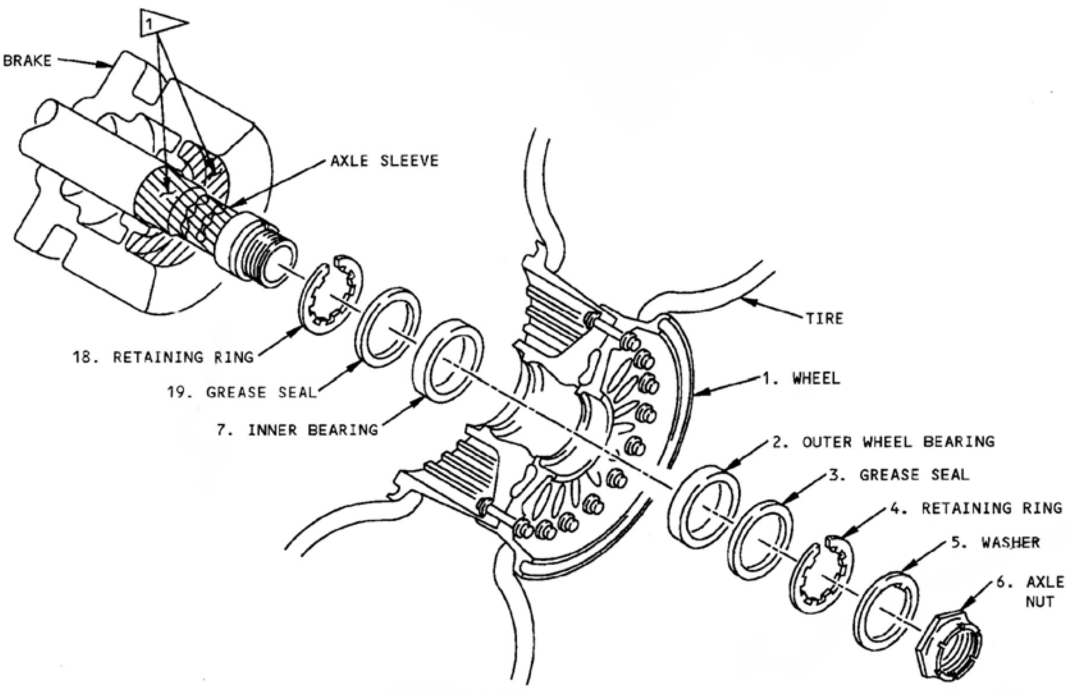

Figure 2

Boeing 747-400 main wheel bearing installation diagram

Examination of the damage

The debris recovered from the taxiways included the hub cap, part of the TPIS in-axle assembly with a severed cable, rollers, parts of the retaining rings and broken pieces of outer bearing cone. The axle nut was found seized to the axle. Both axle nut lockbolts were reportedly in place and were removed by the operator's engineers, although one of these was subsequently lost. The remaining lockbolt was bent with a sheared shank, indicating that it was installed at the time of the failure. The washer was in place but had been flattened, Figure 3. The upper surface of the axle sleeve was in good condition but the lower surface had been partially abraded away; discolouration associated with high temperatures and evidence of molten metal was present, Figure 4. There were large deposits of molten aluminium alloy from the wheel hub inside the brake-liner heat shield, and the wheel hub was extensively damaged with loss of material both inside and around the outside hub circumference, Figure 5. The section of inner wheel hub that would have supported the inner cone had been completely removed. There was no evidence of inner bearing rollers or cage material inside the hub, although the inner bearing cone was found intact around the axle. There were no remains of outboard bearing rollers, roller cage or cone inside the wheel, although the outboard wheel bearing cup was still in place in the outboard hub, and this exhibited significant surface erosion

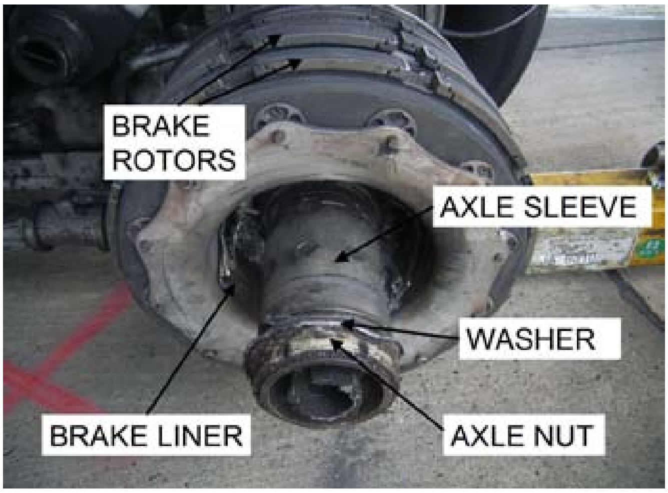

Figure 3

Damage to wheel axle

Figure 4

Damage to wheel axle underside (6 o'clock position)

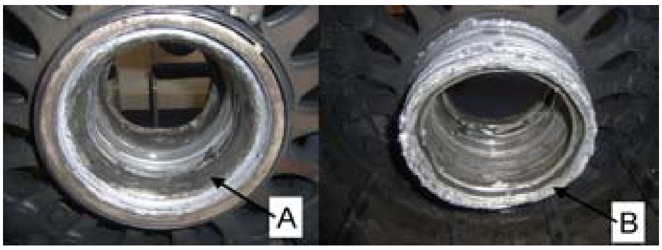

Figure 5

Left: Outer wheel hub showing remains of outer bearing cup (A).
Right: Inner wheel hub showing that at (B) the inner bearing hub support and inner bearing cup are missing.

Recorded data

The Cockpit Voice Recorder (CVR) recording for the incident had been overwritten, but the Flight Data Recorder (FDR) contained data for the incident. The FDR had recorded the aircraft's groundspeed and heading from which the approximate ground track in Figure 1 was established. The data showed that the No 7 wheel tyre pressure was indicating 200 psi (normal) during the pushback, and then the signal was lost about 1 minute and 15 seconds after start of taxi. This loss of signal occurred at the end of the aircraft's first turn from a heading of 045° to a heading of 270°. Since this loss of signal was attributed to the severing of the TPIS cable, it was established that the failure occurred during or prior to the first taxi turn, and therefore prior to the aircraft crossing Runway 27L. The peak lateral acceleration during this turn was recorded at -0.1g at a groundspeed of about 10 kt. Five and a half minutes later, at time 2116:50, the No 7 wheel brake temperature started to rise from level '0' to level '2'. There were no other abnormal indications in the data.

The Quick Access Recorder (QAR) contained data for the aircraft's previous 12 landings. These were analysed by the AAIB and by the aircraft manufacturer. The highest peak normal acceleration at touchdown was 1.31 g, and this occurred during the aircraft's last landing. This corresponded to a sink rate at touchdown of 2.9 ft/sec. The highest peak lateral acceleration at touchdown was 0.24 g, and this occurred during the seventh-last landing during a crosswind. The aircraft manufacturer concluded that all of the landings analysed were within the normal range of touchdown acceleration and sink-rate parameters, and would not have contributed to a wheel bearing failure. The aircraft operator later carried out further analysis, using their stored data system, and were able to study the aircraft's landings dating back to 20 May 2008, when the No 7 wheel was installed. None of these landings exhibited vertical or lateral accelerations at touchdown that were significantly above normal.

Maintenance history

The aircraft had accumulated 53,549 hours and 6,012 cycles at the time of the incident. The subject wheel had been installed on the aircraft in the No 7 position on 20 May 2008, which was 95 days prior to the failure. During this period, the aircraft completed 134 cycles. The only recorded maintenance on the wheel after 20 May 2008 was the replacement of its TPIS sensor, and this would not have involved disturbing the axle nut or any part of the wheel installation.

The maintenance records for the wheel in question revealed that it was removed for the first time since new from aircraft G-CIVO, on 15 April 1998. As this aircraft was first registered on 5 December 1997, the wheel had been in service for about 11 years at the time of the failure. Between 15 April 1998 and the date of the incident, the wheel had been returned to a workshop for a tyre change on 26 occasions. The wheel itself had been overhauled twice, once on 27 November 2000 and again on 12 September 2004. On 26 February 2007, the wheel was returned for an 'IRAN' (Inspect and Repair As Necessary) occurrence, which could have been necessary because of a problem with the tyre, other than normal wear. The last tyre change occurred on 17 May 2008, three days prior to the wheel's installation on G-CIVK. The records did not reveal any history of abnormalities with the wheel, any bearing cup or cone changes, or of any repairs having been carried out in the bearing boss area. Thus, it was apparent that the bearings had probably been in service in the same wheel since 1997. The bearing parts are 'on condition', and therefore do not have a life limit.

Detailed examination of failed bearings

The wheel hub and bearing remains were taken to the aircraft operator's wheel workshop for detailed examination, under the supervision of the AAIB and an investigator from the bearing manufacturer. A total of 37 rollers were recovered and examined out of a total of 73 rollers; 37 are used in the inboard bearing and 36 in the outboard bearing. The rollers for the inboard bearing and the outboard bearing had the same part number, but it was possible to separate the rollers into two groups on the basis of a batch mark indentation (shaped like a house) present on some of their ends. This indentation revealed that the rollers were from a batch manufactured in 1995. The rollers without the indentation mark were blackened, and exhibited evidence of high temperature exposure and some minor plastic deformation (the lower row in Figure 6). Some of the rollers with the indentation mark were relatively undamaged and had not been exposed to high temperatures; others exhibited crushing damage (the upper row in Figure 6). The sliding ends of both sets of rollers were in good condition, which is an indication that lubrication was present. Also, the roller bodies had not elongated, which is an indication that failure occurred rapidly and at relatively low rotational speed.

Figure 6

Some of the recovered rollers from the outer bearing (lower image) and inner bearing (upper image)

Figure 7 shows new rollers installed in their cage and fitted around the cone.

The outer bearing cone had fractured into six large pieces (left image in Figure 8) and its race surface exhibited evidence of elevated temperatures. The inner bearing cone was recovered intact from the axle and did not exhibit evidence of elevated temperature (right image in Figure 8). The original ground surface was visible with

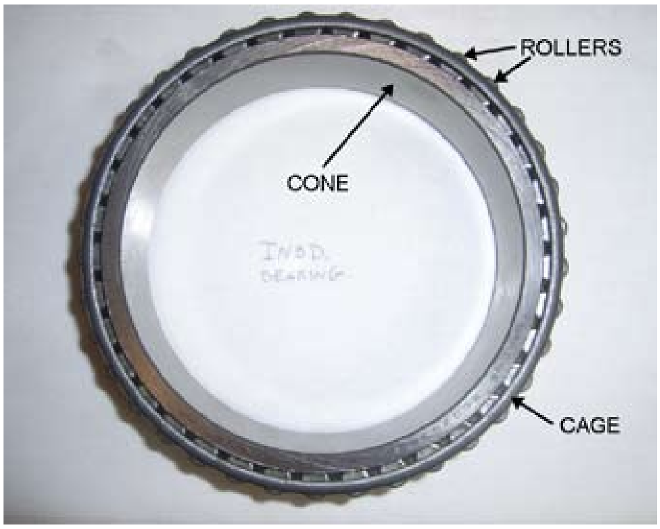

Figure 7

Example of a new inner bearing showing the cone, rollers and cage

deposits of smeared steel, probably originating from the cup, and smeared aluminium from the wheel hub. On the basis of the bearing cone evidence it was established that the rollers with the elevated temperature characteristics were from the outer bearing and the rollers without the elevated temperature signatures were from the inner bearing.

The bearing manufacturer's report concluded that the outer bearing was the first to fail, because the first bearing to fail normally generates the most heat, and that the failure probably occurred due to the outboard bearing cage becoming trapped between rollers and the rotating cup. The report stated that:

Figure 8

Damaged outer bearing cone (left) and inner bearing cone (right)

'This allowed the rollers to be released from the cage at low rotational speed. The absence of the rollers caused the cone to spin on the axle sleeve as the result of friction between the cone, a few trapped rollers and ultimately contact with cup and wheel. This friction generated heat and caused mechanical damage to the cone. The disintegration of the bearing allowed the wheel to collapse onto the brake pack and migrated outward, putting extreme loads onto the inboard wheel hub, subsequent overturning loads on this sliding aluminium to brake pack surface fractured the inboard cup support from the wheel.'

The report further stated that the known causes for a wheel bearing cage to become trapped between rollers and rotating wheel hub/cup were, in order of probability, as follows:

'1. Low axle nut torque – or incorrectly applied nut torque resulting in very small bearing load-zone and abnormal cage stress.

2. A bearing with a severely worn cage being returned to service.

3. Lack of grease causing roller wear and cage wear.

4. Massive radial shock load – very heavy landing.'

Examination of the wheel hub

The wheel hub was examined by the wheel manufacturer's metallurgical laboratory to determine, for example, if a fatigue crack in the inner bearing bore area had contributed to the bearing and hub failure. Following this examination, the manufacturer stated that they could not determine the actual pattern of failure of the structure supporting the inner bearing. However, they had not previously experienced any problems with fatigue cracking in that area and the wheel type had existed virtually unchanged in geometry since 1989. They said that if there had been a likelihood of fatigue cracking, they would have expected to have already witnessed such occurrences in older wheels.

Wheel bearing inspection process

The incident wheel's last two tyre changes had been carried out by a component engineering company that was relatively new to wheel maintenance. The company began maintaining Boeing 737 wheels in November 2007 and, in January 2008, took on maintenance of Boeing 747-400 wheels. The company had carried out the last two tyre changes on the incident wheel on 30 January 2008 and 17 May 2008 respectively.

When a 747-400 wheel arrives at the company for a tyre change, the inner and outer bearing cones are removed for cleaning and inspection, while the cups are cleaned and inspected in-situ. A detailed inspection of the rollers and cage is carried out prior to re-greasing and re-fitting to the wheel. The wheel hub also undergoes an NDT[2] inspection. The company's common practice is to keep the same cups and cones together, even though the component maintenance manual permits 'mix and matching'. The technician who carried out the last inspection of the bearings on the incident wheel had previously been a pneumatics engineer and had started his training on 'wheels and brakes' in October 2007. He completed the required one-day manufacturer's bearing inspection course on 1 November 2007. The

Footnote

2 Non-Destructive Test (NDT).

bearing was also inspected and then installed in the wheel by a mechanic who had 10 years experience of working with wheel bearings for a previous employer.

The bearing inspection process in the wheel Component Maintenance Manual (CMM) calls for visual inspection of the bearing cup race, cone race, roller surfaces, cage, and inner diameter of the bearing cone. It includes diagrams showing examples of spalled areas on the rollers and race, and score marks on the ends of rollers that would result in a part being rejected. It also requires a check for nicks, dents, scratches, etched surfaces, stains and pitting, with references to what would be considered acceptable and what would require rejection. The CMM does not contain a 'cage shake test', which involves rotating the cage around the cup by hand and checking for play. The bearing manufacturer trains personnel to carry out a 'cage shake test' and, although they consider this to be an important test, it was not included in the CMM. However, the wheel maintenance company said that, despite this, they do conduct the test.

Following this investigation, the wheel manufacturer stated that they would amend their CMM to include the 'cage shake test', but that they did not believe the lack of this inspection would have contributed to the G-CIVK incident.

Wheel installation process

As previously mentioned, the wheel installation process involves first applying a 'seating torque', then loosening the nut and re-tightening to the 'final flying torque'. The aircraft manufacturer's AMM specified that the wheel should be rotated by hand during the tightening process but that the wheel should be stopped before the loosening process. However, the bearing manufacturer stated that it was also important to rotate the wheel during the loosening process. Information received from the bearing manufacturer stated that:

> *'Wheel rotation between the higher seating torque and the lower final torque is important. If this is not done, the bearings could be re-clamped at the higher seating torque value which could lead to roller end scoring and is cause for removal from service.'*

The operator of G-CIVK carried out wheel installations in accordance with the aircraft manufacturer's AMM and therefore did not rotate the wheel during loosening.

The aircraft manufacturer was contacted regarding the bearing manufacturer's recommended wheel installation procedure, but their view was that fleet experience did not justify any immediate revisions to the AMM procedure. They did not believe that the root cause of the G-CIVK incident was related to not having rotated the wheel during loosening. However, they stated that they would remain open to consideration of any further in-service data relating to the perceived advantages of rotating the wheel assembly while relieving the torque.

Previous 747-400 wheel bearing failures

The operator of G-CIVK had no record of any previous wheel bearing failures on their fleet of Boeing 747-400s. One incident occurred on a Boeing 767 in July 2006, where a wheel bearing failed, but this was attributed to the wheel having been installed without the washer. The aircraft manufacturer was contacted regarding previous Boeing 747-400 wheel bearing failures. They reported that they were aware of a few incidents where cracks in bolt holes were discovered during wheel overhaul, but not of any similar incidents to that of G-CIVK. In

July 2006, a main gear wheel separated from a 747-400 in flight, but this was caused by the axle nut lockbolts backing out of the axle nut and allowing the axle nut to loosen. In that case, it was suspected that the lockbolt/nut combination was being reused to the point where the self-locking feature of the nut was compromised.

Analysis

The AAIB investigated this incident as a serious incident due to the possibility of the aircraft having become airborne without the wheel failure being noticed. The flight crew were unaware of the problem during taxi, until the crew of another aircraft reported seeing a wheel fire. Had it been daylight, any flames might not have been as readily noticeable and it was possible that this could have resulted in the aircraft getting airborne with a wheel-well fire. There was an additional potential hazard to ground personnel in that the wheel could have detached after takeoff. Also, had any wheel or bearing debris been deposited on the runway, a further hazard would have been posed from FOD to landing and departing aircraft.

The evidence from the TPIS sensor failure on the FDR indicated that the bearing failure probably occurred during or prior to the first taxi turn, and therefore prior to the aircraft crossing Runway 27L. High landing gear/wheel loads can be imposed during push-back, so it is also possible that the failure initiated at that time. The FDR and QAR evidence from previous landings did not indicate that any abnormal loads had been sustained in its recent history, so operational factors were unlikely to have contributed to the failure of the wheel/bearings.

It was possible that the failure could have been initiated by a crack in the wheel hub, but no evidence or history of such a failure could be found. It was, therefore, most probable that failure initiated at a wheel bearing. The outer wheel bearing cone and rollers had experienced abnormally high temperatures, whereas the inner bearing cone and rollers had not; this suggested that it was probably the outer bearing that failed first. There was insufficient evidence to determine conclusively the cause of the outer bearing failure but, based on previous experience of bearing failure examinations, the bearing manufacturer thought that it was probably initiated by the cage becoming trapped between rollers. Four possible causes for this were cited: (1) low or incorrectly applied axle nut torque, (2) a worn cage being returned to service (inadequate inspection), (3) lack of grease causing roller or cage wear, and (4) a very heavy landing.

The FDR and QAR data discounted a very heavy landing as the cause. A lack of grease was a possibility, although the roller sliding ends were in good condition which is an indication that sufficient lubrication was present. Therefore, the most likely causes were incorrect wheel installation or an inadequate bearing inspection during the last tyre change.

The wheel was installed 95 days prior to the incident, so it was not possible to get an accurate recall of how the wheel was installed. The physical evidence revealed that the washer was correctly installed and the axle nut appeared to be in the correct position. It was also considered that at least one, if not both, lockbolts were installed. If there had been a gross under-torque during wheel installation, the wheel bearings would not have lasted for 134 cycles over the 95 day period; failure would normally have occurred immediately. However, it was considered possible that a bearing with a 'flying nut torque' that was slightly below requirements might incur damage and not fail until after a high number of cycles.

The second most likely possibility was that the bearing was returned into service during the last tyre change with a defect that went undetected. The technician who carried out the inspection was relatively new to the job, as was the company he worked for. Nevertheless, he had completed all the required training and there were no indications that there were issues with his workmanship. Furthermore, the mechanic who installed the bearing had significant wheel bearing experience with a previous employer.

The 'cage shake test' was missing from the wheel CMM, but the technician had been trained to carry out this test and it was company policy to carry out this test, so the fact that the procedure was missing from the CMM was probably not a factor in the incident. The wheel bearing manufacturer and aircraft manufacturer disagreed over the wheel installation requirement to rotate the wheel during loosening, and this could be a factor in premature wear of components, but there was insufficient evidence to indicate that it was a factor in this incident.

SERIOUS INCIDENT

Aircraft Type and Registration:	Boeing 757-2T7, G-MONK
No & Type of Engines:	2 Rolls-Royce RB211-535E4-37 turbofan engines
Year of Manufacture:	1988
Date & Time (UTC):	13 December 2008 at 1045 hrs
Location:	On approach to London Gatwick Airport, West Sussex
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 8 Passengers - 78
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	10,350 hours (of which 6,750 were on type) Last 90 days - 81 hours Last 28 days - 23 hours
Information Source:	AAIB Field Investigation

Synopsis

During an approach, in demanding weather conditions, the crew inadvertently left the speedbrakes deployed with the auto-throttle disengaged; the aircraft's speed decayed until the stick shaker activated. The Quick Reference Handbook (QRH) actions for stick shaker activation were not completed properly and during the go-around the speedbrakes remained extended. Subsequently, the Flight Director Pitch Bars disappeared from the Primary Flying Displays (PFDs) and the commander became disorientated. He handed over control to the co-pilot and stowed the speedbrakes realising that they were still deployed. The crew subsequently completed an uneventful ILS and landed safely.

History of the flight

The commander and co-pilot reported for duty at 0430 hrs for a return flight from Gatwick (LGW) to Innsbruck. They had flown together previously and each had a high regard for the other's abilities. For the commander this was his first flight in three weeks, and for the co-pilot his first flight in two weeks. During the previous week, the crew had both flown simulator checks on the procedures for Innsbruck.

The operator required the commander to perform both the landing and the takeoff at Innsbruck. It was therefore decided that the co-pilot would be the pilot flying (PF) for the outbound leg from LGW, handing over to the commander for the landing at Innsbruck. The commander would then be the PF for the return leg and the approach, with the co-pilot performing the landing at LGW. Having checked the weather information, the crew decided on a 30 minute delay to ensure that the weather was suitable for their arrival at Innsbruck. The outbound flight from LGW, the turnaround and departure from Innsbruck were all uneventful and the aircraft was back on schedule as it approached LGW.

The weather was wet and windy; the surface wind was recorded as 14 kt gusting to 26 kt from the south east. Runway 08R was in use, and aircraft were being radar vectored to intercept the ILS from the south. The wind at 2,000 ft was 50 kt from the south.

At 1040 hrs, ATC advised the crew that they had 28 track miles to run. The aircraft was becoming a little high on the approach profile so the co-pilot reminded the commander about the strong tailwind on base leg; the commander deployed the speedbrakes.

At 1044 hrs, the final approach controller asked the crew to slow to 180 kt and, shortly afterwards, gave them instructions for the final turn to intercept the ILS. This instruction was issued when the aircraft was approximately 8.5 nm from touchdown and displaced 2.4 nm to the south of the ILS centreline; the Mode S showed the aircraft's speed as 190 kt at this time[1]. There was a pause of a few seconds before the aircraft began its turn, following which it was cleared to descend to 2,000 ft, and then to descend further with the ILS.

The commander tried different autopilot modes in an attempt to reduce the airspeed, but the aircraft was high on the approach profile. The crew therefore lowered the landing gear to increase the aircraft's drag and subsequently its rate of descent. The co-pilot then prompted the commander that the localiser (LOC) selection on the Mode Control Panel (MCP) had not yet been armed. As soon as it was selected, the autopilot captured the localiser; however, it was too late to prevent the aircraft from flying through the ILS centreline. Localiser capture however, was still active and the autopilot turned the aircraft onto a heading of 145° to intercept the ILS centreline from the north.

The commander was now concerned that, as he should not capture the glide slope until fully established on the localiser, the autopilot would go into ALT CAPTURE mode and level the aircraft at 2,000 ft. To prevent this from happening he disconnected the autopilot and flew the aircraft manually onto the ILS, whilst the co-pilot changed the radio to the tower frequency, reset the MCP altitude and signalled the cabin crew to take their seats for landing. The commander then instructed the co-pilot to re-engage the autopilot. As the co-pilot was concerned that the airspeed was decaying below the Flap 5 speed, he prompted the commander, and selected Flap 20.

A short time later, the stick shaker activated. The commander immediately lowered the aircraft's nose and increased engine thrust. The airspeed increased and the stick shaker stopped, but the crew decided that the best cause of action was to go-around. The commander therefore ordered a go-around and pressed the Take-Off Go-Around (TOGA) button.

The commander increased the pitch attitude, the co-pilot called a 'positive climb' but the commander did not respond. After repeating the call, the co-pilot raised the landing gear and advised ATC that they were

Footnote

[1] The preceding aircraft had been given the same turn from a position of 9 nm from touchdown and displaced by 2.7 nm, with a Mode S speed of 180 kt, enabling the aircraft to intercept the localiser directly.

going around. The commander called for Flap 5 but the co-pilot cautioned that the speed was still too low. The commander was now becoming confused as the aircraft attitudes did not appear normal, and the aircraft was not responding in the usual manner. The Flight Director pitch guidance had disappeared from the commander's and co-pilot's PFDs and, aware that he was becoming disorientated and that the co-pilot seemed to have a better situational awareness, he instructed the co-pilot to take control. The co-pilot did so and lowered the nose.[2] The commander subsequently realised that the speedbrakes were still extended and retracted them.

The second approach was initially flown by the co-pilot, but control of the aircraft was handed back to the commander for the landing, who, by then, had regained his situational awareness.

Recorded information

The Flight Data Recorder (FDR) was removed from the aircraft and taken to the AAIB to be downloaded and analysed. The recordings on the Cockpit Voice Recorder (CVR) during the incident had been over written with more recent recordings.

Data downloaded from the FDR is shown in Figure 1. The data starts about 30 seconds after both the autopilot and auto throttle have been disengaged on the approach to LGW. The aircraft is at 2,400 ft pressure altitude, descending at 140 kt computed airspeed and slowing with the flaps extending to Flap 20 and the speedbrakes out. The engines are at a nominal Engine Pressure Ratio (EPR) of 1.10 and nose-down pitch trim was being manually applied.

As the flaps reached Flap 20, the autopilot was re-engaged. The aircraft continued to descend and slow; however, no further nose-down pitch trim was applied apart from one small burst (ie less than one second in duration). The pitch attitude then started to increase, from a nominal 7º nose-up, reaching 10º about 13 seconds later as the airspeed slowed to 123 kt. The angle of attack (alpha) was also increasing, and as the pitch reached 10º, the rate of increase for both alpha and pitch rose sharply. As alpha passed through 10.3º (the stall warning threshold for Flap 20), at a height of about 1,000 ft, the stick shaker activated and the autopilot disengaged. The stick shaker stayed active until the aircraft's pitch attitude was reduced and thrust applied: it was active for no more than two seconds. The speedbrakes remained extended.

About six seconds later, with the speedbrakes still out and as the aircraft accelerated to about 150 kt, the TOGA button was pressed. The aircraft continued to accelerate to 158 kt before slowing as it pitched up and climbed away. During the climb the maximum recorded nose-up pitch attitude was 28º (although the alpha was only about 2º) and the minimum recorded airspeed was 125 kt. The rest of the climb was uneventful, and, as the aircraft passed through 3,600 ft pressure altitude, the speedbrakes were retracted; 70 seconds after the stick shaker first activated.

Flight crew training records

An examination of the flight crew training records showed that both pilots were appropriately qualified and licensed and that they normally operated the aircraft to the required high level of proficiency. The commander had, until recently, been employed by the operator as a line training captain.

Footnote

2 At this point the crew thought that the stick shaker had activated again, but there was no evidence of this on the Flight Data Recorder.

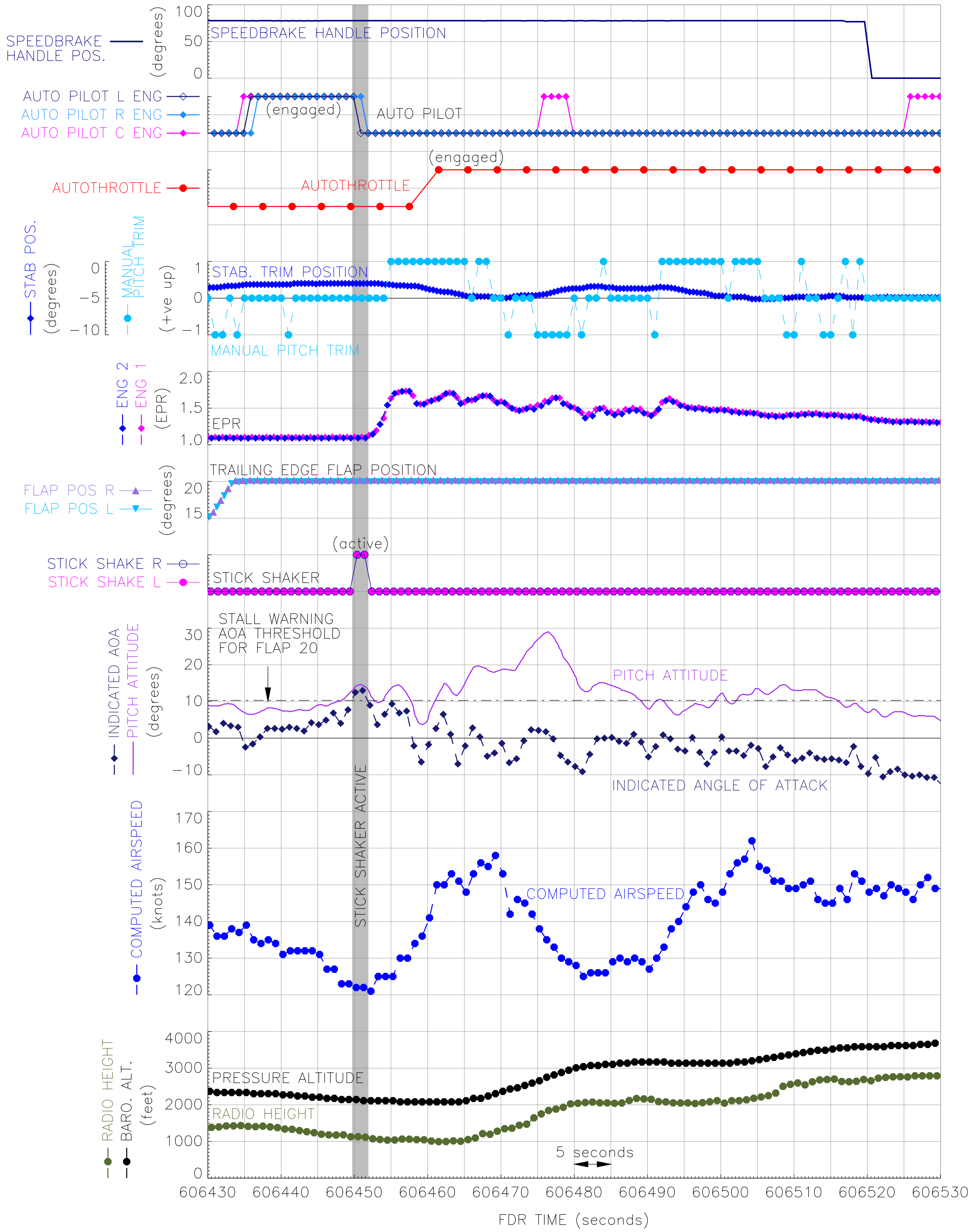

Figure 1

Salient FDR Parameters for the serious incident to G-MONK

Speedbrake warning

The Boeing 757 aircraft was originally fitted with a warning system that provided an EICAS message ("Speedbrakes EXT") when the commander's radio altitude indication was between 800 ft and 15 ft, and the speedbrake lever was beyond the ARMED detent. No warning of speedbrake extension, based on thrust lever position, was provided.

The Flight Crew Training Manual for the aircraft contains the advice:

> *'the PF should keep his hand on the speedbrake lever whenever the speedbrakes are used in-flight. This will preclude leaving the speedbrake extended.'*

In 1999, Boeing modified the speedbrake alert system for all B757s built after June 1999, to include a warning light whenever the speedbrake lever is beyond the ARMED detent and the engine thrust lever is forward of the flight idle position for more than 15 seconds. Boeing considered a retroactive change to the fleet, but this was not implemented.

As a part of this investigation, the AAIB conducted a survey of UK B757 operators that record, as part of their Flight Data Monitoring programmes, incidents where the speedbrakes are deployed whilst the engines are producing significant thrust. It is unlikely that the speedbrakes would be intentionally deployed with the engines set above flight idle; therefore, this would give an approximate indication of how often the speedbrakes are inadvertently left out on the B757. On approximately 1% of the sectors covered by the survey, at some stage during the flight, crews were using the speedbrake 'against power'.

Stick shaker

The B757 Flight Crew Operations Manual, Non-Normal Manoeuvres section, requires certain actions to be accomplished immediately at the first indication of pre-stall buffet or stick shaker. These actions include for the PF to *'Retract the speedbrakes'* and for the pilot monitoring (PM) to '*verify all required actions have been completed and call out any omissions'*

Flight Director Guidance

During a go-around with the localiser captured, the Flight Director roll bar will give directions to maintain the runway track. The pitch mode, after a positive rate of rotation and a positive vertical speed is achieved, should give guidance to maintain the selected MCP speed. The autothrottle will adjust the thrust levers to achieve a rate of climb of 2,000 fpm.

Boeing reviewed the FDR data and conducted various tests, but they were unable to explain why, during the go-around, the Flight Director Pitch Bars disappeared from both the commander's and co-pilot's PFDs

Simulator Assessment

The AAIB, with the assistance of an experienced B757 Type Rating Examiner (TRE), reviewed the approach and go-around in a simulator. The following was observed:

- The aircraft adopted a 15º nose-up pitch attitude in the climb during a normal 'autopilot engaged' go-around from just above stick-shaker speed. This increased to 20º with the speedbrakes extended.

- The autopilot applied approximately 11 units of nose-up trim during a go-around from a speed just above stick-shaker operation. A significant forward force was required to maintain the desired pitch attitude when the go-around was flown with the autopilot disengaged. In this circumstance, when control was handed over from one pilot to another, there was a significant risk of the pitch attitude increasing.

- Flying a go-around with the speedbrakes extended felt abnormal to the TRE, as the power and attitude required were unusual.

Comment

This incident developed during a rushed approach, putting the crew under increasing pressure. However, having allowed the aircraft to slow to a speed where stick shaker activation occurred on final approach, the situation was recovered by the commander making best use of the resources available to him by handing over control to the co-pilot, who retained his situational awareness throughout.

The crew considered that stick shaker activation had resulted from low airspeed on final approach. This was caused by a combination of the autothrottle being deactivated when the autopilot was disengaged and the speedbrakes being left extended. Disengaging the autothrottle had not been the commander's intention, but more a 'force of habit', as the autothrottle is normally disengaged together with the autopilot when landing. When he asked for the autopilot to be re-engaged, he was unaware of the status of the autothrottle.

INCIDENT

Aircraft Type and Registration:	Boeing 777-268ER, HZ-AKC
No & Type of Engines:	2 General Electric GE90-90B turbofan engines
Year of Manufacture:	1997
Date & Time (UTC):	11 February 2009 at 1810 hrs
Location:	Stand 319, London Heathrow Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 14 Passengers - 114
Injuries:	Crew - None Passengers - None
Nature of Damage:	Minor damage to door L2
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	49 years
Commander's Flying Experience:	15,065 hours (of which 6,029 were on type) Last 90 days - 181 hours Last 28 days - 50 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft was parked on Stand 319, with the parking brake set and the passengers disembarking, when the aircraft began to roll backwards. Pressure in the parking brake system had dissipated causing a loss of brake application. The right hydraulic system AC electric pump was activated and this reinstated the hydraulic brake pressure, which brought the aircraft to a stop.

A failure of the parking brake valve was identified as the cause of the loss of hydraulic pressure in the parking brake system.

History of the flight

The aircraft arrived on Stand 319 at London Heathrow Airport and stopped in the correct parking position. The parking brake was selected ON and both main engines were shut down, with the Auxiliary Power Unit supplying the aircraft electrical and environmental services. The ground engineer connected his headset to the aircraft intercom system and noted that the amber 'parking brake set' light on the nose landing gear was illuminated.

The normal operating procedure when an aircraft is parked on a stand is for wheel chocks to be placed in front of and behind the nose landing gear wheels. Due to two stand changes, the chocks, which were supplied by the ground handling agent, did not arrive. The ground engineer asked the aircraft commander if positioning the jetty to the aircraft and disembarking the passengers with the brakes set, without chocks in place, was acceptable. The commander ensured that the parking brake was ON and that the Engine Indicating and Crew Alerting System (EICAS) message confirming this was displayed. He then agreed to the ground engineer's request and the jetty was placed against door L2 in the normal way. The door was opened and disembarkation of the passengers was commenced.

When approximately 10 passengers and all of the crew were left onboard, the aircraft began to move slowly backwards. The ground engineer notified the operator's maintenance manager, who was on the jetty, of the movement. He boarded the aircraft and entered the flight deck. Both pilots were in their seats carrying out post-flight activity and were unaware that the aircraft was moving. The maintenance manager selected the right hydraulic system to AUTO, which activated the right hydraulic system AC electric pump; this re-pressurised the right hydraulic system, applied the parking brake and stopped the aircraft. The aircraft had moved backwards approximately two metres, exposing the open door. The jetty structure made contact with the side of the door causing a minor abrasion to its surface.

Parking brake system

The parking brake utilises hydraulic pressure supplied by the right hydraulic system. The nominal 3,000 psi pressure is provided by an engine-driven hydraulic pump mounted on the right engine accessory gearbox. With the engine shut down, a hydraulic accumulator maintains pressure in the parking brake system. A secondary source of hydraulic pressure can be provided by a pump powered by the aircraft's AC electrical system. A brake pressure indicator gauge is located on the flight deck below the commander's Primary Flight Display (PFD) screen. This allows the crew to monitor the system and accumulator pressure. The gauge is also fitted with a BRAKE SOURCE caption which illuminates when there is no pump pressure. Two non-return valves and an accumulator isolation valve are designed to prevent hydraulic fluid leaking back into the system and pressure being lost.

Maintenance action

The aircraft was taken out of service and engineers using the Boeing Fault Isolation Manual determined that the parking brake valve was defective. The valve component was changed and a pressure decay test was carried out. The test was successful, which confirmed the failure of the original valve. The engineers were informed that there may have been a previous problem with loss of accumulator pressure on the aircraft but this could not be verified.

Safety action

Following the incident, the operator introduced a requirement that their engineering vehicle would carry a set of chocks when attending an aircraft that was parking on a stand, in addition to the ones provided by the ground handling agent.

Analysis

The flight crew had applied the parking brake, confirmed that the brake was set and that the accumulator pressure was normal with the BRAKE SOURCE light extinguished. There was no requirement to continuously monitor the indicator and no audio alert if pressure in the accumulator reduced. With the post-flight activity, the crew did not notice the loss of pressure or the gentle aircraft movement. The maintenance manager's prompt action in activating the right hydraulic system AC electric pump prevented any further rearwards movement of the aircraft.

The parking brake valve was identified as the cause of the pressure loss in the right hydraulic system. This incident illustrated the need for wheel chocks to be in place when an aircraft is parked. The operator has instigated a safety action to ensure that wheel chocks are always available when one of their aircraft arrives on stand.

INCIDENT

Aircraft Type and Registration:	BN2A Mk.III-2 Trislander, G-RLON
No & Type of Engines:	3 Lycoming O-540-E4C5 piston engines
Year of Manufacture:	1975
Date & Time (UTC):	24 March 2009 at 0758 hrs
Location:	Jersey Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 1 Passengers - 15
Injuries:	Crew - None Passengers - None
Nature of Damage:	Forward baggage bay door missing
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	56 years
Commander's Flying Experience:	5,133 hours (of which 1,596 were on type) Last 90 days - 123 hours Last 28 days - 41 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

Shortly after taking off, the nose baggage bay door OPEN warning light illuminated. The commander initiated a turnback but, while over the sea, the door separated. The aircraft landed safely. In the absence of any physical evidence from the door and its latch, it was not possible to conclude the exact cause of the separation. However from an inspection of the operator's other aircraft some wear was identified in the door latching mechanism. The manufacturer has subsequently issued a Service Bulletin which specifies an inspection of the door latching mechanism.

History of the flight

The aircraft was departing from Runway 27 at Jersey when, as the aircraft rotated, the commander noticed the nose baggage bay door OPEN warning light was illuminated. He decided to continue the take-off but, at around 200 ft, the commander saw the door open. He requested an immediate return to the airfield, and flew a 'teardrop' pattern to land on Runway 04. During the turnback, whilst over the sea, the baggage bay door separated from the aircraft. The commander continued the approach and the aircraft landed safely.

Description of baggage bay door and examination

The upward-opening nose baggage bay door is located on the left side of the nose of the aircraft and is hinged at the top (see figure below). It is secured at the lower edge by shoot bolts which engage at the front and rear of the door. When the handle is rotated from the outside, a square drive turns an eccentric lever plate which engages the shoot bolts into their locks (marked D in the figure below). Rotating the lever also engages a bottom lock (marked C).

A licensed engineer was sent to examine the aircraft and noted that the door hinges were still attached, but the complete door, with the handle mechanism and the shoot bolts had separated. The door had first struck the left windscreen, leaving scratch marks, and then contacted the left propeller spinner causing a slight dent, before finally striking the rear face of one of the left propeller blades and its de-ice boot.

Safety action

Initial enquiries made by the operator regarding the dispatch of the aircraft, concluded that the door was unlikely to have been incorrectly latched prior to departure. Without any physical evidence from the door and its latch, which had fallen into the sea, the operator carried out an inspection of its remaining six aircraft. This inspection called for a detailed visual examination and revealed evidence of movement between the lever assembly and the eccentric lock. The square drive on the lever showed evidence of 'rounding off'. Subsequent movement between the square drive and the lever could

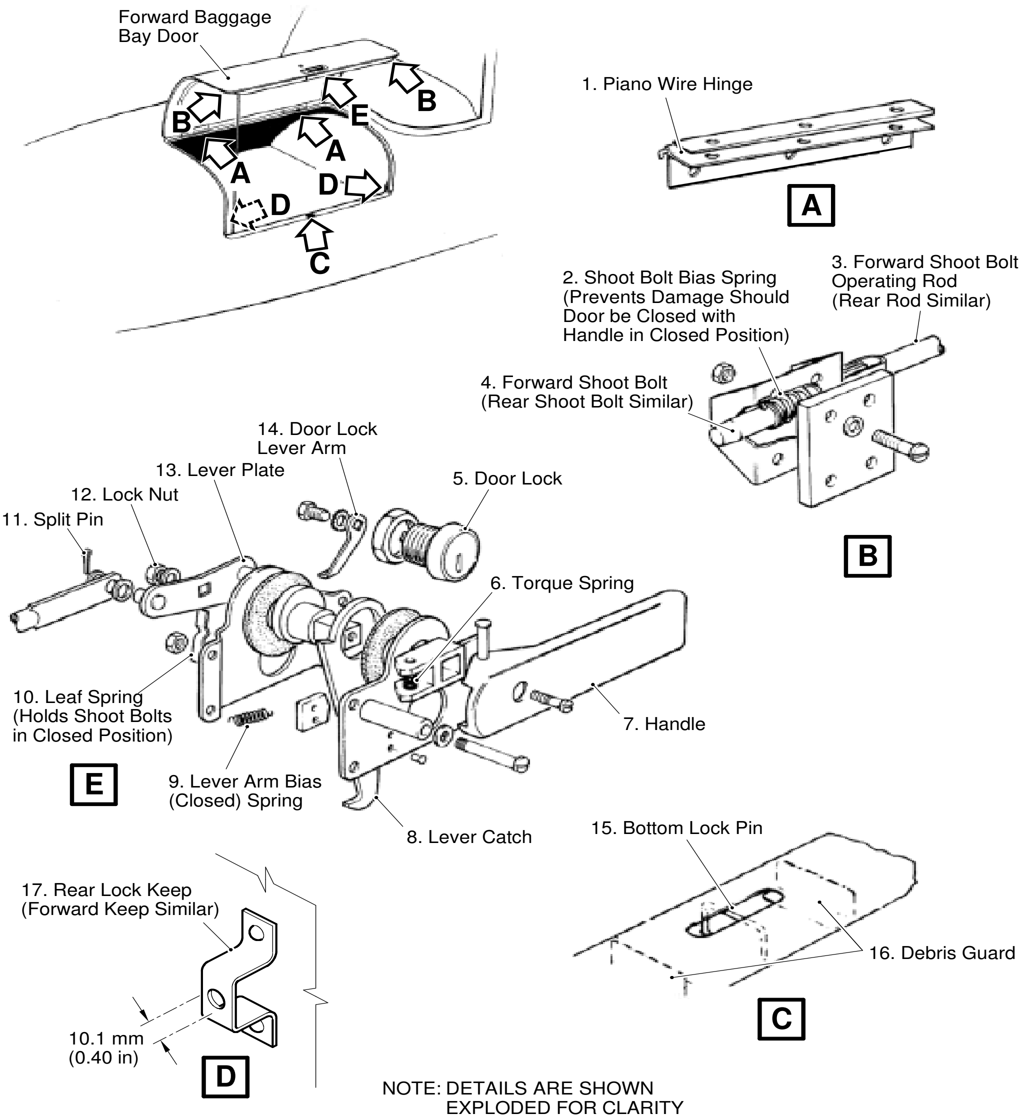

Diagram extracted from SB BN2A Mk111-319 result on the lock nut becoming loose and the handle detaching.

The operator decided to repeat the inspection every 100 hours.

The manufacturer has since issued a Service Bulletin (SB) BN2A Mk111-3 SB319, dated 30 June 2009. The SB 'highly recommends' an inspection of the forward baggage bay door to be performed at the earliest opportunity, but not later than 50 hours. An amendment to the maintenance manual is proposed which will include a periodic inspection.

ACCIDENT

Aircraft Type and Registration:	Avions Pierre Robin DR400-120, F-GMGP
No & Type of Engines:	1 Lycoming O-235-L2A piston engine
Year of Manufacture:	1993
Date & Time (UTC):	26 July 2009 at 0944 hrs
Location:	Alderney Airport, Channel Islands
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 2
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to propeller and pitot tube
Commander's Licence:	Private Pilot's Licence
Commander's Age:	66 years
Commander's Flying Experience:	1,145 hours (of which 1,145 were on type) Last 90 days - 12 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

After landing, following an uneventful flight from Lessay, France, the aircraft was cleared to taxi via Taxiway B to its parking position. Taxiway B slopes down before making a 90° turn to the right. The pilot had not used the foot brakes during the landing and, when she applied them on the downhill taxiway, her seat slid violently backwards. The pilot was then unable to reach either the rudder pedals or foot brakes. The aircraft continued straight ahead running off the left side of the taxiway as the taxiway curved round to the right. The pilot shut down the engine and applied the hand operated parking brake but, although able to slow the aircraft, was unable to prevent it from hitting the airfield boundary hedge and fence at low speed. The pilot reported having checked that the seat was locked in position before departure from Lessay and was later unable to account for the seat movement.

ACCIDENT

Aircraft Type and Registration:	Cessna 152, G-BMSU
No & Type of Engines:	1 Lycoming O-235-L2C piston engine
Year of Manufacture:	1978
Date & Time (UTC):	24 May 2009 at 1215 hrs
Location:	Sandtoft Airfield, Lincolnshire
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nose landing gear, propellor, engine and bulkhead damaged
Commander's Licence:	Student pilot
Commander's Age:	53 years
Commander's Flying Experience:	44 hours (of which 44 were on type) Last 90 days - 23 hours Last 28 days - 7 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft was low and slow on the final approach. The subsequent landing was heavy and the aircraft bounced onto its nosewheel. The nose landing gear detached, the propeller struck the ground and the aircraft came to rest on its nose. The student pilot was uninjured.

History of the flight

The student pilot had completed four satisfactory circuits with his instructor, in good weather conditions, so the instructor authorised him to carry out his second solo flight. The first solo circuit was uneventful but on the second circuit the approach was low and slow. The student pilot recognised this late on in the final approach and increased power, to maintain height, but the aircraft landed heavily and bounced. The subsequent landing was on the nose landing gear, which detached allowing the aircraft's propeller to make contact with the runway. The aircraft came to a halt resting on its nose and the pilot vacated it uninjured. There was no fire.

The student pilot considered that the accident was caused by his approach being too low and too slow. The General Aviation Safety Sense Leaflet Number 1e, entitled '*Good Airmanship Guide*', which is published by the CAA, includes the following advice:

'A good landing is the result of a good approach. If your approach is bad, make an early decision and go-around. Don't try to scrape in'

In his honest report, the student pilot concluded that this should have been his course of action.

ACCIDENT

Aircraft Type and Registration:	Cessna 172P Skyhawk, G-BOJR
No & Type of Engines:	1 Lycoming O-320-D2J piston engine
Year of Manufacture:	1982
Date & Time (UTC):	25 July 2009 at 0928 hrs
Location:	Kemble Airport, Gloucestershire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 2
Injuries:	Crew - None Passengers - None
Nature of Damage:	Collapsed nosewheel and firewall pushed back
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	72 years
Commander's Flying Experience:	243 hours (of which 12 were on type) Last 90 days - 4 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot stated that shortly before touchdown on tarmac Runway 26 at Kemble, the aircraft began to descend with "more of a sink than usual". He thought that he would be able to arrest the descent but the aircraft landed heavily and sustained damage to its nose landing gear and firewall. There were no injuries and the pilot was able to taxi the aircraft clear of the runway.

Based on comments made by the passengers, both of whom held pilot's licences, the Chief Flying Instructor of the flying school which operated the aircraft concluded that the heavy landing occurred because the aircraft lost flying speed at too great a height above the runway. The pilot has undertaken additional training to reinforce the appropriate technique for controlling the aircraft in this situation.

INCIDENT

Aircraft Type and Registration:	Cessna 310R, G-RODD
No & Type of Engines:	2 Continental Motors Corp IO-520-M piston engines
Year of Manufacture:	1976
Date & Time (UTC):	31 May 2009 at 1527 hrs
Location:	Ladydrove Airstrip, near Downham Market, Norfolk
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to fuselage and propellers; engines shockloaded
Commander's Licence:	Private Pilot's Licence
Commander's Age:	65 years
Commander's Flying Experience:	3,700 hours (of which 2,177 were on type) Last 90 days - 12 hours Last 28 days - 7 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

As only a local flight had been planned and the weather was hot, the pilot had not taken a headset and flew with the cockpit quarter window open. The loudspeaker was used to maintain a listening watch on a local frequency.

Following a normal approach to the grass strip, the aircraft settled onto its belly. The pilot then became aware that the landing gear warning horn was sounding and that he had omitted to lower the landing gear.

ACCIDENT

Aircraft Type and Registration:	Dart Kitten II, G-AEXT
No & Type of Engines:	1 J.A.P. J99 piston engine
Year of Manufacture:	1937
Date & Time (UTC):	11 August 2009 at 1815 hrs
Location:	Marsh Hill Farm, Aylesbury, Buckinghamshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Inner tube blown, tyre shredded, part damage to right wheel, minor damage to underside of right wing skin
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	64 years
Commander's Flying Experience:	232 hours (of which 1 was on type) Last 90 days - 14 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

Whilst landing at a relatively narrow airstrip, in an aircraft unfamiliar to the pilot, a heavy landing ensued on the right main gear. This caused the right main wheel tyre to burst. Debris released from the tyre and wheel caused minor damage to the underside of the right wing. The aircraft slewed to the right and came to rest at the edge of the strip.

History of the flight

The pilot had only recently become the owner of the aircraft, and had not flown it previously.

On the day the accident, it had been planned that the owner of the aircraft for the previous 22 years would fly it from its new home base at Marsh Hill Farm Airstrip to RAF Halton, where the new owner would conduct his initial flights and generally familiarise himself with it, taking advantage of the wider runways at Halton. These are some 60 m wide, compared with 15 m at Marsh Farm. In the event, the previous owner was unfit to fly that day but, after discussing the situation with him, the new owner felt confident that he could fly it safely to Halton himself, where he would carry out his familiarisation flying and return to Marsh Farm as planned.

After waiting until the afternoon for a light wind straight down Runway 21, he took off without incident and, after about 25 minutes, executed a successful approach and landing at Halton. He then took off again but, owing to restrictions imposed at the airfield, he was unable to carry out any further circuits or landings to further familiarise himself with the aircraft's handling and landing characteristics. After a further 25 minutes airborne, he returned to Marsh Farm and set up for a final approach to Runway 21.

During the approach, he concentrated on his height and positioning accurately for the runway centreline. Once over the hedge, he found that he had allowed the aircraft to drift left sufficiently to put the left wing over standing crop bordering the runway. He closed the throttle and applied aileron to regain the runway but did not lower the nose. During the course of this manoeuvre, the right wingtip stalled and the aircraft landed heavily on its right main gear, breaking away a segment of wheel rim and bursting the tyre, causing its carcass to shed from the wheel. Wheel and tyre debris struck the underside of the right wing, causing minor damage, and the aircraft slewed to the right before coming to rest at the edge of the strip. After stopping the engine and shutting off the fuel, the pilot was able to leave the aircraft in the usual manner, without difficulty.

The pilot attributed the accident partly to his lack of familiarity on type and the relatively narrow width of the runway, bordered by standing crop, and to his failure to lower the nose upon closing the throttle. He also thought that the inappropriate use of ailerons at the resulting low airspeed contributed to the heavy landing.

ACCIDENT

Aircraft Type and Registration:	De Havilland DH82A Tiger Moth, G-AXAN
No & Type of Engines:	1 De Havilland Gipsy Major 1F piston engine
Year of Manufacture:	1943
Date & Time (UTC):	4 July 2009 at 0930 hrs
Location:	Sandtoft Aerodrome, Lincolnshire
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to all wings, the left main landing gear and the right engine bearer
Commander's Licence:	Private Pilot's Licence
Commander's Age:	50 years
Commander's Flying Experience:	1,837 hours (of which 80 were on type) Last 90 days - 7 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The aircraft was taking off from Runway 23 in good weather conditions. Its initial climb was described by the pilot as normal until, at a height of about 250 ft, the engine faltered but continued to run. The pilot judged that there was insufficient runway ahead to land safely and that the field beyond was unsuitable, as it contained high standing crops in which the aircraft might turn over. He managed to gain some height and selected a short mown field to the right of the field of crops. He turned towards it and thought that he had cleared a tree in the undershoot, when the engine lost all power. He lowered the nose of the aircraft to maintain flying speed, the aircraft struck the tree and became lodged in it. The pilot and his passenger unstrapped and climbed down from the tree, uninjured. The aircraft was extensively damaged but there was no fire. At the time of writing, neither the pilot nor his maintenance organisation had determined the cause of the engine problem.

ACCIDENT

Aircraft Type and Registration:	Denney Kitfox Mk3 Kitfox, G-BXCW
No & Type of Engines:	1 Rotax 582 piston engine
Year of Manufacture:	2005
Date & Time (UTC):	1 September 2006 at 1200 hrs
Location:	Rollington Farm, near Corfe, Dorset
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to landing gear struts and anchor points
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	67 years
Commander's Flying Experience:	260 hours (of which 25 were on type) Last 90 days - 5 hours Last 28 days - 2 hours (all hours approximate)
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The pilot made a steep approach due to the presence of power lines close to the landing area. This resulted in the aircraft bouncing on touchdown which the pilot attempted to control by lowering the nose, causing the aircraft to tip forward when it next touched down.

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The accident occurred on 1 September 2006 and was reported to the AAIB on 20 April 2009.

History of the flight

The pilot had completed a local flight and was returning to land at the farm where the aircraft was based. The landing area comprised a large field with no marked strip, allowing takeoff and landing in any direction. The pilot reported that the weather was good with a north-westerly wind favouring a landing from the south-east. This required a steep approach over power lines close to the edge of the field. The resultant touchdown caused the aircraft to bounce which the pilot attempting to recover from by lowering the nose. The aircraft touched down again and tipped onto its nose before falling back onto the landing gear. The pilot was uninjured and after making the aircraft safe, vacated the aircraft unaided.

Cause

The pilot considered the cause of the accident was his decision not to go around when high on the final approach. Having bounced, his natural reaction was to push the nose forward which led to the aircraft tipping onto its nose.

ACCIDENT

Aircraft Type and Registration:	Isaacs Fury II, G-BBVO
No & Type of Engines:	1 Lycoming O-320-E2A piston engine
Year of Manufacture:	1987
Date & Time (UTC):	2 August 2009 at 1835 hrs
Location:	Battle Flats Airfield, Ellistown, Leicestershire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Substantial - beyond economical repair
Commander's Licence:	Private Pilot's Licence
Commander's Age:	57 years
Commander's Flying Experience:	536 hours (of which 2 were on type) Last 90 days - 8 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

During takeoff, with the aircraft approximately 2 ft off the ground, the pilot's goggles became dislodged, obscuring his vision. The aircraft veered to the right into a standing crop of corn which caused the aircraft to rotate about its nose and come to rest inverted.

SERIOUS INCIDENT

Aircraft Type and Registration:	Jodel D112, G-BEZZ
No & Type of Engines:	1 Continental Motors Corp A65-8F piston engine
Year of Manufacture:	1956
Date & Time (UTC):	14 July 2009 at 1815 hrs
Location:	City Airport (Manchester Barton)
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to cockpit floor and stiffening rib
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	62 years
Commander's Flying Experience:	17,820 hours (of which 100 were on type) Last 90 days - 153 hours Last 28 days - 55 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The aircraft was on the downwind leg of the circuit, after a one hour flight, when smoke began to enter the cockpit, coupled with a strong smell of burning wood. The crew saw that a small hole in the cockpit floor had formed, approximately 30 mm in diameter, between and just aft of the rudder pedals. The edges of the hole were glowing and sparks were entering the cockpit. A MAYDAY call was transmitted and the aircraft made an expeditious landing with the airfield Fire and Rescue Service in attendance. During the final approach, the amount of smoke generated reduced and by the time the aircraft had completed its ground roll, the glowing around the edge of the hole had ceased. A modification to the exhaust system, approved by the Light Aircraft Association (LAA), had been made to improve the silencing of the engine. The original exhaust system consisted of four stub pipes exhausting below the cowling. An inspection of the aircraft confirmed that a hole in the modified exhaust system had allowed hot gases to impinge on the lower fuselage, which had led to the eventual 'burn through' of the cockpit floor.

There have been no other reported incidents of this nature resulting from this modification but the LAA will be reviewing the modification to determine if any changes are required.

ACCIDENT

Aircraft Type and Registration:	Jodel D117, G-BBPS
No & Type of Engines:	1 Continental Motors Corp C90-14F piston engine
Year of Manufacture:	1957
Date & Time (UTC):	9 August 2009 at 1040 hrs
Location:	Westfield Farm Airstrip, Hailsham, East Sussex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to propeller and left wing
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	69 years
Commander's Flying Experience:	732 hours (of which 600 were on type) Last 90 days - 4 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

After landing, whilst the pilot was applying the brakes, the aircraft began to swerve off the airstrip. The pilot attempted to regain control by reverting to rudder pedal steering, however the tail wheel had become unlatched and was castoring. The aircraft continued off the airstrip and struck a fence.

Background

Westfield Farm Airstrip is approximately 580 m long and orientated 06/24. The weather at the time of the accident was good with a southerly wind of between 5-10 kt, which the pilot reported was variable in both strength and direction. The pilot commented that on the Jodel D117 the brakes and rudder are operated by different sets of pedals which he could not operate simultaneously. Directional control on the ground is achieved using either differential braking or the rudder pedals which are linked to a steerable tail wheel. The tail wheel will become unlatched from the steering mechanism when it passes through a certain angle, resulting in it castoring.

History of the flight

The pilot had completed a short local flight and was returning to land at the airstrip from an easterly direction. He stated that he completed a normal approach and flare and after a short float made a gentle touchdown. After touchdown he initially used the rudder pedals for directional control but, concerned that the aircraft was not slowing sufficiently, switched to using the brakes instead. The aircraft then began to swerve to the left causing the pilot to return his feet to the rudder pedals. By this time, the tail wheel had become unlocked resulting in a loss of capability to steer the aircraft via the rudder pedals. The aircraft continued to swerve to the left, departed the airstrip and the left wing collided with an adjacent wooden fence. The propeller also struck the fence causing the engine to stop. The pilot was uninjured and after making the aircraft safe was able to vacate unaided.

Comment

The pilot believes the aircraft began to swerve due to the direction and strength of the wind. Differential braking would have been available to try and regain control but, as he did not normally use the brakes after landing, it was a more natural response for him to have reverted to the rudder pedals instead.

ACCIDENT

Aircraft Type and Registration:	Jodel D117, G-BGTX
No & Type of Engines:	1 Continental Motors Corp C90-14F piston engine
Year of Manufacture:	1957
Date & Time (UTC):	29 June 2009 at 1130 hrs
Location:	After takeoff from Shobdon Aerodrome, Herefordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to both wing leading edges, superficial damage to tailplane and wing fabric and right hand canopy; possible engine shockload
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	74 years
Commander's Flying Experience:	530 hours (of which 174 were on type) Last 90 days - 4 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

After taking off from Runway 09, at a height of 350 ft, the engine lost power and began to run roughly. Due to unsuitable terrain ahead, the pilot initiated a 180º turn to land back on Runway 27. During the turn the pilot applied carburettor heat and changed fuel tanks, but with no effect on the rough running engine. He made a downwind flapless landing but was unable to slow the aircraft significantly before reaching the boundary fence. The aircraft was, however, travelling with sufficient speed to allow the pilot to 'hop' over the fence, touching down in a fenced compound beyond. It was brought to a halt when it struck the fence on the opposite side of the compound. The pilot was uninjured. The cause of the loss of engine power has not been determined but the weather conditions for the day (temperature 24ºC and a dew point of 17ºC) were conducive to moderate carburettor icing at cruise power and serious icing at descent power. The pilot commented that the pre-takeoff application of carburettor heat may have been insufficient to clear any carburettor ice that may have formed during taxiing.

ACCIDENT

Aircraft Type and Registration:	Jodel D117A, G-AYHX
No & Type of Engines:	1 Continental Motors Corp C90-14F piston engine
Year of Manufacture:	1958
Date & Time (UTC):	30 May 2009 at 1025 hrs
Location:	Henstridge Airfield, Somerset
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to left landing gear, left wing and propeller tip.
Commander's Licence:	Private Pilot's Licence
Commander's Age:	45 years
Commander's Flying Experience:	200 hours (of which 14 were on type) Last 90 days - 12 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

The aircraft was landing on Runway 07 at Henstridge Airfield with a reported wind of 5 to 10 kt from a direction of 110°. Following a normal touchdown, the pilot retarded the throttle and, initially, the aircraft rolled out along the runway. However, it then began to weathercock into wind. The pilot applied left rudder but was unable to stop the aircraft continuing to turn. During the turn, the left landing gear collapsed. The aircraft continued to slide, scraping the left wing on the ground, and departed the runway before coming to rest on the grass. The pilot exited the aircraft without difficulty. He commented that this was his first landing of a tailwheel aircraft onto a concrete surface. It was a hot day and, with little airflow over the rudder to provide control authority, he was not able to react quickly enough to prevent the ground loop.

ACCIDENT

Aircraft Type and Registration:	Jodel DR1051-M1 Sicile Record, G-BHTC
No & Type of Engines:	1 Potez 4E20A piston engine
Year of Manufacture:	1964
Date & Time (UTC):	14 June 2009 at 1410 hrs
Location:	Turweston Airfield, Northamptonshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 2
Injuries:	Crew - None Passengers - None
Nature of Damage:	Broken propeller, slightly damaged right landing gear
Commander's Licence:	Private Pilot's Licence
Commander's Age:	59 years
Commander's Flying Experience:	301 hours (of which 71 were on type) Last 90 days - 12 hours Last 28 days - 6 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Following an uneventful flight from Beccles, Soffolk, the aircraft made an approach to land on Runway 27 at Turweston Airfield. The wind was light and almost aligned with runway, and the aircraft touched down on the centreline shortly after passing the threshold. However, after landing, with the main and tail wheels on the ground, as the pilot applied the wheel brakes using the hand operated lever, the aircraft swung slightly to the right. A left rudder input was made, but this resulted in a larger swing to the left, followed by a very sharp swing to the right as corrective right rudder was applied. This caused the aircraft to leave the right edge of the runway at a speed of around 10 kt before coming to a halt in an adjacent crop.

This aircraft is equipped with a hydraulic braking system operated by a handbrake-style lever in the cockpit, which applies braking effort to both main wheels. In addition, differential braking is available from the rudder pedals, which become effective at approximately half-travel.

The pilot commented that during the evening prior to the incident, he had turned the aircraft around by hand whilst it was parked. Although the parking brake was 'lightly set' at the time, the left wheel appeared to rotate relatively easily compared with the right. This subsequently led him to believe it possible that the hand operated brake may have developed a bias to the right wheel. However, this could not be confirmed as, by the time he mentioned the matter to the organisation repairing the aircraft, the brakes had already been dismantled. The pilot additionally commented that if there had been a brake bias, this may have initiated the swing to the right after landing, with the subsequent swings being the result of large rudder pedal deflections that applied differential braking. He also noted that the use of the handbrake had probably been unnecessary, as there was adequate runway remaining.

ACCIDENT

Aircraft Type and Registration:	MCR-01 VLA Sportster, G-TOMX
No & Type of Engines:	1 Rotax 912ULS piston engine
Year of Manufacture:	2009
Date & Time (UTC):	31 August 2009 at 1800 hrs
Location:	Sittles Farm Airfield, Staffordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to noseleg and spat, left and right spats, left leading edge and top of fuel tank
Commander's Licence:	Private Pilot's Licence
Commander's Age:	44 years
Commander's Flying Experience:	1,007 hours (of which 15 were on type) Last 90 days - 38 hours Last 28 days - 12 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

After a normal approach to Runway 09 with a 10 kt crosswind, of which the pilot was aware and had taken into account, the aircraft landed normally. However, when wheel brakes were applied it did not decelerate as expected and, after over-running the landing strip, the aircraft struck a hedge and came to rest.

After evacuating the aircraft in the usual way, the pilot noted that the grass was both wet and unusually long. He attributed the accident to an inability of the long grass to disperse moisture and dry out as it would otherwise have done had it been shorter. Although reporting the temperature at the time as 'unknown', he commented that he… "may well have landed on a frozen lake".

ACCIDENT

Aircraft Type and Registration:	Pelican Club GS, G-BWWA
No & Type of Engines:	1 Rotax 912-UL piston engine
Year of Manufacture:	1996
Date & Time (UTC):	5 September 2009 at 1230 hrs
Location:	Eldersfield Airstrip, Gloucestershire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Left main landing gear, left wingtip and propeller
Commander's Licence:	Private Pilot's Licence
Commander's Age:	57 years
Commander's Flying Experience:	275 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

After observing the windsock and assessing that the crosswind was acceptable, the pilot completed a normal approach and landing. As the aircraft slowed the aircraft began to veer to the left and, although the pilot applied right rudder, he was unable to stop the turn. The left main wheel entered a depression at the edge of the runway, causing the aircraft to spin to the left, and come to rest in a ploughed field adjacent to the runway. The pilot attributed the incident to the tail of the aircraft remaining high for longer than normal after landing, and the insufficient use of right rudder to correct the ensuing turn.

ACCIDENT

Aircraft Type and Registration:	Piper L18C (Modified) Super Cub, G-BPJH
No & Type of Engines:	1 Continental C90-14F piston engine
Year of Manufacture:	1952
Date & Time (UTC):	1 June 2009 at 1900 hrs
Location:	Blackhill Airfield, Draperstone, Co. Londonderry, Northern Ireland
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Aircraft damaged beyond economic repair
Commander's Licence:	Private Pilot's Licence
Commander's Age:	61 years
Commander's Flying Experience:	395 hours (of which 72 were on type) Last 90 days - 12 hours Last 28 days - 7 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

During the latter stages of the approach to his home airstrip the pilot realised that he was too low and increased engine power. Before the aircraft could respond, it struck a hedge near the threshold of the strip with sufficient force to tear off the landing gear.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28-140 Cherokee, G-ATUD	
No & Type of Engines:	1 Lycoming O-320-E3D piston engine	
Year of Manufacture:	1966	
Date & Time (UTC):	11 September 2009 at 1130 hrs	
Location:	Belle Vue Airstrip, Yarnscombe, Devon	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - 1 (Minor)	Passengers - 1 (Serious)
Nature of Damage:	Extensive	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	74 years	
Commander's Flying Experience:	403 hours (of which 303 were on type) Last 90 days - 4 hours Last 28 days - 2 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

The pilot made an approach to Runway 08 at Belle Vue in benign conditions with an easterly wind estimated at 10 kt. The approach became slightly high and the pilot reduced power. He became distracted by a high-sided lorry travelling along the road immediately short of the runway, and watched it clear the runway centreline. Returning his attention to the ASI, he realised he had not been monitoring his speed and the aircraft was low and slow. He added power but the aircraft sank and the landing gear caught on the boundary hedge, causing the aircraft to pitch inverted and impact the ground on the runway threshold, sustaining substantial damage. Both occupants vacated the aircraft through the door. There was no fire.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28-181 Cherokee Archer II, G-EFIR
No & Type of Engines:	1 Lycoming O-360-A4M piston engine
Year of Manufacture:	1980
Date & Time (UTC):	30 June 2009 at 1900 hrs
Location:	Jericho Farm airstrip, Lambley, Nottinghamshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 2
Injuries:	Crew - None Passengers - None
Nature o f Damage:	Damage to landing gear, right wing, flaps and stabilator
Commander's Licence:	Private Pilot's Licence
Commander's Age:	54 years
Commander's Flying Experience:	130 hours (of which 55 were on type) Last 90 days - 4 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

During a landing on a narrow farm strip, the aircraft contacted the high crop with a wing tip and was spun around.

History of the flight

The pilot departed Leicester, with two passengers, after discussing the intended flight with the club CFI. Weather conditions were good, CAVOK with light winds, and the flight to Jericho Farm was uneventful.

The pilot later commented that, arriving overhead Jericho Farm, he was cautious as another aircraft was executing a missed approach. In the right-hand circuit to Runway 26 he lowered the third, and final, stage of flap and approached the runway at a speed of about 73 KIAS. The pilot reported that the landing was smooth and not far from the threshold. However, after a ground roll of about 200 metres he noticed the left wing beginning to catch the rape seed crop on that side and, despite gentle right pedal, after a further 100 metres the crop "bunched up", effectively stopping the plane's forward movement and spinning it through 180°. This collapsed the right landing gear, ripped out the flap and did further damage to the airframe. The pilot and his two passengers were unharmed and left the aircraft by the door, as normal.

In assessing the accident afterwards, the pilot considered that he had not taken sufficient note that the airstrip's width of 15 metres would be challenging for landing an aircraft of approximately 10 metres wingspan, particularly as there was no marked runway centreline and there was a high crop on both sides of the runway. Further, he considered that he did not become aware soon enough of the first contact with the crop and did not apply sufficient right pedal to correct.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28-181 Cherokee Archer III, G-JACS
No & Type of Engines:	1 Lycoming O-360-A4M piston engine
Year of Manufacture:	1997
Date & Time (UTC):	23 June 2009 at 1310 hrs
Location:	Runway 25, Fowlmere Aerodrome, Hertfordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to propeller, landing gear and right wing
Commander's Licence:	Private Pilot's Licence
Commander's Age:	78 years
Commander's Flying Experience:	442 hours (of which 92 were on type) Last 90 days - 4 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

After flaring over the threshold of Runway 25 whilst landing at Fowlmere, the aircraft 'floated' and landed deep into the runway. Despite braking hard, the aircraft did not stop until it encountered a ditch across the far end of the runway. No reason was found for a failure of all the radio and navigational equipment reported by the pilot prior to the landing.

History of the flight

Earlier on the day of the accident, the aircraft had taken off from Fowlmere, an airstrip located approximately three miles to the west of Duxford, and landed at Wellesbourne Mountford. On the return flight, the pilot made a radio call to Duxford prior to joining the Fowlmere circuit. There was no response, at which point he noted that all the communication and navigational equipment had ceased to operate, although it had operated normally earlier during the flight. The pilot checked that no circuit breakers had tripped and that the alternator switch was ON.

In the absence of information as to the runway in use, the pilot decided to land on Runway 25, which was the one from which he had taken off some three hours earlier. At that time, he had listened to an automated weather information service, which had given the wind at Luton Airport as 160°/5 kt, variable between 110° and 210°. Although he flared over the threshold, the aircraft 'floated' and landed deep into the runway. Despite braking hard, the aircraft did not stop until it ran into a small ditch across the end of the runway. The situation was exacerbated by the fact that the runway has a downward slope on its latter half. After the aircraft had come to rest, the pilot switched the battery master off and exited the aircraft without injury.

Duxford subsequently confirmed that they had received the radio call from G-JACS and advised that the runway in use was Runway 24 which, had he heard the message, would have confirmed the pilot's choice of Runway 25 at Fowlmere. The light and variable wind conditions had not altered significantly during the day.

An examination of the aircraft revealed no obvious reason for the electrical problem. In fact, shortly after the accident a successful radio call was made to Duxford, indicating that the battery, if it had been discharged, had recovered.

The pilot later reflected that despite the distraction posed by his concern over the loss of the electrical services, it was his decision to continue with the landing following the late touchdown, rather than to go-around, that resulted in the accident.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28-236 Dakota, G-FRGN
No & Type of Engines:	1 Lycoming O-540-J3A5D piston engine
Year of Manufacture:	1994
Date & Time (UTC):	29 June 2009 at 1545 hrs
Location:	North Moreton, Oxfordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to port wing, engine mountings and propeller. Nose landing gear sheared off.
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	65 years
Commander's Flying Experience:	2,594 hours (of which 2,300 were on type) Last 90 days - 13 hours Last 28 days - 12 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft landed some 200 m into the 800 m long grass runway at a private airstrip. When the brakes were applied, they appeared to have no effect and the aircraft overran the runway, impacting a hedge. The aircraft sustained damage to its port wing, propeller, engine mountings and nose landing gear. The pilot was uninjured and vacated the aircraft through the normal exit.

The pilot had not appreciated that there had been a recent heavy rain shower and the aircraft skidded on the wet grass.

History of the flight

The pilot was returning to a private airstrip at North Moreton following a flight from Oxford (Kidlington) Airport. The weather was generally good with a light easterly wind and CAVOK, but there were some isolated heavy showers. The aircraft joined downwind in the left hand circuit for Runway 35. As the pilot flew past the windsock, she noted that there was a crosswind from the right and that the runway was clear. Full landing flap was set and the IAS reduced on the final approach to 72 kt. The approach was normal and the aircraft touched down approximately 200 m into the 800 m long grass runway. The landing distance for the aircraft on that runway was normally approximately 350 m using moderate braking. The pilot informed Benson ATC that she had landed and, 100 m after touching down, applied the brakes.

There was no retardation and the pilot thought that the brakes had failed or that the aircraft was skidding on the grass surface. With insufficient distance remaining to initiate a safe go-around, she attempted to veer the aircraft to the left but, having no directional control, the aircraft overran the end of the runway and impacted a substantial hedge. The pilot isolated the aircraft's fuel and electrical systems and vacated the aircraft through the normal exit, uninjured. The aircraft suffered damage to its port wing, propeller, engine mountings and nose landing gear.

The grass was wet from a recent heavy shower and the runway surface had patches of standing water. The pilot had not been aware of this before she landed. Had she known, she would have touched down earlier. Immediate application of the brakes would also have reduced the length of the landing roll.

The CAA's General Aviation Safety Sense Leaflet 7, entitled *Aeroplane Performance*, gives guidance on the safety factors to add to takeoff and landing distances. When landing on wet, slippery grass, it advises that the Landing Distance Required may increase by up to 60%.

ACCIDENT

Aircraft Type and Registration:	Piper PA-30 Twin Comanche, G-ATEW
No & Type of Engines:	2 Lycoming IO-320-B1A piston engines
Year of Manufacture:	1965
Date & Time (UTC):	30 May 2009 at 1340 hrs
Location:	Sturgate Airfield, Lincolnshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to both propellers and damage to fuselage and wing underside (beyond economic repair)
Commander's Licence:	Private Pilot's Licence
Commander's Age:	66 years
Commander's Flying Experience:	711 hours (of which 475 were on type) Last 90 days - 0.6 hours Last 28 days - 0 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

Synopsis

During the ground roll following a firm landing, all three landing gear legs retracted. The aircraft slid along the runway on its belly before coming to rest. There was insufficient information available to determine what had caused the gear to retract.

History of the flight

The aircraft had departed from Newcastle Airport for a flight to Sturgate airfield. The weather at Sturgate was CAVOK with a south-easterly wind of 8 to 10 kt. The pilot manoeuvred the aircraft to join overhead the airfield at 2,000 feet and then descended to join a downwind leg for Runway 09. He decided to carry out a flaps-up approach to the paved runway which had an unlicensed length of 820 metres. During final approach he made a "Finals gear down" radio call and checked that the single green (gear down and locked) light was illuminated. He did not visually check the gear position using the mirror on the left engine cowling. His passenger, who was also a pilot, also noted seeing the green light. The pilot reported that the aircraft arrived over the runway threshold at 100 KIAS and then he reduced the power and flared slightly. He stated that the aircraft made a harder landing than normal but not "over-hard" and then rolled normally along the runway. After a ground roll of about 300 feet the pilot looked to his right and then moved his hand to turn off the fuel pumps. At about the same time he became aware of a sinking feeling which continued until the aircraft was sliding along the runway on its belly. When the aircraft came to rest, his passenger opened the main door and exited the aircraft. The pilot turned off the fuel selectors and the electrical switches before exiting as well. Shortly thereafter the airfield's fire service arrived at the scene but there was no fire.

Landing gear system description

The landing gear retraction and extension system of the Piper PA-30 consists of an electric motor and transmission assembly, torque tube assembly, push-pull cables to each main gear leg and a push-pull tube to the nose gear leg. Limit switches are installed which shut off the motor when the gear is either fully extended or fully retracted. The limit switches also operate the gear indicator lights in the cabin. The gear is held in the down position by an over-centre geometric locking mechanism. To prevent the gear from being inadvertently retracted on the ground there is an anti-retraction safety switch located on the left main gear leg which will prevent the gear from retracting until sufficient weight is lifted from the gear to enable the strut to extend to within 0.75 inches of full extension. A gear warning horn sounds if the engine manifold pressure is reduced below 10 to 12 inches while the landing gear is not selected down.

Examination of the aircraft

The aircraft was examined by the chief engineer from the maintenance organisation based at the airfield. When he entered the cabin of the aircraft he found that the gear selector was in the DOWN position and the electrical master switch was off. He reported that after he turned the master switch on he could hear the 'whirring' noise of the landing gear electric motor, but with no movement of the gear it was clear to him that the motor's drive had sheared. The aircraft was raised and supported with the combination of a crane and jacks. When the aircraft was lifted, the nose gear and right main gear dropped down, but the left main gear only came down to a 45° angle. He pulled the nose gear leg forward which appeared to cause the right main gear leg to lock down, but the left main gear leg did not move. When he tried to pull the left main gear leg down he noticed that there was a bend in the push-pull cable. After cutting this cable the left gear dropped down to the extended position. The engineer assessed that there was no internal wing damage which he would have expected to see if the aircraft had suffered a heavy landing.

The aircraft was later determined to be beyond economic repair so no further examination of the aircraft was carried out and the anti-retraction safety switch was not checked.

The position of the fuel pump switches in relation to the position of the gear switch is shown in Figure 1.

Pilot's assessment of the cause

The pilot considered that either the landing gear had collapsed or retracted. He thought that a retraction might have been caused by the landing gear switch not latching down or perhaps his arm catching it when he moved his hand to turn off the fuel pumps. Since it was a flaps-up landing he did not believe he had made the mistake of reaching for the gear lever instead of the flap lever.

Analysis

According to the pilot the aircraft made a harder than normal landing and then had a ground roll of about 300 feet. If the gear had not been locked down prior to

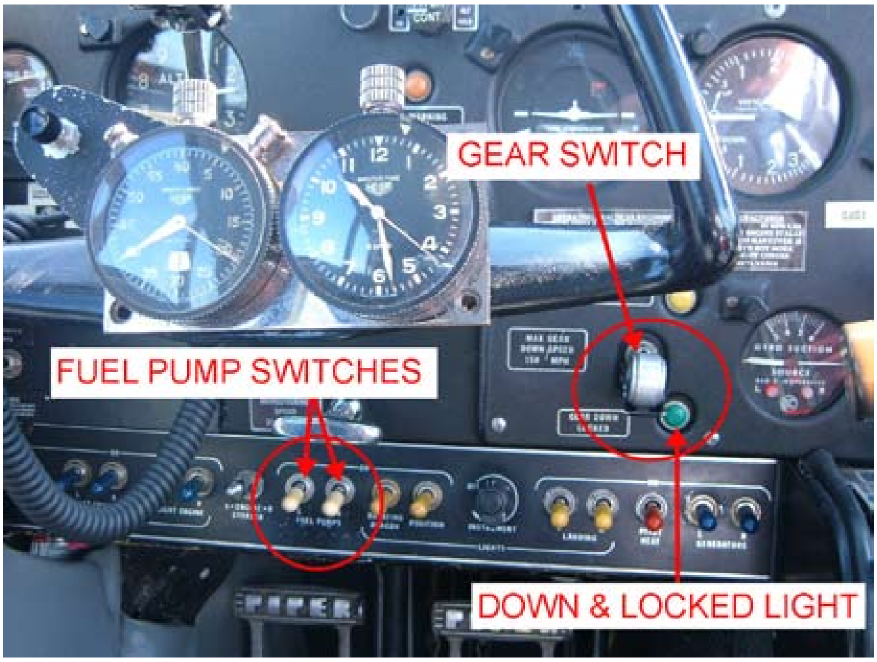

Figure 1

Location of gear switch and fuel pump switches on G-ATEW

landing, the gear would have collapsed at touchdown. The 300-foot ground roll indicates that the gear was down and locked during the initial part of the landing which is also consistent with the pilot's and passenger's reports of seeing the green 'down and locked' light during final approach. After the ground roll all three landing gear legs either collapsed or retracted. Apart from the bent push-pull cable to the left main gear leg, there was no damage that would explain all three gear legs collapsing simultaneously. If only one gear leg had collapsed then a heavy landing or a misrigging would be suspected. However, since the aircraft sank on all three gear legs simultaneously a gear retraction was the most probable cause. The bent push-pull cable to the left main gear leg could have been the result of the motor trying to re-extend the landing gear leg while the weight of the aircraft was trying to retract it. This would also explain why the drive from the motor had sheared.

It is possible that the gear switch was inadvertently and briefly selected up when the pilot decided to turn the fuel pump switches off. However, the action to turn the fuel pump switches off would have been to move the switches down, whereas the action to raise the gear would have been to move the gear switch up. Furthermore, the anti-retraction switch should have prevented a commanded gear retraction when there was weight on the left main gear leg. The aircraft had landed with its flaps up and following a 300-foot ground roll there would probably have been sufficient weight on the gear leg to trip the switch. However, since the anti-retraction switch was not tested, a fault with the switch or its rigging could not be ruled out.

In summary, the landing gear probably retracted during the ground roll but there was insufficient information available to determine why this had happened.

ACCIDENT

Aircraft Type and Registration:	Piper PA-32R-300 Cherokee Lance, G-BSYC
No & Type of Engines:	1 Lycoming IO-540-K1G5D piston engine
Year of Manufacture:	1977
Date & Time (UTC):	5 April 2008 at 0948hrs
Location:	Cairn Gorm, Cairngorms, Scotland
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Fatal) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	45 years
Commander's Flying Experience:	Approximately 440 hours (of which at least 126 were on type) Last 90 days - not known Last 28 days - not known
Information Source:	AAIB Field Investigation

Synopsis

The pilot had planned to fly the aircraft from the United Kingdom (UK) to the United States of America (USA) and was en route from Carlisle to Wick. He was flying VFR and was in receipt of a Flight Information Service from ATC. Heading north-north-east over the northern part of the Cairngorms, he descended the aircraft from an altitude of 8,300 ft amsl to 4,000 ft amsl, whereupon he encountered severe weather and icing conditions. The pilot elected to divert and, while flying south-south-east in cloud, the aircraft struck 150 ft below the summit of Cairn Gorm, which rises to 4085 ft amsl. The pilot suffered fatal injuries. No fault was found with the aircraft.

History of the flight

The pilot had planned to fly from the UK to Orlando, Florida, USA. He began the journey at Gamston Airfield, Nottinghamshire on Friday 4 April 2009, departing from there at 1025 hrs. He then flew to Wolverhampton Halfpenny Green Airport, arriving there at 1111 hrs and uplifted 177 litres of fuel. At 1123 hrs he departed for Carlisle. At some point that morning he telephoned a handling agent at Wick Airport, advising him of his intended journey to the USA and requesting the hire of a liferaft. The implication was that the aircraft would be arriving at Wick the same day.

As the aircraft approached Carlisle, the pilot advised Scottish Information that he was over the sea, unsure of his position and 'experiencing cloud in the vicinity'. He was advised to contact the Distress and Diversion Cell at London Centre on 121.5 MHz, which, despite some reported problems with his radio, he did successfully.

Scottish Information contacted Carlisle ATC and informed them that the aircraft was inbound and had been experiencing difficulties. At 1359 hrs, Carlisle ATC advised Scottish Information that they were in contact with the aircraft. While G-BSYC was in the circuit at Carlisle, the pilot, again, seemed to be having problems with his radio. The aircraft landed at 1404 hrs and, having shut it down, the pilot spoke to one of the local flying instructors. The instructor gained the impression that the pilot had miss-selected the audio panel controls and this had caused the communication difficulties.

The pilot decided to spend the night at Carlisle and informed the handling agent at Wick. They discussed the weather forecast for the flight to Wick the following day but the pilot gave no ETA. While at Carlisle Airport he purchased a 1:500,000 scale aeronautical chart for Scotland, a ruler and some pens. He was also provided with some meteorological information for the following day's flight.

At 0812 hrs the next day, Saturday 5 April, the aircraft departed Carlisle Airport. It had not been refuelled. At 0908 hrs the pilot contacted Scottish Information, reporting that he was north of RAF Leuchars at an altitude of 4,000 ft, on a pressure setting of 1011 mb and on a direct track to Wick. He confirmed that this would take him to the west of the Aberdeen Control Area and his ETA at Wick was 1125 hrs. He was given a Flight Information Service (FIS). At 0920 hrs the pilot requested a climb to an altitude of 6,000 ft because he was experiencing turbulence. He was advised that there was no known traffic to affect his climb to that altitude and was asked if he was flying IFR or VFR. The pilot confirmed that he was flying VFR.

At 0930 hrs, in response to a request from Scottish Information, the pilot estimated that he was 42 nm west of Aberdeen at an altitude of 8,300 ft. He also requested the weather information for Inverness Airport and was given details of the conditions at 0920 hrs, which were: surface wind 350°/12kt, visibility 25 km, nil weather, few clouds at 1,200 ft agl, scattered clouds at 4,200 ft agl, temperature plus 5°C and a QNH pressure setting of 1021 mb. At 0933 hrs he was transferred to Inverness Approach.

The pilot advised the Inverness Approach controller that he was en route from Carlisle to Wick, 44 nm west of Aberdeen at 8,300 ft and requested clearance to descend to an altitude of 4,000 ft. The controller asked the pilot to 'squawk' 6174 on his transponder and to confirm that he was VFR. The pilot acknowledged the 'squawk' and confirmed that he was operating VFR. He was asked to notify Inverness ATC when he reached 4,000 ft and was informed that the Inverness QNH pressure setting was 1021 mb. The pilot confirmed the pressure setting and Inverness ATC advised him that he was identified 10 nm south of Lochindorb, which is 4.5 nm north-east of Aviemore, and that he was receiving a Flight Information Service. The pilot acknowledged this. The time was 0935 hrs.

Between 0936 hrs and 0940 hrs Inverness ATC called the pilot four times but there was no reply. The aircraft, which was visible on secondary surveillance radar (SSR) only, was observed turning away from Inverness. It was 20 nm to the south-south-east of Inverness in the vicinity of Aviemore and Grantown-on-Spey, indicating that it was at a pressure altitude of 3,600 ft. This equated to 3,840 ft amsl. At 0940 hrs and 0941 hrs Inverness ATC received carrier wave transmissions only, but not speech. On the second occasion, they called the unknown station, advising it that it was unreadable. At 0943 hrs, Inverness ATC carried out a radio check with the pilot. There was no reply, so they asked him to 'squawk ident'[1].

At 0944 hrs the pilot called Inverness ATC. The Approach controller advised the pilot that he had been trying to call him without success. The pilot reported that he seemed to have a problem with his 'comms one'. In a broken transmission, he advised Inverness ATC that he was diverting to Aberdeen. He had encountered some severe weather, mentioned some icing and asked for details on Aberdeen or that he be given a vector. He was asked if he would rather go to Inverness, which was only 20 nm away; he was 40 nm to the west of Aberdeen. The pilot acknowledged the transmission and asked if it was 'ok' to divert to Inverness. ATC advised that Aberdeen was probably busier than Inverness and that Inverness would probably prefer to accept him. Inverness was on a bearing of 320°(M) from him.

Inverness ATC informed the pilot, whose transmissions were becoming broken, that they were very quickly going to lose radio contact and gave him the Aberdeen Approach and the Distress and Diversion Cell frequencies, telling him that they would be advised. The pilot responded that he was not 'reading' Inverness ATC and the crew of a commercial aircraft, that was inbound to Inverness, offered to relay the transmissions between the pilot and Inverness ATC. The commercial crew established communications with the pilot and advised him that Inverness ATC were losing radio contact with him as he travelled towards 'the hills' and gave him the same frequencies to call as previously advised by Inverness. They also gave the pilot details of the recent weather conditions at Aberdeen. Following that transmission, the commercial crew sought confirmation from the pilot that he had copied the information. There was no reply. It was 0948 hrs. The commercial crew advised Inverness ATC that they had probably lost communications with the pilot but agreed to continue trying to make contact with him.

At about 0950 hrs, an employee of the 'sportscotland Avalanche Information Service' (SAIS) was standing outside the top station of the funicular railway that serves the Cairngorm ski resort. She was approximately 800 m north of the summit of Cairn Gorm, facing south, observing the weather and the conditions underfoot. She recalled it being very cold and snowing, with visibility of about 50 m and a moderate northerly wind. She heard an aircraft approaching from behind her and immediately looked up to see the grey shape of a small aircraft passing overhead. She couldn't distinguish any colouring or details but estimated that it was at a height of approximately 100 ft agl. The aircraft, which was travelling south-south-east, quickly vanished from sight and the engine noise, which sounded steady, faded rapidly. At about the same time, a member of staff who was working as a lift operator in the same vicinity heard a light aircraft flying in a north-south direction. He did not see the aircraft but thought that it was at a low height. The engine noise, which was muffled by the wind and cloud, sounded normal. He estimated that the visibility was about 40 m and the temperature was approximately -4°C. The wind was northerly, gusting to about 35 kt. After the aircraft had passed overhead he did not hear it again.

The Aeronautical Rescue Coordination Centre (ARCC) at RAF Kinloss was informed that the aircraft was missing at 1003 hrs. A Search and Rescue (SAR)

Footnote

[1] This is a selection on the aircraft's transponder control panel which gives a particular indication on ATC's radar screen

operation was initiated and a SAR helicopter took off from RAF Lossiemouth. This was joined by another SAR helicopter from the Royal Naval Air Station at Prestwick. A number of Mountain Rescue Teams (MRTs) were also deployed to the aircraft's last radar position. The search was hampered by the snow and poor weather; however, the following day, at 1040 hrs, the aircraft wreckage and the body of the pilot were discovered near the summit of Cairn Gorm by a MRT.

A post mortem concluded that the pilot had died as a result of multiple injuries, including a particularly severe head injury, sustained during large deceleration forces when the aircraft struck the ground. There was no evidence of any medical condition that could have contributed to the accident.

Meteorology

Following the accident, an aftercast for the area was obtained from the Met Office. This indicated that, at the time of the accident, Scotland was covered by an Arctic Maritime airmass. The weather in the vicinity of the accident site included variable cloud cover with scattered showers of snow. Hill fog would have covered the hills and mountains of the Cairngorm, almost certainly above 1,800 ft amsl, and at times lower.

The cloud cover was calculated to have been few or scattered, locally broken, cumulus or cumulonimbus with a base at between 1,400 ft and 2,800 ft amsl. Further scattered and broken stratocumulus/altocumulus layers were estimated to have been between 2,000 ft and 6,000 ft amsl, with other isolated layers of scattered and broken stratocumulus/altocumulus clouds between 6,000 ft and 13,000 ft amsl. In general, cloud would have been covering the hills and mountains of the Cairngorms.

The wind at 4,000 ft amsl was estimated to be 010°/35 to 40 kt. The direction and strength varied little between 1,500 ft and 5,000 ft amsl. Visibility outside cloud and precipitation was estimated to be 40 km, reducing to between 300 m and 3,000 m in moderate or heavy showers of snow, and less than 200 m in hill fog.

The freezing level was between 1,500 ft and 2,200 ft amsl.

These conditions were reflected in the forecasts for the period covering the pilot's intended flight from Carlisle to Wick. For the north and east of Scotland, including the Grampians, the forecasts also warned of moderate icing and turbulence in cloud, and severe icing and turbulence in cumulonimbus clouds.

An automatic observation at the meteorological station on the summit of Cairn Gorm, taken at 0945 hrs on 5 April 2009, recorded a temperature of -5.4°C and a wind speed of 350°/37kt, with a maximum gust of 51 kt in the previous hour. Another automatic station at nearby Aviemore, which recorded more parameters, reported that the local barometric pressure, corrected to mean sea level, was 1020.8 mb.

Radar

Recorded primary and secondary surveillance radar data on the aircraft was obtained from a number of civilian and military radar heads. The data showed that at 08:13:00 hrs the aircraft was approximately one and a half nautical miles north-east of Carlisle airport, tracking in a northerly direction, past Dundee, towards the Cairngorms. Figure 1 shows the final part of this track in the Cairngorms from 09:27:00 hrs until contact was lost at 09:45:21 hrs.

The initial part of the track in Figure 1, from the Allenshill radar head, shows the aircraft's route as it

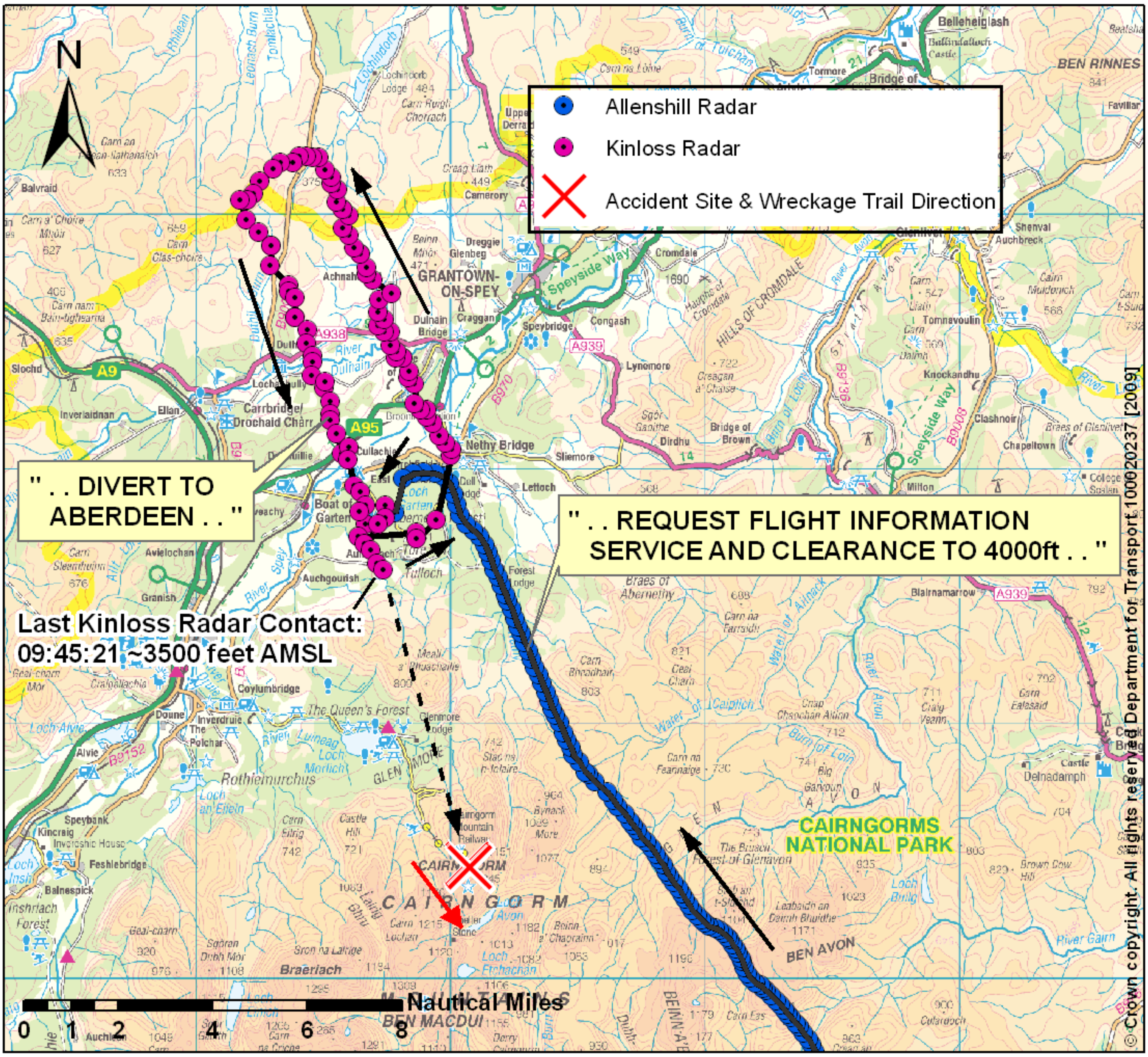

Figure 1

G-BSYC radar track near Cairn Gorm and location of accident site

climbed from an altitude of 6,700 ft[2] to 9,000 ft (see Figure 2). Two and a half minutes after reaching 9,000 ft, the pilot requested clearance to descend to 4,000 ft, beginning the descent one minute later. As the aircraft passed through 7,000 ft, it started a turn to the left through almost 180º during which it descended a further 2,000 ft. Allenshill radar lost contact in the process, but at 09:36:30 hrs the aircraft's progress was picked up by the radar at RAF Kinloss[3].

Footnote

[2] The Mode C altitudes have been corrected for the reported Inverness QNH of 1021 mb.

Footnote

[3] The aircraft track from the Kinloss radar had to be manually digitized from the controllers screen when it was played back later, to generate the track presented in Figure 1.

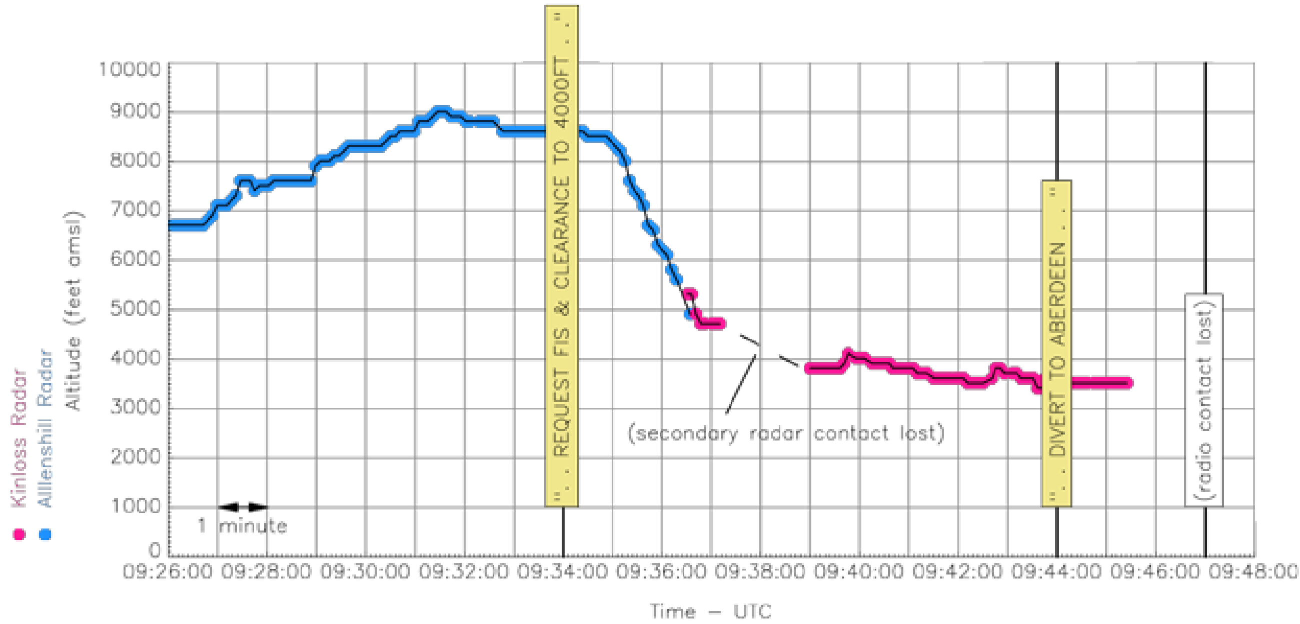

Figure 2

G-BSYC Mode C altitude (corrected to Inverness QNH of 1021 mb)

The Kinloss radar track shows that the aircraft continued the left turn through a full 360º as it levelled just below 4,000 ft, before continuing to track in a north-north-westerly direction for a further eight nautical miles. The aircraft then turned left through 90º and, after another two nautical miles, to the left again on a track back towards Cairn Gorm (elevation 4,085 ft amsl), 15 nm ahead. After five nautical miles (09:44:00 hrs), the pilot reported severe weather, some icing and his intention to divert to Aberdeen.

Kinloss lost contact with the aircraft at 09:45:21 hrs, by which time the aircraft had descended to an altitude of 3,500 ft, with Cairn Gorm seven nautical miles ahead. Playback of the Inverness radar recording showed that contact was lost at around the same time and position. The average ground speed over the last eight nautical miles of the track was approximately 168 kt.

Accident site

The poor weather conditions that affected the region on the day of the accident persisted for the next few days, with sub-zero temperatures and continuous snowfall resulting in most of the wreckage being buried in snow. In addition, visibility was down to a few metres for much of the duration of AAIB's on-site activity.

The main wreckage, consisting of the fuselage and nose section, had come to rest at an elevation of 3,936 ft amsl, approximately 200 m to the north east and 150 ft below the summit of Cairn Gorm. This is a dome-shaped feature with a rocky surface which, at the time of the accident, is likely to have been covered with patchy snow. A GPS plot of the debris, made by the police on the day the aircraft was found, indicated that the wreckage trail was some 200 m in length and that the impact track was 162°(M). This was confirmed by the AAIB in a subsequent plot, albeit with fewer debris items visible due to the accumulation of snow on the mountainside.

The initial wreckage items were found to be parts of the right wing, with the substantially intact left wing being found approximately halfway along the wreckage trail. The main cabin entry door, on the right hand side of the aircraft, was found a few metres short of the main wreckage. The fuselage, minus the nose, windscreen and instrument panel, had come to rest upright, facing back along the impact track, while the engine and propeller assembly, together with the associated cowlings, were lying just beyond the tail.

Some of the cabin contents had spilled out in the area of the main wreckage. Documentation included pages from an aircraft Maintenance Manual and material relating to business concerns. There was also an aeronautical chart of Scotland. It seemed probable that many of the loose documents would have been blown away in the immediate aftermath of the accident.

The horizontal stabilisers had sustained damage consistent with being scraped over the rocky surface, although it was clear from the absence of damage to the cabin roof that the fuselage had remained upright throughout the impact sequence. The top of the fin and rudder had sustained some impact damage, either from a rock thrown up during the ground slide, or from the engine as it became detached prior to the fuselage coming to rest.

The direction of the impact track indicated that the aircraft had flown into rising ground on the northern flank of Cairn Gorm. This had brought the propeller and nose underside into violent contact with the ground, resulting in serious disruption to the forward fuselage including the removal of much of the floor in the forward cabin area. The degree of damage was consistent with the aircraft having struck the ground at a typical cruising speed and attitude. The fact that the fuselage had come to rest facing back along the track suggested that the wing contact with the ground had resulted in a horizontal cartwheel manoeuvre. When all the wing structural parts eventually became available for inspection, it was found that both wings had been damaged to a similar degree; it was thus not possible to conclude in which direction the aircraft had rotated.

The left wing, which, as noted earlier, was almost complete, had come to rest inverted. The left main wheel was in its retracted position and the flaps were also retracted. There was a strong smell of fuel and the snow in the immediate area was stained with the characteristic blue colour of Avgas.

The accident site was close to the Aviemore ski area, with the main wreckage lying approximately 500 m south of the top station of the funicular railway. Access was thus relatively straightforward and one of the tracked vehicles used for piste preparation was used to recover the main wreckage to the base of the mountain. The remainder of the wreckage was gathered over the following weeks as the snow and ice thawed; all of it was ultimately delivered to AAIB's facility at Farnborough for a more detailed examination.

Examination of the aircraft

The propeller blades had all been bent during the impact, with the tips having been heavily scored as a result of contact with the rocks on the ground. In addition, the blade pitch change mechanism in the hub was broken. The nature of the damage indicated that the engine had been developing power at impact although it was not possible to quantify this.

Examination of the engine showed it to be in good condition, consistent with a recent overhaul. There were no significant combustion deposits on the pistons or cylinder heads, and the spark plugs were normal in appearance. The oil filter was found to be clean.

The engine driven fuel pump was stripped and found to be in good condition, with the rubber gasket intact. Some of the fuel lines had remained primed with fuel. The vacuum pump, which powered the gyroscope within the artificial horizon, and which was mounted on the accessory gearbox, was examined and found to be functional.

The disruption that had occurred to the forward cabin area had resulted in the complete detachment of the instrument panel. The instruments were all registering their normal, power off indications, thus little useful information could be gained from them. However, it was noted that the altimeter subscale was set at 1021 mb, which was the regional QNH setting at the time of the accident.

Elsewhere in the cabin it was noted that the flap operating lever was in its lowest detent, which corresponded to the flaps retracted position. The pilots harness consisted of a lap belt and shoulder restraint. The webbing showed evidence of distress where it passed through the lap buckle; however, the shoulder strap was in pristine condition, suggesting that it was not fastened at the time of the accident. Examination of the flying control system revealed no evidence of a pre-impact failure or disconnect.

The lack of documentation prevented the compilation of a detailed history of the aircraft. However, it had achieved comparatively few flight hours since being repaired following an accident, with the same pilot, at Wolverhampton airfield in June 2005 (see AAIB Bulletin 10/2005). The engine overhaul formed part of this repair.

The pilot

The pilot qualified for his Joint Aviation Authorities (JAA) Private Pilot's Licence in August 2003, valid until August 2008. At the same time, he was issued with a Single Engine Piston (Land) (SEP(land)) rating which was valid for two years. In February 2004 he was issued with a night qualification (aeroplanes). This was valid for life and enabled him to act as pilot in command of an aeroplane at night. In September 2006 he was issued with a Federal Aviation Administration (FAA) PPL. This was *'issued on* [the] *basis of and valid only when accompanied by United Kingdom pilot license* [sic] *... All limitations and restrictions on the United Kingdom license apply.'*

The pilot did not hold a qualification to fly in visibility of less than 3 km or out of sight of the surface; however, he had completed a course to qualify for an Instrument Meteorological Conditions (IMC) rating in 2004. This included 20 hours of instructional flying with sole reference to instruments. The pilot then successfully completed the flight test for the rating in April of that year but his application for its issue was not received by the Civil Aviation Authority until April 2005, by which time the validity of the test had expired. Subsequently, he was known to have flown in cloud on occasion. During a flight from Perth to Wolverhampton in 2006 the aircraft he was flying entered cloud, encountered icing conditions and the pilot diverted to Edinburgh Airport.

Records show that by June 2005 the pilot had accrued a total of 340 hours, of which 126 hours were on the Piper PA-32R-300. Following the accident, his logbook was recovered from the aircraft but was in poor condition. There was evidence that in September 2006 he flew a Piper PA-28 Warrior II from Florida, USA to the UK.

There were also entries for instrument flying training in a Cessna 172 at Winter Haven's Gilbert Airport, Florida, USA, in January and February 2007. His last flight was recorded as being in the UK in a Piper PA 28 on 21 April 2007. Due to the state of the log book it was not possible to verify the date of his most recent SEP (Land) revalidation.

The pilot held a JAA Class 2 medical certificate which was valid until June 2008.

Procedures

The accident flight was being flown VFR outside controlled airspace, in accordance with the Rules of the Air Regulations 2007. For an aircraft flying in that airspace, between Flight Level (FL) 100 and 3,000 ft amsl, at an indicated airspeed of 140 kt or less, the Rules state that it:

> *'shall remain at least 1,500 metres horizontally and 1,000 feet vertically away from cloud and in a flight visibility of at least 5 km.'*

The pilot held a Private Pilot's Licence. The Air Navigation Order 2005 states:

> *'He shall not…. unless his licence includes an instrument rating (aeroplane) or an instrument meteorological conditions rating (aeroplanes), fly as pilot in command of such an aeroplane on a flight outside controlled airspace when the flight visibility is less than 3 km…. or out of sight of the surface.'*

The pilot was in receipt of a Flight Information Service (FIS) from ATC. The Manual of Air Traffic Services (MATS) Part 1 stated that:

> *'a FIS is a non-radar service supplied, either separately or in conjunction with other services, for the purposes of supplying information useful for the safe and efficient conduct of flights. Under a FIS the following conditions apply: a) Provision of the service includes information about weather, changes of serviceability of facilities, conditions at aerodromes and any other information pertinent to safety….'*

Also,

> *'the controller may attempt to identify the flight for monitoring and co-ordination purposes only. Such identification does not imply that a radar service is being provided or that the controller will continuously monitor the flight.'*

Under a FIS the pilot was responsible for his own navigation, collision avoidance and terrain clearance.

The aircraft was not cleared for flight in icing conditions.

Discussion

Evidence from the accident site indicated that the aircraft was in a nominally level attitude and at a typical cruising speed when it struck rising ground. Subsequent examination of the wreckage indicated that the engine was delivering power and that the aircraft was intact and serviceable prior to impact.

The pilot did not hold an IMC rating; however, in 2004 he had successfully completed the syllabus and passed the flight test and examination for the rating. Due to the delay in his application reaching the CAA, the validity of the flight test had expired. There was also evidence of some more recent instrument flying instruction in 2007 in the USA. The last entry in his logbook was for an SEP (Land) flight in April 2007. Owing to the state of the logbook, it was not possible to verify the date of his most recent SEP (Land) revalidation.

The pilot was flying VFR, under a FIS from ATC. This implied that, at an altitude of 4,000 ft amsl, he was clear of cloud, in visibility of at least 5 km and responsible for his own navigation and terrain avoidance. When he commenced the descent from 8,300 ft amsl to 4,000 ft amsl, the aircraft was about 6 nm north of Cairn Gorm. During the descent the aircraft appears to have circled to the left before continuing on its original track in the direction of Inverness Airport. Why it orbited is unclear. When it was within 15 nm of Inverness Airport, and the highest ground (elevation of 2162 ft amsl) was 5 nm to the west of its track, the aircraft turned left through 180° and flew back towards higher terrain. The pilot did not respond to radio calls from early in the descent until he was established on the south-south-easterly track, approximately 10 nm from Cairn Gorm.

The Met Office aftercast and the pilot's report of severe weather and icing suggest that, by then, he was flying in very challenging conditions. This seems to have prompted his decision to divert to Aberdeen, twice the distance to Inverness and with higher ground en route. The difficulty of the situation was compounded by radio problems. Having advised ATC that he was flying VFR, it is not clear when the pilot first encountered cloud. He was not qualified to fly in such conditions but had some experience of doing so. However, the previous day, in cloudy conditions he had become unsure of his position and this may have influenced his request for a vector to Aberdeen. In addition, requesting the weather conditions at Aberdeen would have increased his workload even further.

The aircraft was not cleared for flight in icing conditions and it seems to have climbed only about 400 feet during the last seven track miles before it struck Cairn Gorm, approximately 150 feet below the summit. This suggests that the pilot may have been attempting to climb above the high ground. Witness reports of the conditions at the time also suggest that the pilot would not have seen the terrain ahead of him in sufficient time to avoid the impact, which proved fatal. The severity of the pilot's injuries, in particular to his head, may not have been as great had he been wearing his shoulder restraint, in addition to his lap strap. However, although considered unlikely, it was not possible to determine whether the accident would have been survivable had he done so.

ACCIDENT

Aircraft Type and Registration:	Rockwell Commander 112, G-FLPI
No & Type of Engines:	1 Lycoming IO-360-C1D6 piston engine
Year of Manufacture:	1974
Date & Time (UTC):	25 May 2009 at 1129 hrs
Location:	Newcastle International Airport
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to propeller, nose gear, and forward fuselage
Commander's Licence:	Private Pilot's Licence
Commander's Age:	61 years
Commander's Flying Experience:	797 hours (of which 669 were on type) Last 90 days - 9 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The accident occurred during landing on Runway 25 at Newcastle International Airport. The aircraft veered violently to the left on touchdown. The pilot was unable to prevent it from departing the runway and it came to an abrupt stop in long grass. The nosewheel collapsed, the propeller and fuselage suffered damage, but the pilot was uninjured. According to the METAR at 1120 hrs, the wind was from 180° at 9 kt, variable between 130° and 210°. From ascent data taken close to Newcastle at 1115 hrs, the Met Office subsequently estimated that gusts of up to 13 kt could be expected between 180° and 200°.

ACCIDENT

Aircraft Type and Registration:	Vans RV-6, G-GDRV
No & Type of Engines:	1 Lycoming O-320-E2D piston engine
Year of Manufacture:	1993
Date & Time (UTC):	11 April 2009
Location:	Enstone Aerodrome, Oxfordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to left landing gear leg, wheel spat and mounting plate; tail steering linkage broken
Commander's Licence:	Private Pilot's Licence
Commander's Age:	53 years
Commander's Flying Experience:	1,400 hours (of which 3 were on type) Last 90 days - 5 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Forms submitted by the pilot and passenger

Synopsis

The pilot had difficulty controlling the aircraft during several landing ground rolls and when taxiing. Subsequent inspection revealed that the tail wheel steering linkage was disconnected.

History of the flight

The aircraft was being flown in the circuit at Enstone for the purpose of familiarising a new pilot member of the group which owned it. The pilot, who occupied the left seat, had previous experience of tail-wheeled aircraft but not of the RV-6 and was being observed by a more type experienced pilot who occupied the right seat. Control of the brakes was only possible from the left seat. According to the observer there was a light westerly surface wind and visibility in excess of 10 km.

During the fourth landing on asphalt Runway 26 the observer made rudder inputs to correct a swing which developed during the ground roll. On the fifth landing the observer again made rudder inputs, this time attempting to correct a more pronounced swing which developed into what he described as a ground loop. After bringing the aircraft to rest the occupants inspected the landing gear and found that the left spat was scuffed and its mounting plate bent.

The pilot then flew the aircraft back to its base at Gloucester Staverton Airport, where the observer completed the landing without incident. During subsequent ground manoeuvres the occupants noticed that the aircraft was not responding to rudder control inputs and the pilot steered the aircraft back to its hangar using differential braking. Subsequent inspection revealed that the tail wheel steering linkage was broken and that the left landing gear leg was bent.

Pilot's assessment of the cause

The pilot and observer did not determine when the steering linkage became detached and if it was the cause or result of the control difficulties, but the pilot's assessment of the cause of the accident was his lack of experience of this type and of tail-wheeled aircraft generally.

ACCIDENT

Aircraft Type and Registration:	Aerospatiale/Westland SA 341G Gazelle, YU-HEW
No & Type of Engines:	1 Turbomeca Astazou IIIA turboshaft engine
Year of Manufacture:	1977
Date & Time (UTC):	26 January 2008 at 1625 hrs
Location:	Rudding Park, Harrogate, North Yorkshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Fatal) Passengers - 1 (Fatal)
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence (Helicopters)
Commander's Age:	43 years
Commander's Flying Experience:	853 hours (of which 56 were recorded as helicopter and 46 recorded on type - see text) Last 90 days - 46 hours Last 28 days - 1.5 hours (approx)
Information Source:	AAIB Field Investigation

Synopsis

The pilot, who was experienced in fixed-wing aircraft but newly-qualified in helicopters, was undertaking a helicopter flight with a passenger, in gusty wind conditions. He was seen flying slowly, at a low level, near a chalet he owned in the grounds of an hotel when the aircraft was seen to spin around, before pitching up and falling to the ground, fatally injuring the two occupants.

It is considered that the pilot lost control of the helicopter whilst flying at low forward airspeed in strong and gusty wind conditions. The investigation revealed inconsistencies, and probable deficiencies, in the training of the pilot and inconsistencies, and possible deficiencies, in his subsequent PPL(H) Skills Test.

Deficiencies in the aircraft's maintenance were also identified, although these are not considered causal or contributory to the accident.

Five Safety Recommendations are made.

Background

On being purchased by the new owner, the aircraft involved in this accident, YU-HEW[1] (Figure 1), had been flown to Stapleford Airfield, Essex, in December 2007 to have its Certificate of Airworthiness renewed. The work was completed in January 2008 and the

Footnote

[1] A Serbian-registered aircraft.

(Photo courtesy of John Allan)

Figure 1

SA 341G Gazelle YU-HEW

owner, who had recently gained his PPL(H), planned to drive from his home in West Yorkshire to Stapleford, a distance of some 200 miles, to collect the aircraft. He then intended to fly it to an hotel near Harrogate where he was to be spending the weekend with family members.

On the morning of the accident the owner of YU-HEW contacted the owner of the training organisation he had used to gain his licence. Due to the forecast weather conditions and the length of the journeys involved, the owner of the training organisation offered to fly him to Stapleford in another helicopter and to provide an experienced pilot to accompany him on the return flight to the hotel. The owner of YU-HEW accepted this offer and on the morning of the accident was flown, along with the experienced pilot, in a Gazelle (registration HA-LFQ[2]) to Stapleford to collect YU-HEW. Accompanied by the experienced pilot, he then flew YU-HEW to a private landing site in East Ardsley, near Harrogate, to collect his wife before flying on to the hotel. HA-LFQ had been flown back from Stapleford with YU-HEW and both aircraft landed and shut down at the hotel at about 1535 hrs, the entire flight having taken 1 hour and 19 minutes. The owner of YU-HEW then went to check into the hotel with his wife whilst the experienced pilot, who had accompanied him on the flight, departed as a passenger in HA-LFQ at about 1546 hrs, when it returned to its base at Breighton.

The owner of YU-HEW had a chalet in the hotel grounds where he was expecting to meet with the family members after his arrival. After checking in at the hotel reception he contacted them by 'phone to discover that they had left for the afternoon to go to a shopping centre in Knaresborough, about 3 nm from the hotel.

History of the flight

At 1617 hrs the owner of YU-HEW took off from the hotel grounds in his aircraft, accompanied by his wife. The owner's intentions are unknown, but after departure the aircraft was seen by witnesses flying towards Knaresborough. This is supported by radar and GPS data which record that on reaching Knaresborough the aircraft circled the area of the shopping centre three times at heights recorded as varying between 548 feet and 1,212 feet agl, before heading back towards the hotel. Some witnesses described seeing the aircraft gaining and losing height and its tail moving from side to side, so that its flight path appeared at times erratic.

Radar and GPS data show the aircraft's return to the hotel was from the north and that it flew along the hotel grounds' south-west boundary at between 539 and 278 feet agl, the latter being the last height recorded by the aircraft's GPS unit, on a track of 127°T. In this direction the path flown would have taken the aircraft close to some chalets situated in the hotel grounds, including the one owned by the pilot. Witness descriptions of the aircraft's final moments varied, but

Footnote

2 A Hungarian-registered aircraft

they generally described the aircraft "appearing to hover" in the vicinity of the chalets, just above the tops of some nearby trees. The aircraft then seemed to turn rapidly about its vertical axis, with descriptions varying from half a rotation to several rotations. There was no clear indication of the direction of rotation. The aircraft was then seen to pitch nose up and drop to the ground tail first, the impact fatally injuring both occupants.

Wreckage site

The wreckage was located in an area of deciduous trees 600 m south-west of the helicopter landing site from which it had taken off. The aircraft was significantly disrupted and was situated at the foot of a ring of six trees that were approximately 30 m high, the trunks of which formed a circle approximately 10 m in diameter. The engine was still inside its pod, although it had become detached from the fuselage. The jet pipe in the Gazelle faces rearward, and it appeared to have been damaged from the rear.

The vertical tail fin had become detached from the fuselage. Its trailing edge had been damaged by a load applied from the rear and a square-shaped 'cut out' had been made from right to left in the fin leading edge. The damage was consistent with the trailing edge of the vertical fin striking a branch, thus causing the fin to fail where it was attached to the fuselage, and the leading edge of the fin to enter the disk of the rotating main rotor blades, thus making the 'cut-out'. There were clear signs of rotation of the fenestron blades within the duct.

The tail rotor control quadrant (in several pieces), the quadrant support and the tip of a main rotor blade (mass 2.3 kg) were all found in a narrow wreckage path within 5° of a line north-east radially from the main wreckage. The rotor blade tip and the quadrant support were both located over 300 m from the main wreckage. There were many chordwise witness marks on the blade tip and these were consistent with the blade tip having struck something metallic; there were further witness marks from the main rotor blades on the horizontal tail surfaces, which are below the quadrant for the tail rotor control.

There were many freshly-broken branches on the ground, some up to 10 cm thick, and evidence of newly-broken branches in the trees above. On several of the fresh fracture surfaces of the broken branches there were green marks, and these were consistent with having been made by the main rotor blades, which were painted green. The location of the broken branches in the trees was assessed both from the ground and from photographs taken during an aerial survey conducted by the Police's North East Air Support Unit, and all the broken branches were on the inner side of the ring of six trees, with no evidence of broken branches on the outside of this ring. Thus, there was very strong evidence that the helicopter had struck the tops of these trees before falling almost vertically to the ground inside the ring of trees.

The fuselage had rolled over and was lying on its upper right side and facing due east. An indeterminate, but significant, quantity of fuel had leaked from the two fuel tanks, and over 60 litres were subsequently recovered from the tanks at the wreckage site.

Recorded information

Radar data from the Claxby radar head were available for YU-HEW during the accident flight, starting at 16:18:13 hrs and ending at 16:25:57 hrs, with returns approximately eight seconds apart. No altitude information was available. The aircraft was, however, equipped with a Bendix King KMD 150 GPS that

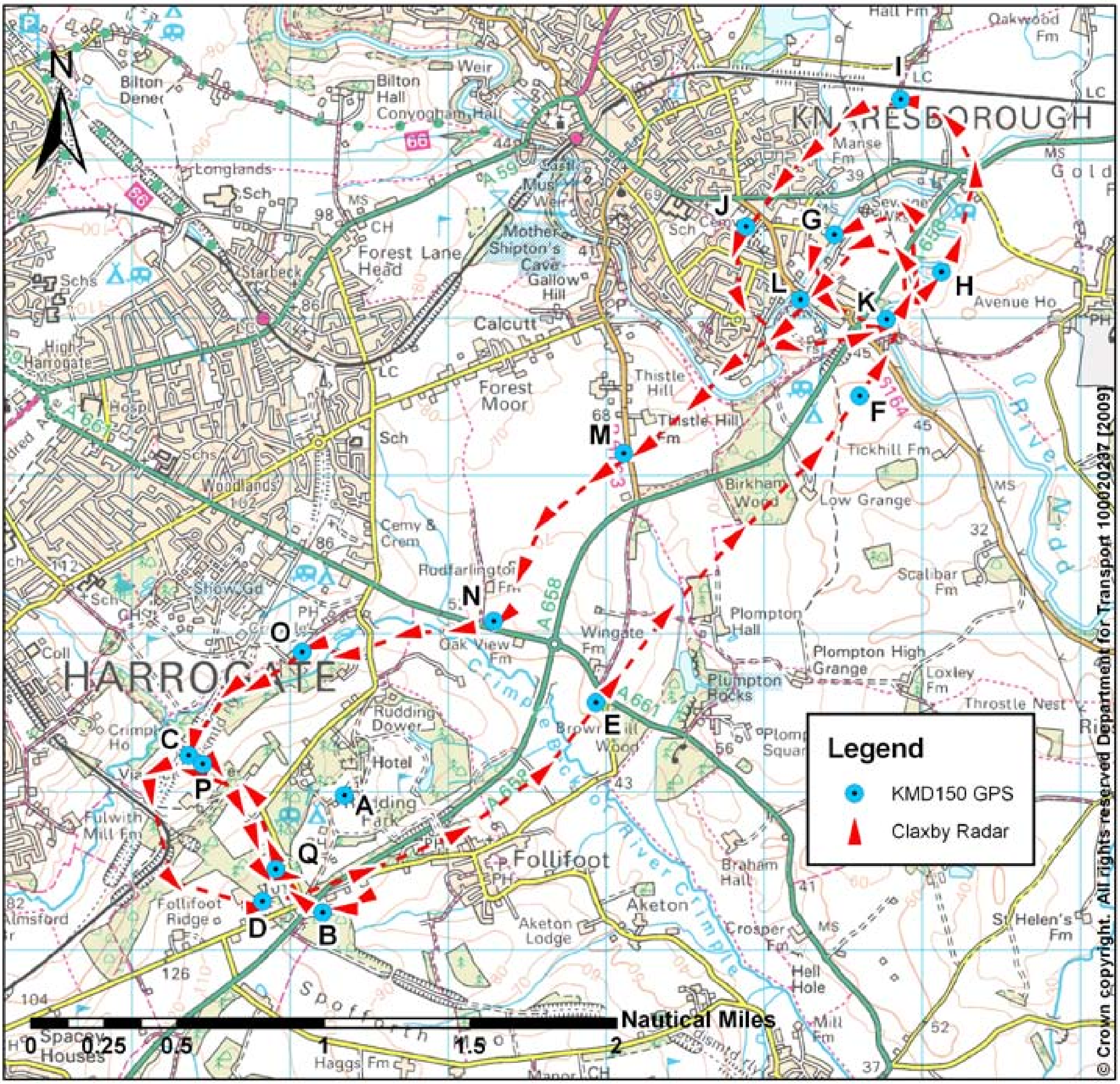

Figure 2

Radar and GPS tracks

recorded position, ground speed and ground track angle every 30 seconds, giving 17 points starting 16:17:54 hrs (just after takeoff) and ending 16:25:54 hrs. The radar track (in red) and GPS points (in blue and labelled A-Q) are illustrated in Figure 2.

The time, ground speed and height above ground level for each of the GPS logged points are given in Table 1.

An expanded view of the start and end of the accident-flight track is given at Figure 3.

Point	Time (UTC)	Ground Speed (knots)	Height (feet agl)	Track (degrees true)
A	16:17:54	22	66	193
B	16:18:24	68	456	260
C	16:18:54	82	768	289
D	16:19:24	154	914	93
E	16:19:54	158	877	39
F	16:20:24	167	572	39
G	16:20:54	80	702	233
H	16:21:24	106	548	40
I	16:21:54	82	673	275
J	16:22:24	97	754	213
K	16:22:54	92	1212	52
L	16:23:24	96	1179	221
M	16:23:54	95	840	236
N	16:24:24	86	567	221
O	16:24;54	72	440	256
P	16:25:24	68	539	170
Q	16:25:54	38	278	127

Table 1

Logged GPS data for points in Figures 2 & 3

Aircraft information - general

The Gazelle is a single-engine helicopter (Figure 1). YU-HEW's fuselage was painted black and the main rotor blades painted green. YU-HEW featured a stretched fuselage and did not have a Stability Augmentation System (SAS) fitted. The diameter of the Gazelle main rotor is 10.5 m and it comprises three blades, which rotate clockwise when viewed from above. In the case of an abnormal and extreme downward flapping motion, the blades would touch the vertical fin just above the junction between the fin and the rear fuselage.

The engine is mounted in a pod aft of the main rotor gear box and has a distinctive rearward-facing exhaust pipe.

The Gazelle has a fenestron, or 'fantail', which is a shrouded fan, enclosed inside the vertical tail fin. Eurocopter's Service Letter 1673-67-04, issued in February 2005, describes how, when transitioning from cruise to hover flight, a larger yaw pedal control input is required for a fenestron-tailed helicopter compared to a conventional tail rotor. Also noted in this Service Letter is that, if the wind is coming from the left or from behind, it will increase the rotation speed of the helicopter and hence more right rudder pedal is required to counteract this effect.

Engineering investigation - mechanical

The control runs for collective, cyclic, tail rotor, throttle and rotor brake were all checked and no evidence of a pre-accident defect, foul or discontinuity was found. A

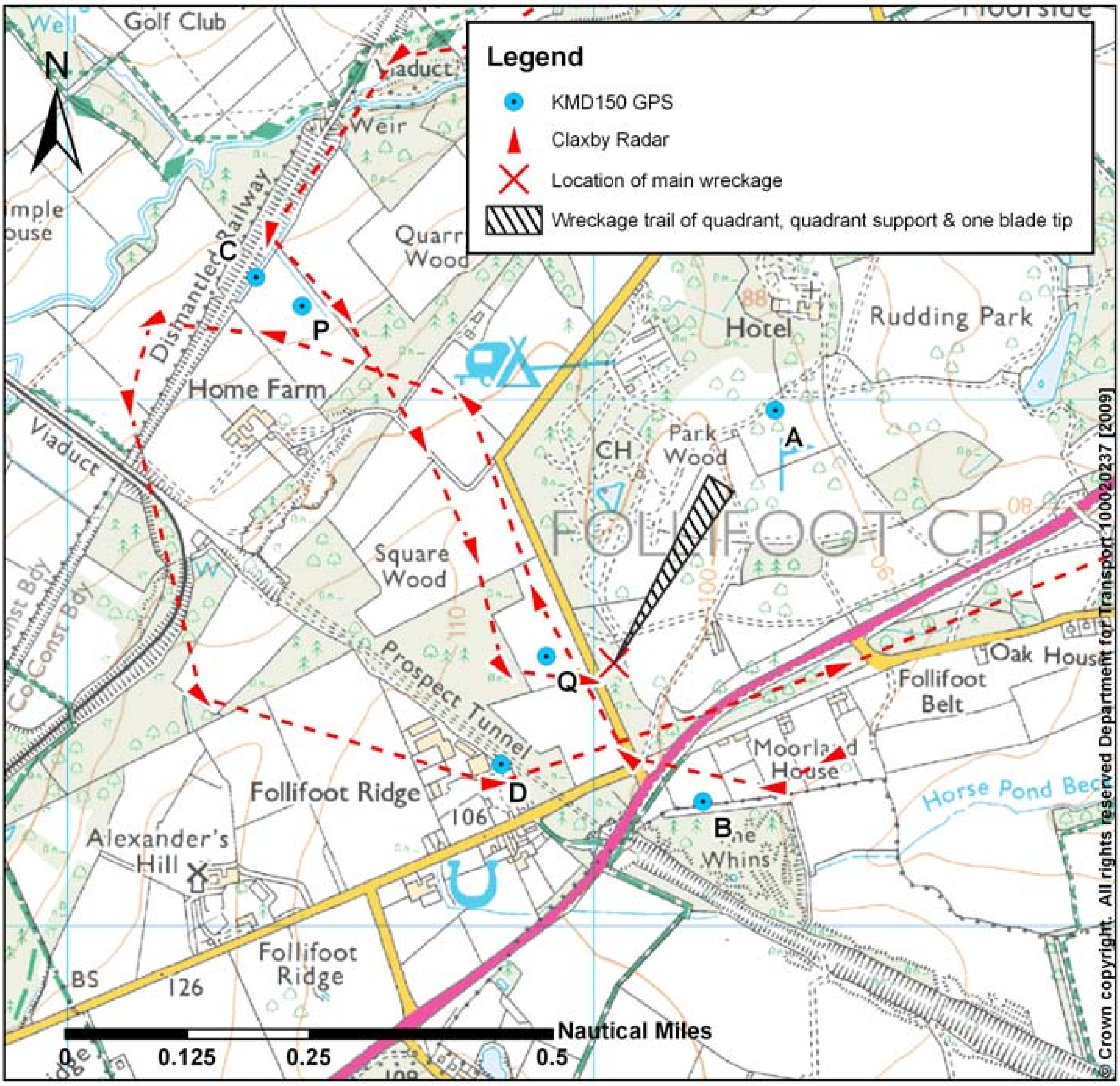

Figure 3

Expanded view of flight track, with wreckage locations

sample of fuel taken from the ruptured supplementary tank at the wreckage site was analysed at a fuels laboratory and was found to be fit for use as Jet A-1. The pieces of the tail rotor control quadrant and its support, which were found a significant distance from the main wreckage, were inspected by a metallurgist and the fracture surfaces were found consistent with overload from the impact of a main rotor blade, with no evidence of a pre-impact failure.

The engine was stripped at the manufacturer's facility under AAIB supervision and, whilst there was nothing found that was judged causal or contributory to the accident, the following observations were made:

a) a crack in the combustion mixing chamber was present. This was subsequently analysed by a specialist forensic engineer using a scanning electron microscope (SEM). Whilst fatigue striations were present it was "not possible to determine the age of the crack"

b) there was corrosion on the axial compressor blades

c) there was erosion on the first stage diffuser

It is not clear whether the items above were present when the engine was last overhauled. The engine manufacturer considered that the combustor crack and the corrosion could have developed in the 150 hours and 25 months since overhaul, however an operating regime in which this high level of diffuser erosion could occur was unlikely.

The fuel control unit (FCU) was functionally tested and this did not reveal any discrepancy that could have contributed to the accident.

Engineering investigation - maintenance documents

This SA 341G, a civilian version of the Gazelle, was manufactured in France in 1977. It was transferred to the Serbian register in January 2006 and prior to that it had been on both the French and UK registers. The certificate of airworthiness for the aircraft had been issued by the Serbian Civil Aviation Directorate (CAD) on 25 January 2008 (the day before the accident). At the time of the accident it had completed 2,868 flying hours.

The engine was a Turbomeca Astazou IIIA and was manufactured in 1990. It was overhauled by the manufacturer in 1994. In 2003 it was returned to the manufacturer for an overhaul quotation, was subsequently returned to the owner without any maintenance being undertaken and was declared '*unserviceable*' in the logbook. It was then overhauled by an organisation in Serbia, and an EASA Form 1[3] was issued on 16 December 2005. At the time of the accident the engine had completed 151 hours since overhaul.

The Serbian CAD confirmed in a letter to the AAIB that:

> *'at the time of issuing the Licence to Use on 16.12.2005, the maintenance organisation was not authorised by the CAD for this type of engine, but only for the Astazou IIIB model.'*

The Astazou IIIB is a military variant of the Astazou engine.

The EASA was contacted and confirmed that there were, at that time, no organisations in Serbia approved by EASA to undertake EASA Part 145 maintenance on either the Astazou engine or the Gazelle aircraft.

An attempt was made by the AAIB to assess whether there were other Gazelle aircraft maintained in the UK on the Serbian register that had engines that had been overhauled by an organisation not approved for the type of engine. Four Serbian-registered Gazelle aircraft were found, with engines overhauled in 2005 by an organisation in Serbia (and with EASA Form 1s issued) that was not approved for the type of Astazou engine. One aircraft was fitted with an Astazou IIIA and three were fitted with Asatzou XIVH.

In *'CAP 393 - The Air Navigation Order'* (ANO), Part 3, Article 8(1) states that:

Footnote

3 An EASA Form 1 is a certificate for the release to service of an aircraft part.

> *'…an aircraft shall not fly unless there is in force in respect thereof a certificate of airworthiness duly issued or rendered valid under the law of the country in which the aircraft is registered or the State of the operator, and any conditions subject to which the certificate was issued or rendered are complied with.'*

Since the EASA Form 1 appears to have been issued by an organisation that was not approved to do so, the Certificate of Airworthiness may have been invalid and hence the operation of this aircraft, and the other four Serbian-registered Gazelles based in the UK, may have contravened the ANO.

Weather

Aftercasts of the weather conditions in the area of the accident site were obtained from the Met Office:

> *Synoptic situation* - At 1200 hrs there was a warm front lying northwest to southeast over Yorkshire, moving northeast to lie along the east coast by 1800 hrs. The pressure pattern was significant due to its generation of a strong west to west-northwesterly gradient on the northern flank of a high pressure area that covered France and the southwest approaches. A subsidence inversion associated with this high pressure would have generated mountain wave conditions over the area of the accident site.
>
> *Actual conditions* - Whilst cloudy, it is most likely that the conditions were dry with no significant weather at the time of the accident. Surface visibility is likely to have been of the order 15 to 27 km below cloud, although scattered cloud may have covered hills above 1,600 ft amsl, giving hill fog and visibility of less than 200 metres. There was possibly scattered stratocumulus cloud with a base of 1,300 ft above the accident site. Cloud may have covered high ground in the distance.
>
> *Wind conditions* - The Met Office aftercast indicated turbulent conditions, with winds at 500 feet agl of 270°/15-44 kts and surface winds 260°/20-25 kts, gusting 30 to 35 kts and occasional 10 kts in lulls. Analysis of the synoptic situation indicated that the conditions were conducive to mountain wave activity, and there was evidence from satellite imagery that such activity existed.

Met Office modelling did not provide explicit indications of the magnitude of the turbulence, but their empirical considerations of the flow and terrain suggested that moderate, occasionally severe, low level turbulence was likely in the area.

The pilot who had flown in YU-HEW with the owner, from Stapleford to the hotel, reported that, whilst it had been windy, it had not appeared particularly so after landing at the hotel when he was walking around the aircraft. He believed this may have been due to the shelter afforded the landing site by trees in the hotel grounds. He further commented that he had not expected the pilot to go flying again that day and would have advised him against it under the prevailing weather conditions.

The pilot of the police helicopter which attended the scene about 50 minutes after the accident estimated the wind at about 700 ft agl to be approximately 285° at 30 kt, gusting 40 kt.

Fuel and loading

The aircraft had its main tank filled prior to leaving Stapleford, which would have been sufficient for both the flight to the hotel and the subsequent flight leading to the accident. Calculation by the manufacturer showed that the aircraft was operating within its weight and centre of gravity limits at the time of the accident.

Pathology

The pilot held a valid JAA Class II medical certificate at the time of the accident and there was no past medical history or evidence from the post-mortem of natural disease which could have caused or contributed to the accident. The post-mortem revealed injuries consistent with the pilot having the collective lever in his hand at the point of impact, which implies he was not incapacitated and was actively attempting to fly the aircraft. Toxicological examination revealed no drugs or alcohol in the pilot's blood.

The nature of the injuries sustained by both the pilot and passenger indicated the accident was non- survivable. It is unlikely that the provision of additional or alternative safety equipment would have altered the fatal outcome.

UK flight training regime

In the UK, three classifications of training organisation exist under JAR (Joint Aviation Requirements) for rotary-wing aircraft:

- Flight Training Organisation (FTO) - conducts training of existing licence holders and integrated commercial licence courses
- Type Rating Training Organisation (TRTO) - conducts training for the issue of type ratings only to licence holders
- Registered Training Facility (RTF) - conducts training for the issue of private pilot licences and night flying qualifications.

In order to qualify as either an FTO or TRTO, organisations must seek approval from the CAA. They must have a training and an operations manual and pass an initial inspection as part of the approval process. If successful, approval is granted for an initial period of one year after which another inspection is carried out. If passed, the approval can be renewed for up to a further three years. Each organisation is allocated a CAA inspector who carries out an inspection at least once a year.

To become an RTF no approval needs to be granted; organisations are only required to register with the CAA and certify that they comply with certain required conditions. No inspections are carried out and no training or operations manuals are required. Registration remains valid until either the CAA is informed that PPL training is to cease or the CAA establishes that training is not being carried out safely or is not in compliance with JAR-FCL. In these instances the registration may be revoked.

An FTO or TRTO which provides training for the attainment of private pilot licences would also need to register as an RTF. Inspections undertaken as part of being an approved organisation would not extend to those elements covered by being an RTF. As a result, private pilot training conducted by any category of training organisation is not subject to routine inspections, although the CAA has the authority to conduct such inspections should they believe there is cause to do so. In reality this would only be done as the result of information being received by the CAA that raises sufficient concern about an organisation to warrant possible intervention. At the time of this report there were over 500 RTF organisations in existence, although it is not known how many are active. In the year to February 2009 eight such inspections being made by the CAA.

As a result of this accident the CAA attempted to audit the RTF involved, but were unable to do so as the owner surrendered the registration.

Flight training - JAR-FCL PPL(H) training syllabus

JAR-FCL 2 Subpart C lists a series of exercises, numbered 1 to 28 which form the syllabus for training for the PPL(H), exercise 28 being for night flying. Exercises 15, 23, 25, and 26 are listed below:

Exercise 15
Hover out of ground effect (OGE), vortex ring

- establishing hover OGE
- drift/height/power control
- demonstration of incipient stage of vortex ring, recognition and recovery (from a safe altitude)
- loss of tail rotor effectiveness

Exercise 23
Advanced take-off, landings, transitions

- landing and take off out of wind (performance reduction)
- ground effect, transitional lift and directional stability variation when out of wind
- downwind transitions
- vertical take off over obstacles
- reconnaissance of landing site
- running landing
- zero speed landing
- cross wind and downwind landings
- steep approach
- go-around

Exercise 25
Limited power

- take-off power check
- vertical take-off over obstacles
- in flight power check
- running landing
- zero speed landing
- approach to low hover
- approach to hover
- approach to hover OGE
- steep approach go-around

Exercise 26
Confined areas

- landing capability, performance assessment
- locating landing site, assessing wind speed/direction
- reconnaissance of landing site
- select markers
- select direction and type of approach
- circuit
- approach to committed point and go-around
- approach
- clearing turn
- landing
- power check, performance assessment in and out of ground effect
- normal take-off to best angle of climb speed
- vertical take-off from hover

Flight training - aircraft types approved for training

JAR regulations limit the size of helicopter to be used for ab initio training to those with a maximum of four seats. Exemption from this rule can be applied for under exceptional circumstances.

The helicopter used by the pilot for his training, HA-LFM, had five seats but dispensation was sought, and granted, from the CAA for it to be used. At the time of the accident the CAA considered that owning an helicopter with more than four seats was sufficient justification to allow it to be used for ab initio training of that owner. The CAA considered this justified as it would allow the owner significantly more instructional time on the helicopter than if the licence was gained on a different type followed by conversion onto type via a type rating course.

Flight training - RTF and Operating Permit applications

The pilot had decided that the helicopter type he wished to buy was a Gazelle. In the course of attempting to find a suitable aircraft he had been put in contact with an instructor, who in turn put him in contact with the owner of several Gazelle helicopters based at Breighton Airfield in Yorkshire. It was reported that this resulted in the pilot buying a part share, together with two other unqualified pilots, in one of these Gazelles, a Hungarian-registered aircraft HA-LFM. Investigation has failed to reveal evidence that any of these three people actually purchased a share in the aircraft, which remained registered solely in the name of the original owner.

An application was made by the owner of HA-LFM, dated 27 August 2007 and received by the CAA on 5 September 2007, to set up an RTF in order to train the three individuals who, it was stated, had purchased a share in the aircraft. The RTF was to be registered to the original owner of HA-LFM with the instructor, who had introduced the pilot, registered as the only instructor. It was stated in correspondence supporting the application that the aircraft was maintained to a public transport standard and that the Hungarian authorities would be informed of the intention to use the aircraft for training in the UK in order to ensure their requirements had been met. No evidence has been found of permission being sought from the Hungarian authorities to use HA-LFM for training.

This registration was approved by the CAA on 19 November 2007, dependant on the training organisation seeking the necessary permission from the Department for Transport (DfT) to use a foreign-registered aircraft in the UK for training, as it constituted aerial work. Enquiries confirmed that permission for an Operating Permit from the DfT had been sought concurrently with the RTF application. The DfT rely on the CAA to review aviation-related paperwork as part of their approval process to ensure it complies with required UK aviation regulations. This process is completed by a different department within the CAA from that which deals with RTF applications and was delayed as the applicant originally failed to supply all the necessary information. In addition, the original insurance certificate provided did not provide cover for training and there was no evidence of the named trainee pilots being co-owners. In a subsequent email to the DfT dated 28 September 2007 the owner of HA-LFM stated that of the three pilots in question, one was his spouse and the other two each owned a sixth share. He further stated that:

> *'Training to be from Beverley Airfield on a CAA Registered Training Facility [RTF] with CAA Instructor Capt [A] and CAA Examiner Capt [B].'*

It is believed that the majority of the deceased pilot's instruction was given by 'Capt A'. 'Capt B' was the examiner for the subsequent PPL(H) Skills Test. The owner of HA-LFM, 'Capt A' and 'Capt B' were known to each other professionally, although 'Capt B' later commented that he had not known that he had been mentioned as part of the DfTapplication process.

Pilot's flying experience and training history

Logbook evidence indicates the pilot commenced fixed-wing flying lessons in November 1988, gaining a fixed-wing private pilot's licence on 24 February 1989 and a fixed-wing commercial licence on 4 October 1990, by which time he had logged 771 hours. It is understood that he had intended to become a commercial pilot but went into business instead, there being no further flights logged until February 2007. His records show that he then flew a further 26 hours on fixed-wing aircraft between February and August 2007.

The pilot had expressed a desire to learn to fly a helicopter and to purchase his own. Another logbook held by the pilot records that on 5 July 2007 he started flying lessons on a Schweizer 300 (269C-1) helicopter, undertaking eight lessons between 5 July and 7 August 2007, totalling 10 hours and 18 minutes flying time, with a training organisation based at Sheffield Airport.

There were no flights recorded in the pilot's logbook between 7 August and 19 November 2007, but on 19 November 2007, the day the RTF and DfT Operating Permit for HA-LFM were issued, the logbook records he commenced flying lessons on HA-LFM. It records a number of training flights being flown from Beverley Airfield on ten different days between 19 November and 5 December 2007. The flights were all recorded as being flown on the same aircraft, HA-LFM, and with the same instructor as named in the RTF application, totalling 25 hours dual instruction and 10 hours 6 minutes supervised solo flying. Of the solo time recorded, up to 6 hours 36 minutes was recorded as having been spent on navigation exercises. During this time the pilot also took and passed a theoretical technical exam on the Gazelle.

The pilot's logbook records he undertook a two-hour PPL(H) Skills Test on 12 December 2007 from Beverley Airfield, which he passed, and was issued his PPL (H) on 21 December 2007.

Log book entries made subsequent to the entry recording this Skills Test showed that on the 23 and 24 November 2007 the pilot flew YU-HEW from Stapleford to Aarhus in Denmark and back, in the company of a family member. This was one of the other reported co-owners of HA-LFM, who was also undergoing training with the RTF. They were accompanied on this flight by a qualified Gazelle pilot who held a UK PPL(H) and an FAA helicopter instructor's rating.

The last entry in the pilot's logbook was for a flight on 5 December 2007, this time from Breighton Airfield, with the same instructor who had conducted his PPL training on the Gazelle. The takeoff and landing times indicated the flight took place at night and lasted one hour, although it had been recorded claiming one hour of dual day flying and an additional 42 minutes of dual night flying.

Enquiries into inconsistencies in the pilot's logbook revealed that he had, in fact, commenced flying training on HA-LFM prior to 19 November 2007. The instructor stated there had been delays in getting the RTF issued and so he had begun training with two of the three trainee pilots prior to its issue, although he was unable to say exactly when that was. It had been decided that, in order to satisfy the requirements of the CAA, none of these training flights would be logged, but instead entries would be made in the pilot's logbook indicating that all the training flights post-dated the granting of the RTF. The instructor was not able to produce training records or other supporting evidence to show which flights had actually been conducted by the pilot fatally injured in the accident. In addition, the owner of HA-LFM stated that there were no technical records kept for flights undertaken by the aircraft that might have provided a record of the flights undertaken. The only corroborating evidence available for any of the training flights logged by the pilot on HA-LFM was the cross-country flight certificate for a flight logged on the 29 November 2007.

The instructor, whilst unable to provide supporting evidence, stated that the pilot had nevertheless completed all the necessary flying training. He also stated that the pilot had completed all the ground school training required and had passed his technical exam with a mark of 100%. This ground school training had also included a brief on the effects of a loss of tail rotor effectiveness although there were no questions on this in the exam.

A document subsequently provided by a member of the pilot's family was presented as an apparent record of the pilot's actual flying hours. The first flight date recorded on this document was 20 August 2007 and the last flight recorded was 12 December 2007. Between these dates the sheets recorded the pilot as having flown 25 hours 24 minutes dual instruction, and 8 hours 36 minutes solo. Of these hours, two hours were flown when undertaking the Skills Test and there is evidence that one hour was undertaken in a rear seat, flying as a passenger, whilst another pilot was receiving training. The document would thus indicate the pilot having undertaken 22 hours and 24 minutes dual training and 8 hours 36 minutes supervised solo flying between the dates recorded.

The pilot's logbook recorded all the training flights as originating from Beverley Airfield, although there was no supporting evidence that this was the case. The aircraft was based at Breighton Airfield and the pilot would not have been able to log the transit time between Breighton and Beverley towards his flying training hours. As the unofficial flight time record maintained by the pilot appears to have recorded the total flight times, rather than just training hours, had the training actually been conducted from Beverley Airfield then it follows that his actual training hours might have been less than the total recorded.

Application requirements for PPL(H) Skills Test

An application was made on 12 December 2007 for the pilot to take the Skills Test in order to gain his PPL(H). This application stated that the pilot had flown a total of 45 hours 18 minutes on helicopters, 10 hours 6 minutes solo and 35 hours 12 minutes dual. The normal required minimum flight time on helicopters to undertake the Skills Test is 45 hours; however, due to his previous experience and licences on fixed-wing aircraft the pilot was only required to undertake 39 hours training. Of this at least 25 hours dual instruction and 10 hours of supervised solo flight time were required to have been completed on one type of helicopter and at least five hours of solo cross-country flying conducted. The form was certified by the RTF's instructor that the pilot had completed the necessary training and that the instructor had checked the pilot's logbook to ensure the entries met the flying experience requirements. The logbook, however, contained no record of exercises 23, 25 and 26 of the syllabus having been flown. When interviewed, the instructor stated these exercises had been completed but, in error, had not been recorded in the logbook.

Conduct of PPL(H) Skills Test

The examiner who conducted the test was a freelance pilot who had originally been trained as an instructor in 1994 whilst serving as a helicopter pilot in the military. As a result he had considerable experience instructing on the Gazelle. He was also an experienced civilian examiner, although the majority of the tests he conducted were licence proficiency checks, this being only the second Skills Test he had undertaken.

During the investigation it became apparent that, on one previous occasion, on 14 September 2007, the examiner had flown with the pilot at Breighton Airfield to demonstrate autorotations. The flight had been undertaken with one of the other pilots being trained under the RTF on HA-LFM, the two pilots flying for approximately one hour each, spending the other hour observing from the rear seat. The examiner stated that he had pointed out that these hours could not be included towards their flight training as the RTF had not been issued. These flights were included in the unofficial record maintained by the pilot.

The pilot's navigation log for the Skills Test showed the flight commencing from Breighton Airfield. The first leg recorded on the log was to Beverley Airfield and the examiner stated that this is where the test element of the flight had commenced The examiner reported it was conducted in good weather conditions with only a light wind and that he was impressed by the standard of the pilot. He passed the pilot on all elements of the test, assessing him as well above average ability. The examiner stated that the pilot had, however, allowed the aircraft to weathercock during a spot turn, requiring him to repeat the exercise. The pilot had, however, been able to control the weathercocking without intervention and had repeated the exercise to a satisfactorary standard. The examiner stated that the pilot was 'level headed and capable' and he considered that he had flown to the same standard expected of a pilot undergoing a commercial Skills Test.

Subsequent analysis of radar data identified the Skills Test flight and indicated discrepancies between the route and the timings of the test and those recorded on the examination paperwork.

Previous occurrences

The AAIB has investigated seven previous occurrences to civil Gazelle helicopters involving loss of yaw control, the last being on 8 May 2005 (EW/C2005/05/01). A recurring factor is a lack of pilot experience.

The Gazelle tail fin is considerably larger than most non-fenestron-equipped helicopters, making the execution of a spot turn a challenge due to the weathercock effect in windy conditions. The Gazelle was used extensively by the UK armed services as a training aircraft and incidents where there had been an apparent loss of yaw control led to research by both the UK military and Eurocopter into their cause and, in particular, whether a condition termed 'fenestron stall' existed. Although the existence of fenestron stall was not established, the research led to the provision of advice to pilots on how to avoid the phenomenon of loss of yaw control and how to deal with it should it occur.

The CAA published an amendment to the Gazelle flight manual in 1992 titled 'Uncontrolled Yaw Breakaway'. As previously stated, Eurocopter produced Service Letter 1518-67-01 dated 26 April 2001, and later Service Letter 1673-67-04 dated 4 February 2005 (Annex A) regarding yaw control under various flight conditions. The requirement for instructors to include training on 'loss of tail rotor effectiveness' (LTE) for all types was included in a CAA Helicopter TrainingCom of 1/2003, issued to all instructors and Training Organisations after a previous AAIB recommendation.

Analysis - engineering

Damage to the trees, the compressive damage to the rear of the helicopter, and the damage to the engine jet pipe, demonstrated that the aircraft struck the trees tail-first in an approximately vertical descent. The geometry of this helicopter type is such that the observed damage to the fin leading edge could only have occurred after the fin had detached from the fuselage and moved forward, probably as a result of striking the fin trailing edge against part of a tree as the aircraft fell backwards.

Given that the fin was forced forwards into the arc of the main rotor blades, this would have caused the tail rotor drive shaft to fail and the cable controls for the tail rotor and the tail rotor quadrant to be disrupted. There were witness marks from the main rotor blades on the horizontal tail surfaces, which are below the quadrant for the tail rotor control. Therefore, it would have been the main rotor blade disc which propelled both a blade tip and the tail rotor quadrant support over 300 m from the main wreckage. As the pieces of tail rotor quadrant and the quadrant support were located on an almost straight line over 300 m long, starting at the main wreckage, it is highly probable that the 'cut out' in the fin leading edge, and the damage to the tail rotor quadrant and support, both occurred very close to the main wreckage site, almost simultaneously, and probably when the aircraft was orientated nose vertically upwards. Subsequent analysis by a metallurgist confirmed that the tail rotor quadrant and support failed in overload, and that there was no evidence of an in-flight failure. This indicates high energy in the rotor system at the start of the accident sequence.

The engine strip showed no indication of a mechanical failure, and there was no evidence that any of the flight controls were operating in an abnormal way. The sample of fuel taken from the ruptured collector tank was analysed and assessed as being fit for purpose. In summary, there was no indication of any technical causal or contributory factor in the accident.

Analysis - operations

From the evidence it appears that the pilot, who had limited helicopter experience, was attempting to operate in weather conditions which more experienced pilots might have chosen to avoid. Indeed, part of the reasoning for being accompanied on the flight from Stapleford by another, more experienced pilot included the forecast weather conditions. His colleagues stated that they had been surprised by the pilot's decision to undertake the flight from the hotel and the conditions were such that, had they known his intentions, they would have tried to dissuade him from doing so. They considered it possible that, as the helicopter had been parked in an area affording some protection from the wind, this had given the pilot false confidence about the prevailing weather conditions. Despite this, the pilot had only recently landed at the hotel and so would have been aware of the wind and would certainly have become aware of the deteriorating conditions once airborne again. It is possible that the enthusiasm of having just taken delivery of the aircraft overcame any concerns about the weather. It is also possible that the same enthusiasm led to the low-level nature of the flight around the shopping centre where family members were believed to be present.

The recorded data (radar and GPS) give reasonable indications both of track and ground speed and these correspond well to the witness observations, although they do not give an accurate indication of either the aircraft's airspeed or heading. It is considered likely that, at the time of the accident, the pilot was trying to observe his chalet in the grounds of the hotel. In doing so, however, he had placed the helicopter in a precarious position with a strong blustery wind adversely affecting the controllability of the aircraft whilst flying at a low forward airspeed.

Inconsistencies in evidence provided during the investigation raised concerns about the level of training received by the pilot. The instructor's stated reason for commencing training prior to receiving approval for the RTF was the CAA's apparent delay in registering the training organisation. There was, however, a similar delay in receiving the relevant permission from the DfT which was due in part to the failure to provide the DfT with the required documentation. The instructor was aware that training conducted prior to the RTF being registered could not be counted towards the issue of the pilot's licence and this led to the false entries in the logbook. This in itself should not have affected the standard or amount of training received by the pilot. The absence, however, of documents that might be expected to exist, principally the aircraft technical log, instructor's logbook and training notes, raised further concern about the standard of operation of the RTF and removed the opportunity to confirm which flights had actually been undertaken. The evidence that does exist indicates that the pilot did not complete sufficient training hours and it is unlikely that the full syllabus was completed adequately in this time. Inconsistencies were also identified concerning the Skills Test the pilot undertook and, as a result, the investigation could not reliably ascertain the pilot's flying ability at the time of the accident.

Conclusion

In the absence of any significant technical defect, it is considered that the pilot lost control of the helicopter in yaw due to the strength, direction and gusty nature of the wind acting on the aircraft whilst flying at low forward airspeed. It is likely that in the attempt to recover the situation the pilot also lost control in pitch, causing the helicopter to pitch up severely before falling into the trees and impacting the ground.

Because of the lack of detailed recorded flight data and the fact the pilot died in the accident, it has not been possible to define causal factors beyond the pilot's loss of control of the helicopter. However, it is considered that the main contributing factors to this accident were the pilot's lack of experience and probable inadequacies in his training.

Deficiencies in the aircraft's maintenance were also apparent, although these are not considered causal or contributory to the accident.

Safety Recommendations

Whilst no technical cause for the accident was evident, the engine was found to have been overhauled by an organisation that was not approved for the engine type. Four further UK-maintained Gazelles were found in a similar situation. Therefore the following Safety Recommendations are made:

Safety Recommendation 2009-084

It is recommended that the Serbian Civil Aviation Department review its oversight and audit system to ensure that aviation maintenance organisations in Serbia release to service only items for which they have the correct approvals.

Safety Recommendation 2009-085

It is recommended that the Civil Aviation Authority conduct an audit of Serbian-registered aircraft in the UK to ensure that they meet the requirements of the Air Navigation Order.

The current system of oversight, under JAR-FCL, does not require oversight of RTF organisations. Therefore the CAA does not carry out routine audit of these organisations but only intervenes when a potential problem has already been highlighted to the CAA. It would be more appropriate to carry out proactive inspections to ensure standards are being maintained: at the time of the investigation it was uncertain how many of the RTFs were active. This is important as an RTF is likely to be the first contact for those new to aviation, who may have little understanding of what standards to expect.

Safety Recommendation 2009-086

It is recommended that the Civil Aviation Authority introduce periodic audits of Registered Training Facility (RTF) organisations to ensure appropriate private pilot training standards are being met at the current time and with the introduction of EASA FCL regulation.

The examiner was known to the instructor and had been included in paperwork supporting the setting up of the RTF. It is also known that he had flown with the pilot on at least one occasion prior to his Skills Test. The current system, whereby examiners are selected, and paid for, by those being tested, creates the potential for a conflict of interest and examiners for such tests should be allocated by the CAA.

Safety Recommendation 2009-087

It is recommended that the Civil Aviation Authority allocate examiners for the conduct of PPL Skills Tests.

Loss of tail rotor effectiveness currently forms part of the PPL(H) training syllabus; this is difficult to demonstrate in the air and thus relies upon theoretical briefing in the classroom. Some helicopter types, including the Gazelle, are considered particularly vulnerable to this phenomenon and this theoretical knowledge should, reasonably, be tested in the ground school theory exam. Therefore,

Safety Recommendation 2009-088

It is recommended that the Civil Aviation Authority review the training requirements for 'loss of tail rotor effectiveness' and ensure it is covered in written exam papers.

ACCIDENT

Aircraft Type and Registration:	Robinson R22 Beta, G-ODJB
No & Type of Engines:	1 Lycoming O-360-J2A piston engine
Year of Manufacture:	2003
Date & Time (UTC):	16 April 2009 at 1525 hrs
Location:	Nottingham City Airport, Tollerton, Nottinghamshire
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Extensive
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	29 years
Commander's Flying Experience:	1,011 hours (of which 742 were on type) Last 90 days - 86 hours Last 28 days - 29 hours
Information Source:	Aircraft Accident Report Form submitted by the instructor

Synopsis

The student, on a dual training flight, lost control of the helicopter whilst hover-taxiing downwind in challenging wind conditions. The instructor was unable to intervene in time and the helicopter struck the ground and rolled over.

History of the flight

The helicopter was flown by the student with an instructor to Nottingham City Airport for a training exercise on hovering and hover-taxiing. After a one-hour training detail, the helicopter was hover-taxied to the parking area and shut down for a break of approximately 30 minutes. This was followed by a further, similar training exercise.

The helicopter was started up and the student hover-taxied towards the Runway 09 threshold, with the instructor following through on the controls. After about 15 minutes they repositioned towards the grass to the south of the runway. At the time of the accident the student was hover-taxiing the helicopter slowly downwind at a height of about 5 ft, with the instructor continuing to follow through on the controls. In the instructor's opinion the student was performing reasonably well for the conditions. The student then began over-controlling and, without warning, made a sudden large forward cyclic control input. Before the instructor could intervene, the helicopter adopted a pronounced nose-down attitude and the front of the skids struck the ground. It then rolled onto its left side, sustaining considerable damage. Both occupants were able to exit unassisted.

The surface wind at the time of the accident was variously reported to be 030°/15 kt and 030°/10-20 kt.

Comments

The requirements to which the R22 is certificated call for controllability to be demonstrated in a 17 kt wind from any direction. Although the wind speed was below this figure, hover-taxiing light helicopters in a 15 kt tailwind can be a demanding exercise for students. The student's sudden application of forward cyclic control gave the instructor little time to intervene and he was unable to prevent the helicopter from striking the ground.

ACCIDENT

Aircraft Type and Registration:	Airborne Edge XT912-B/Streak III-B, G-LVPL
No & Type of Engines:	1 Rotax 912 piston engine
Year of Manufacture:	2004
Date & Time (UTC):	10 May 2009 at approximately 1745 hrs
Location:	Stourton, Stourbridge, West Midlands
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Damage to the nose landing gear, wing, pod and propeller
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	54 years
Commander's Flying Experience:	207 hours (of which 207 were on type) Last 90 days - 18 hours Last 28 days - 14 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

While landing at a private grass airstrip, in the lee of a wooded area to its left, the aircraft landed heavily, the nose landing gear collapsed and the aircraft ran off the left side of the runway into a series of fence posts. The pilot concluded that the accident resulted from his failure to appreciate fully the effects of the direction of the surface wind, which put the airstrip in the lee of the trees.

History of the flight

The aircraft was returning to a private grass airstrip near Stourton at the end of a day's flying. The pilot assessed the surface wind as being from the northeast at about 7 kt and gusting, but he was unsure of its maximum strength. He decided to land on Runway 09, which is 320 m long and 10 m wide. With the wind from the northeast, Runway 09 was in the lee of a wooded area which was on raised ground along a canal embankment.

The pilot was prepared for some turbulence on the approach but reported that, at about 30 ft agl, the aircraft encountered a large amount of sink. He applied power but was unable to prevent a hard landing. The nose landing gear collapsed and the aircraft ran off the left side of the runway into a series of fence posts, which had been placed there to prevent construction traffic working on the nearby canal, from infringing the runway.

The aircraft sustained damage to its nose landing gear, wing, pod and propeller. The pilot, who was wearing a helmet and a full harness, received minor injuries and was assisted from the aircraft by nearby witnesses. He concluded that the accident resulted from his failure to appreciate fully the effects of a surface wind from that direction.

Comment

The CAA's General Aviation Safety Sense Leaflet 12, entitled '*Strip Flying'*, refers those considering setting up a strip to Civil Aviation Publication (CAP) 428, entitled *Safety Standards at Unlicensed Aerodromes'*; this latter publication recommends 18 m as a minimum runway width.

ACCIDENT

Aircraft Type and Registration:	BFC Challenger II, G-BYKU
No & Type of Engines:	1 Rotax 582 piston engine
Year of Manufacture:	2007
Date & Time (UTC):	22 July 2008 at 0950 hrs
Location:	On approach to Runway 25 at Otherton Airfield, Staffordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to propeller, fuselage fabric and dorsal longeron
Commander's Licence:	Private Pilot's Licence
Commander's Age:	71 years
Commander's Flying Experience:	243 hours (of which 5 were on type) Last 90 days - 22 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and AAIB inquiries

Synopsis

The propeller and hub assembly detached from the aircraft at a late stage on the approach. The pilot was able to continue with a glide approach and landed safely on the runway. The investigation established that thread locking compound had not been applied to the propeller hub mounting bolts, allowing them to vibrate loose. This resulted in fatigue cracks developing in the bolts, causing them to fail.

History of the flight

The aircraft flew uneventfully in the local area for 10 to 15 minutes before the pilot rejoined the circuit to land. At a late stage on the approach he heard a loud "bang" from behind him and assumed that the drive belt to the propeller reduction gearing had failed. Despite the loss of thrust he was able to land the aircraft safely on the runway, where he discovered that the propeller assembly and propeller hub were missing. All the components were subsequently recovered from a tree on the edge of the airfield.

At the time of the accident the aircraft had flown approximately 12.6 hours since August 2007, when its first Permit to Fly was issued.

Aircraft information

The BFC Challenger II is a high-wing aircraft powered by a two-stroke engine mounted above the rear fuselage in the pusher configuration.

The propeller blades are mounted on a reduction drive assembly (Figure 1) which consists of a propeller assembly, propeller hub and top pulley, all of which are manufactured from aluminium alloy. The propeller hub is attached to the top pulley by six steel Allen head bolts, each of which screws into a threaded blind hole in the top pulley. Steel bolts are used to secure the propeller assembly to the hub.

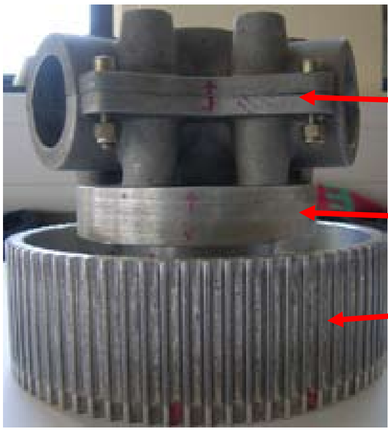

Figure 1

Reduction drive assembly

Examination of the aircraft

The owner of the aircraft reported that the propeller hub had detached from the top pulley and that five of the six hub mounting bolts had broken in two. A report from an Inspector from the Light Aircraft Association (LAA) who examined the aircraft stated that one propeller blade had struck the dorsal longeron area immediately beneath the propeller arc, severely denting the tube and stressing the associated structure forward of the impact area.

Previous occurrences

The LAA informed the AAIB that there had been two previous occurrences of the propeller and hub assembly detaching from this type of aircraft. The first occurred in flight in the USA in 1998, and the second, on the ground in the UK in 2005. The hub mounting bolts were not recovered following either of these occurrences and therefore it was not possible to establish why they had failed.

As a result of these occurrences, the Popular Flying Association (PFA), now the LAA, issued an Airworthiness Information Leaflet[1] on 6 October 2005 requiring owners to check the torque of the propeller hub mounting bolts every 50 hours. Issue 1 of this document referred to the bolts as '*propeller attaching bolts*' and Issue 2, dated 24 January 2006, referred to the bolts as '*propeller adaptor bolt*' and '*counterbored Allen bolts of the drive adaptor plate*'. The manufacturer's build instructions do not use any of these descriptions.

Issue 2 also stated that the bolts should be correctly torqued to '*12 ft/lbs*' in accordance with the manufacturer's specification and any unserviceable bolts should be replaced using '*Red Loctite*'. The manufacturer's build instructions state that the bolts should be torqued to '*15 ft. lbs'*. There are a number of different Loctite products that are coloured red and not all of these are suitable for this application. In the build instructions the manufacturer states that '*#271 Red Loctite*' should be used on the propeller hub mounting bolts.

Build history

The owner started building the aircraft in 1999 and an LAA inspector signed for inspecting the engine assembly on 18 June 2004. The owner was unable to fully recall the activities he undertook in fitting the propeller drive assembly, but believed that he had followed the manufacturer's instructions and had applied a Loctite thread locking compound to the threads on the propeller hub mounting bolts and the corresponding threads in the blind holes in the top pulley.

Footnote

[1] PFA/MOD/177/014.

Examination of the reduction drive assembly

The reduction drive assembly and six propeller hub mounting bolts were inspected by the AAIB and the forensic engineering division of QinetiQ.

Propeller hub mounting bolts

One bolt was recovered intact; the remaining five had all broken between 10 and 16 mm below the bottom of the bolt head. The fracture surfaces of the broken bolts all showed smooth and ductile overload regions indicative of fatigue progression leading to final failure in overload (Figure 2). The threaded portion of the bolts was approximately 29 mm long and the shank approximately 2 mm long.

Top pulley

The top pulley had six blind threaded holes into which the hub mounting bolts were secured. One hole contained part of a bolt that had broken off approximately flush with the surface of the pulley, one hole was in relatively good condition and the remaining holes all showed some damage in the form of stripped threads and ovality. The depths of five of the blind holes were measured and found to range from 33.4 to 34.6 mm. It was not possible to establish accurately the depth of the hole containing the broken bolt.

Propeller hub

There was extensive fretting damage on the face of the propeller hub which was in contact with the top pulley (Figure 3). The clearance holes for the hub mounting bolts were all deformed and an impression of the thread from the bolts had formed on one side of each of the holes. The threads in five of the six holes into which the propeller assembly attachment bolts fit were found to be intact. Part of the thread was missing from the sixth hole.

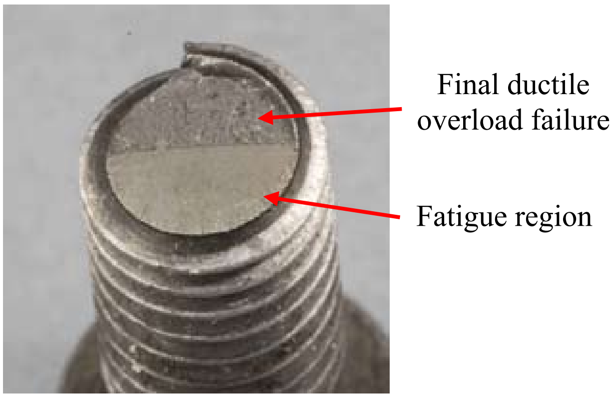

Figure 2

Typical fracture surface on broken Allen head bolt

Integrity of the propeller hub attachment bolt holes

Following this accident, the LAA were concerned that the distance between the side of the threaded hub attachment bolt holes and the edge of the flange of the top pulley might have been insufficient to prevent distortion of the hole and failure of the threads (Figure 4). Therefore, with the permission of the AAIB, the LAA drilled and tapped an additional hole in the flange of the top pulley and established that the threads failed at a torque of 35 lbf ft. This is approximately 2.3 times greater than the torque specified in the build instructions for the hub attachment bolts.

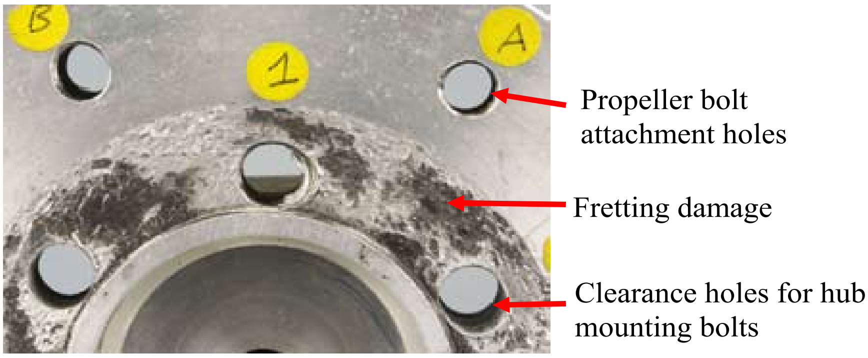

Figure 3

Damage to propeller hub

Testing for the presence of a thread locking compound

Figure 4

Top pulley

The manufacturer of Loctite advised the AAIB that Loctite 271 fluoresces when exposed to ultraviolet light. To determine if Loctite had been applied to the propeller mounting bolts, three test specimens were produced. The first specimen was a clean steel bolt, the second was smeared with a thread cutting fluid and the third had red Loctite 271 applied along its length and a nut wound part way along the thread. The Loctite was left to cure for seven days at a temperature of approximately 20ºC. At the end of this period the Loctite on the portion of the thread not covered by the nut was found to be sticky to the touch, whereas the Loctite in the threads between the nut and bolt had cured and the nut was firmly glued onto the bolt. On unwinding the nut, the cured Loctite was found to be pale pink in colour. The bolts that had been covered with cutting oil and Loctite 271 (cured and uncured) fluoresced when exposed to ultraviolet light; the other bolt did not.

The six propeller hub mounting bolts recovered from the accident aircraft were all exposed to ultraviolet light and, with the exception of a small portion of the thread on the intact bolt, none of the bolts fluoresced. It is suspected that the fluorescence on the sixth bolt was due to cross contamination by the thread cutting oil used during the LAA tests. There was also no physical evidence of any cured or uncured Loctite on any of the bolts. It was not possible to use ultraviolet light to check for the presence of Loctite in the blind holes in the top pulley as the holes had been contaminated with thread cutting oil during the testing by the LAA.

Thread locking compounds

Anaerobic adhesive thread locking compounds such as Loctite form a solid thermoset plastic when they come into contact with metal in the absence of air and work by gluing the threads of the male and female portions of the fastener together. The strength of the locking compound is dependent on the cleanliness of the parts and the curing time, which is dependent on temperature, use of activators and the types of fastener material to be locked together. The technical data sheets for Loctite locking compounds provide information on the strength and curing times for a number of different materials. However, they do not include the combination of steel and aluminium, the materials from which the propeller hub mounting bolts and the top pulley on the BFC Challenger II are manufactured. The manufacturer of Loctite advised the AAIB that this combination of materials can take up to seven days to cure and recommended that tests be carried out to establish the cure time and strength of the adhesive contact before using their products in such applications.

During the investigation the AAIB purchased samples of Loctite 243 and Loctite 271. Whilst the instructions on the bottle of Loctite 243 directed the user to the product technical data sheets there was no such instruction on the Loctite 271. Instead, the instructions on the packaging stated:

> *'Ready for use in 15 minutes. Full strength in 3 hours.'*

The product technical data sheets refer to performance properties such as the 'breakaway torque', 'prevail torque' and 'breakloose torque'. The breakaway torque is the torque that needs to be applied to break the adhesive contact which locks the threads together. Once the adhesive contact has been broken, particles of the cured locking compound remain in the threads and the prevail torque is the torque required to overcome the resistance of these particles. The breakloose torque is the torque required to undo a fastener which has been subject to a pre-torque. As a general rule, the breakloose torque is equivalent to the breakaway torque plus 80% of the pre-torque applied to the fastener but this figure should be established by testing.

The manufacturer advised that Loctite 243 and 271 are both suitable for use in an assembly subject to vibration. Loctite 271 is red in colour and has a breakaway torque of approximately *'22 ft.lb'* and a prevail torque of approximately *'5 ft.lb'*.

The method of applying the locking compound is dependent on whether the bolt is secured by a nut or threaded into a blind hole. If the bolt is secured by a nut, then the locking compound is applied to the threaded portion of the bolt which will be in contact with the nut. However, this technique is not suitable for blind holes, as the introduction of the bolt will compress the air at the bottom of the hole, forcing the locking compound out of the threads. The manufacturer therefore recommends that the locking compound should be applied to the bottom of blind holes so that the escaping air forces it into the threads between the bolt and side of the hole. However, if the reservoir of locking compound at the bottom of the hole is too small, the escaping air may not force the locking compound into the threads. This is a particular problem where there is a relatively large distance between the bottom of the hole and the end of the bolt, as is the case for the propeller hub attachment bolts and holes. In such situations the manufacturer recommends that a plug should be inserted at the bottom of the hole.

Comment

From the available evidence, it is probable that thread locking compound was not applied to the six propeller hub mounting bolts, which subsequently vibrated loose. This led to the initiation of fatigue cracks in the bolts which led to the bolts finally failing in ductile overload during the accident flight.

Although not an issue in this accident, the investigation identified a number of issues concerning the use of thread locking compounds on aircraft.

In order to prevent fatigue failure of the hub mounting bolts, it is necessary to apply a sufficient clamping force to prevent movement between the propeller hub and top pulley. This is achieved by applying the aircraft manufacturer's specified torque of 15 lbf ft to the hub mounting bolts. As the breakaway torque for Loctite 271 is 22 lbf ft, any subsequent torque check of these bolts would only confirm the integrity of the adhesive contact between the threads and would not prove that the clamping force between the components had been correctly applied. There is also a risk, particularly if the thread locking compound has not had sufficient time to reach its full strength, that any subsequent torque check of the hub mounting bolts may break the adhesive contact, thereby rendering the locking compound ineffective. It is for these reasons that torque checks should not be carried out on assemblies where a thread locking compound has been used. As a result of these findings, and given the discrepancies between instructions issued by the aircraft manufacturer and the PFA (now the LAA), the Airworthiness Information Leaflets for the inspection of the Challenger II propeller reduction drive assembly have been amended[2] and the requirement for the routine checking of the torque on the hub mounting bolts has been rescinded.

It is apparent that there are a number of misconceptions regarding the correct use and application of thread locking compounds. The information on the packaging may be ambiguous and therefore the technical data sheets should be consulted before the products are used in a safety-critical application. Moreover, given the number of factors which can affect the strength of the adhesive bond, it would be advisable to prepare a test specimen to establish the curing time and strength before thread locking products are used on aircraft.

The LAA intends to highlight to its members the issues raised in this investigation regarding the use of thread locking compounds in aircraft applications.

Footnote

2 MOD/177/014 issue 3 dated 6/10/08.

ACCIDENT

Aircraft Type and Registration:	BFC Challenger II, G-CAMR
No & Type of Engines:	1 Rotax 582 piston engine
Year of Manufacture:	1999
Date & Time (UTC):	21 April 2009 at 1614 hrs
Location:	Old Sarum Airfield, Wiltshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Minor) Passengers - 1 (Serious)
Nature of Damage:	Aircraft badly damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	60 years
Commander's Flying Experience:	600 hours (of which 9 were on type) Last 8 years - 4 hours on type Last 90 days - 6 hours Last 28 days - 6 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and inquiries by the AAIB

Synopsis

An experienced flexwing microlight pilot had recently started flying a three-axis microlight aircraft. Whilst attempting to land he applied the incorrect control input, which resulted in a heavy landing. The pilot and passenger were injured and the aircraft was badly damaged.

History of the flight

The pilot's friend, who held a Private Pilot's Licence with a Microlight class rating, flew the aircraft from the pilot's private airstrip near Bournemouth to Old Sarum, where he was met by the pilot. The intention was for the pilot to fly a number of circuits with his friend sitting in the rear seat. The first circuit was flown without incident. The pilot reported that on his second approach, instead of applying backward pressure on the control column to flare the aircraft, he pushed the column forward. The passenger commented that the pilot had made a good approach until about 20 ft above the ground, when the passenger felt "some negative 'g'" and noticed that the control column had been pushed fully forward. The aircraft landed heavily, causing the nose and right landing gear to detach and the pusher propeller to strike the rear fuselage. After coming to rest, the pilot turned off the ignition to stop the engine, which was running at high rpm. He and the passenger then vacated the aircraft.

The airfield crash procedure was initiated by the air/ground controller. The emergency response crew assessed that both occupants were suffering from back injuries and alerted the local emergency services who took them to the local hospital. The pilot was found to have suffered a cracked rib and severe bruising to the lower back. The passenger sustained a broken vertebra and spent four weeks in hospital.

The pilot believes that the accident occurred because he reverted to his previous flexwing experience and applied the incorrect control input when flaring the aircraft.

Background

The BFC Challenger II is a three-axis microlight aircraft which the pilot purchased as a kit in 1999, but did not start building until approximately two years before the accident.

The pilot held a PPL (Aeroplanes) with a Microlight class rating. A total of 595 flying hours was recorded in his flying logbook, of which the last four hours were flown in his Challenger aircraft. Prior to this, he had last flown a three-axis microlight aircraft in July 2001, when over a period of two days he flew 5 hours 25 minutes as Pilot in Command (PIC). His last flight with an instructor was in 1992, some 420 hours before the accident flight, when he received approximately 12 hours instruction in Single Engine Piston class aircraft.

The pilot's logbook contained a stamped certificate titled '*Aircraft Rating – Certificate of Experience*', which was dated 14 December 2008 and signed by a CAA authoriser. The certificate stated that he had satisfied the authoriser:

> *'that he had appropriate experience to act as pilot in command (P1) or as co-pilot (P2) on Microlight (Landplane) type(s) of aircraft'.*

The certificate was valid for 13 months from 14 December 2008 and made no distinction between flexwing and three-axis microlight aircraft.

Previous accidents

Previous AAIB reports have highlighted the dangers of pilots flying aircraft equipped with control systems on which they have limited experience. In 1998, following a fatal accident to a Kolb Twinstar Mk III microlight aircraft, the AAIB made Safety Recommendation 98-62 which stated:

> *'This accident may have resulted from a loss of control by the pilot. The pilot had no training and limited experience on the type of aircraft control system that he was using. Given the fundamental differences between weight shift and 3-axis control systems, notably the diametrically opposed control movements for pitch and roll, it is recommended that the CAA should consider making the guidance contained in CAP53... a mandatory requirement.'*

In March 2005, following an accident in which a third party was seriously injured, the AAIB made Safety Recommendation 2005-128 which stated:

> *'The Civil Aviation Authority should require holders of the Private Pilots Licence (Aeroplane) (Microlights) converting from weight shift to three-axis control systems, or the reverse, to undertake adequate conversion training and pass a Flight Test conducted by an appropriately qualified microlight pilot examiner.'*

Changes to the Air Navigation Order regarding difference training

As a result of the AAIB recommendations, Schedule 8 of the Air Navigation Order[1] (ANO) was amended in January 2008 to include the requirement for appropriate difference training to be undertaken when the holder of a Microlight class rating acts as PIC of a microlight aircraft. The ANO states:

> *'Where the aeroplane has 3-axis controls and his previous training and experience has only been in an aeroplane with flexwing/weightshift controls; before he exercises the privileges of the rating, appropriate difference training, given by a flight instructor entitled to instruct on the aeroplane on which instruction is being given, must have been completed, recorded in his personal logbook, and endorsed and signed by the instructor conducting the differences training.'*

There is no record in the pilot's logbooks of any three-axis training having being carried out since July 1992. The pilot stated that he was unaware of the change to the ANO and did not know that he was required to undertake difference training.

AAIB comment

The pilot held a current certificate of experience to fly microlight aircraft, which did not differentiate between flexwing and three-axis control systems. Whilst he had received training in flying three-axis (SEP class) aircraft in 1992, he had not undertaken any recent instruction on such aircraft. This lack of recency is believed to be a contributory factor to the accident.

Footnote

1 CAP 393 Section 1 Schedule 9 Page 22 Section 2.1.(1)(b)(i).

ACCIDENT

Aircraft Type and Registration:	Flight Design CTSW, G-CFAZ
No & Type of Engines:	1 Rotax 912 ULS piston engine
Year of Manufacture:	2007
Date & Time (UTC):	8 October 2008 at 0855 hrs
Location:	Saddleworth Moor, Lancashire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Fatal) Passengers - None
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	41 years
Commander's Flying Experience:	123 hours (of which 29 were on type) Last 90 days - 11 hours Last 28 days - 0 hours
Information Source:	AAIB Field Investigation

Synopsis

The pilot was flying from Manchester Barton to Shacklewell Lodge, a small private airstrip near RAF Cottesmore. To the east of Manchester the aircraft descended rapidly and crashed into the ground at Saddleworth Moor, probably as a result of a loss of control following an inadvertent entry into cloud. One Safety Recommendation is made, concerning baggage restraints.

History of the flight

The pilot prepared the aircraft for a solo flight from Manchester Barton to Shacklewell Lodge, a small private airstrip near RAF Cottesmore, and placed three shotguns, in cases, into the rear of the aircraft; no ammunition was loaded into the aircraft.

The pilot started the engine and taxied to the holding point, where the aircraft was seen to stop and the engine was shut down. The pilot walked back towards the hangars and told the Chief Flying Instructor of his flying club that the electronic flight display in the aircraft had been left on prior to flight, that he had shut the aircraft down to resolve a 'voltage problem', and that now, the engine would not start. The pilot obtained assistance from an engineer and re-started the aircraft.

The aircraft took off without further incident at 0842 hrs, and the pilot transmitted to the aerodrome flight information service officer (AFISO) at Barton that he was changing frequency to Manchester Approach. No transmission was made on the Manchester

Approach frequency (it was usual for pilots departing Barton to monitor the Manchester frequency, without transmitting).

Later in the day, a member of the pilot's family, who was expecting to meet him at Shacklewell Lodge, telephoned a local air traffic control unit to express concern that the aircraft had not arrived. Overdue action was taken, and Search and Rescue operations began.

At about 1530 hrs, two farmers found the wreckage of the aircraft, and reported it to the police. The wreckage was on Saddleworth Moor, high ground to the east of Manchester, at an elevation of about 1,540 ft amsl.

Accident site

The aircraft had struck the ground close to the A635 on Saddleworth Moor and had suffered significant disruption on impact, with the wreckage trail extending for 155 metres.

The first ground mark was made by the right wing tip and the nature of the groove indicated that the aircraft was in a bank of 45° to 55° to the right at impact. Beyond this mark there was a large area of disturbed ground which formed a shallow crater and, further on, several transverse slash marks characteristic of a rotating propeller.

The wreckage trail continued for approximately 150 metres beyond the crater on a bearing of 084°. Both the wing fuel tanks had been disrupted and there was a strong smell of fuel across the accident site, with significant areas of grass discolouration, indicating the spillage of fuel. The engine, its mounting structure and propeller were located 1.5 metres under the surface of the main impact point and the peat surrounding the engine was heavily contaminated with fuel. One propeller blade was found attached to the hub and the remaining two blades were recovered separately, with one blade showing damage consistent with striking an object whilst rotating.

Three shotguns, which had been in the aircraft, were recovered from the wreckage by the police. After initial examination the wreckage of the aircraft was recovered for detailed examination.

The pilot

The pilot learnt to fly first on gliders and then as a member of a University Air Squadron in 1987-88, accruing 22 hours flying experience. He then did not fly for some years, but took flying lessons at Manchester Barton beginning in August 2006 and he obtained a National Private Pilots Licence in April 2007 following 27 hours of training.

Having obtained his licence, he bought a share in an Ikarus C42 aircraft, which he flew regularly until November 2007 when he sold that share. He then bought a share in the accident aircraft and began flying it in January 2008.

The club CFI (Chief Flying Instructor) described the pilot as being very proficient at handling the aircraft but had, on a number of occasions, expressed concern to the pilot about his judgement. The areas of concern included decisions on whether to fly in weather which was marginal or unsuitable, and instances of flight recorded as flown at unusually high speeds and power settings. Members of the group which owned the aircraft had also discussed concerns about the pilot's judgement, and whether he would continue as a member of the group.

The pilot's licence validity expired on 4 May 2008. The pilot did not hold a radio licence.

Aircraft description

The P&M Aviation/Flight Design CTSW is a two-seat, high-wing three-axis microlight powered by a Rotax 912 UL engine, with a cruising speed of 120 kt. The ailerons are operated through a series of rods and bellcranks, which pass from the control columns, under the cockpit floor and upward behind the rear cockpit bulkhead. The aircraft is equipped with electrically-operated flaps which have a range of -12° (cruise) to +40° (landing). The flaps are connected to the aileron system through a mixing unit which causes the ailerons to droop when the flaps are deployed, to improve the aircraft's short field performance. The rudder is operated by a pair of cables from the rudder bars and the elevator is operated by a 'push-pull' Teleflex-type cable. The elevator is fitted with a mass balance arm at its hinge point within the fuselage.

The fuselage is of carbon fibre/foam sandwich monocoque construction, without bulkheads or substantial fuselage frames. The manufacturer's Operator's Manual states that the aircraft has a maximum baggage weight of 25 kg, to be stowed in the rear fuselage immediately behind the rear cockpit bulkhead. Access is provided by a removable panel on either side of the fuselage immediately behind each cockpit door; the seatbacks can also be pulled forward to stow larger items. Any baggage is secured under two bungee nets (Figure 1).

The aircraft was fitted with basic VFR flight instrumentation, much of it integrated into an electronic multi-function (MFD) display which showed airspeed, propeller rpm and altitude. The aircraft had a magnetic compass but was not fitted with an artificial horizon or direction indicator. The GPS fitted to the aircraft was capable of displaying a synthesised panel of 'flight instruments'[1] (though not an artificial horizon), but the club CFI believed that the accident pilot was not aware of this feature. The aircraft was fitted with an altitude-encoding transponder; the pilot often left it switched off during flight.

The Garmin GPS fitted to the aircraft was capable of displaying terrain and obstacles on its moving map. Terrain within 100 ft vertically of the aircraft's present GPS altitude was shown in red, terrain within 1,000 ft was shown in yellow.

Figure 1

G-CFAZ baggage restraint

Footnote

[1] Derived from GPS information; the device contained no gyroscopic instruments.

Recorded Information

A number of avionic devices were recovered from the aircraft cockpit, including the Multi-Function Display (MFD), hand-held GPS and a panel-mounted VHF radio. G-CFAZ's position was recorded on the Manchester Approach radar and the aircraft was also captured on CCTV prior to departing Barton Aerodrome.

GPS equipment

The pilot carried a hand-held GPS receiver which was powered throughout the flight, recording time, position and GPS altitude. This device was successfully downloaded at the AAIB and contained three flights within the track memory, the first two being a return trip to Mona in Anglesey and the third the accident flight. Also downloaded were a number of user-defined waypoints and routes. One of the routes was labelled 'BTN-SHACKLEWELL' consisting of a number of joined waypoints which made up a route from Barton Aerodrome to Shacklewell.

On the day of the accident, power was first applied to the GPS at 07:46:54 hrs. Over the next hour, the recorded track log showed G-CFAZ taxiing before finally stopping at the eastern edge of Barton Aerodrome. At 08:41:52 hrs, G-CFAZ taxied towards Runway 27R and began its takeoff run at 08:42:40 hrs.

After takeoff, the aircraft climbed to a GPS altitude of around 1,000 ft, turned to the right onto a true heading of approximately 050° and began tracking around the north of Manchester (Figure 2, with expanded final section in Figure 3). Groundspeed, derived from rate of change of position increased to around 110 kt.

At 08:52 hrs, when located north-east of Manchester and tracking towards one of the waypoints on the 'BTN-SHACKLEWELL' route, G-CFAZ began to climb from a GPS altitude of approximately 1,500 ft (Point 'A', Figure 2). This climb continued with the aircraft initially tracking approximately parallel to the 'BTN-SHACKLEWELL' route before deviating to the left, ultimately achieving a maximum GPS altitude of 3,366 ft at 08:54:50 hrs (Point 'B', Figure 3).

After achieving the maximum GPS altitude, the recorded positions indicate a turn to the left followed by a descent. The derived average rate of descent between the maximum GPS altitude and the final recorded position was 2,800 ft/min. The final recorded GPS position was at 08:55:18 hrs at a GPS altitude of 2,043 ft and heading of 013°T. This position was a distance along the ground of 129 m from the initial ground impact mark. Terrain elevation of the initial impact was estimated at 1,541 ft, around 500 ft below the last recorded GPS altitude

Multi-Function Display (MFD)

The MFD was used to present information such as engine, fuel, airspeed and altitude data to the pilot using a liquid crystal display (LCD). This device also contained a number of alarms to produce stall and V_{NE} warnings where appropriate. It also recorded the maximum values of a number of parameters from the last 25 flights.

This MFD sustained significant damage in the impact but the circuit board containing the volatile memory was successfully recovered by the AAIB. The memory on this circuit board was a volatile type, requiring a battery power supply to maintain the memory contents. When measured, the battery charge was insufficient to maintain the memory and the data was therefore lost.

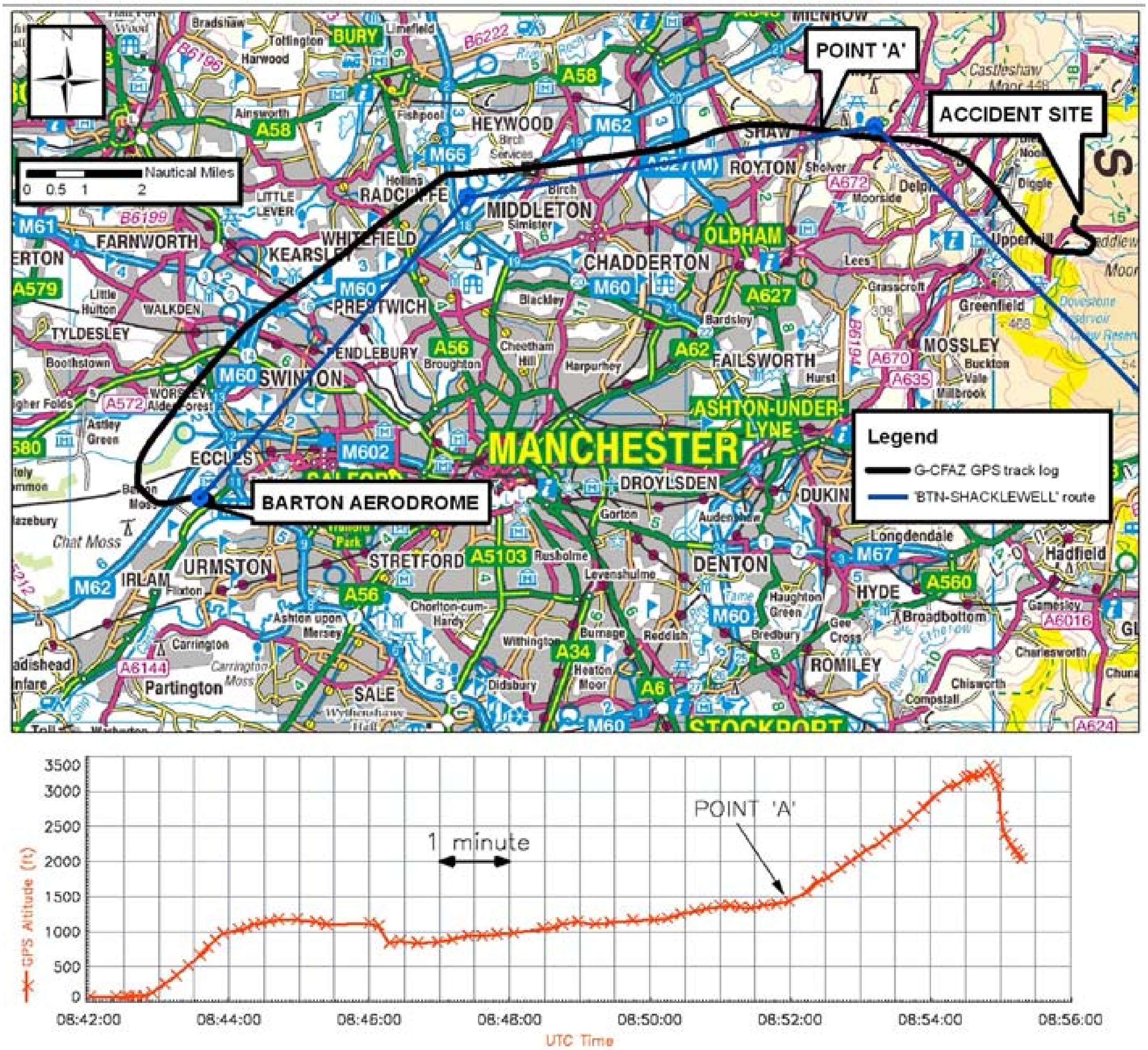

Figure 2

G-CFAZ GPS data – accident flight

Radar

Recorded radar data was provided by NATS, the UK air traffic services provider. The aircraft was identified by three radar heads with the Manchester Approach radar providing the most complete recording of the G-CFAZ track. The other two radar sites only identified fragments of the flight, possibly due to the low aircraft altitude. Only primary radar was recovered, indicating that the Mode C transponder was not operating.

Meteorology

The unofficial weather observation at Barton at 0826 hrs showed that the surface wind was 230/10 kt, visibility was 10 km or more with showers in the vicinity of the aerodrome, there were one or two octas of cloud base 2,300 ft above the aerodrome, the temperature was 11ºC and the QNH was 1,015 mb.

No forecasts were produced for Barton, but the Terminal

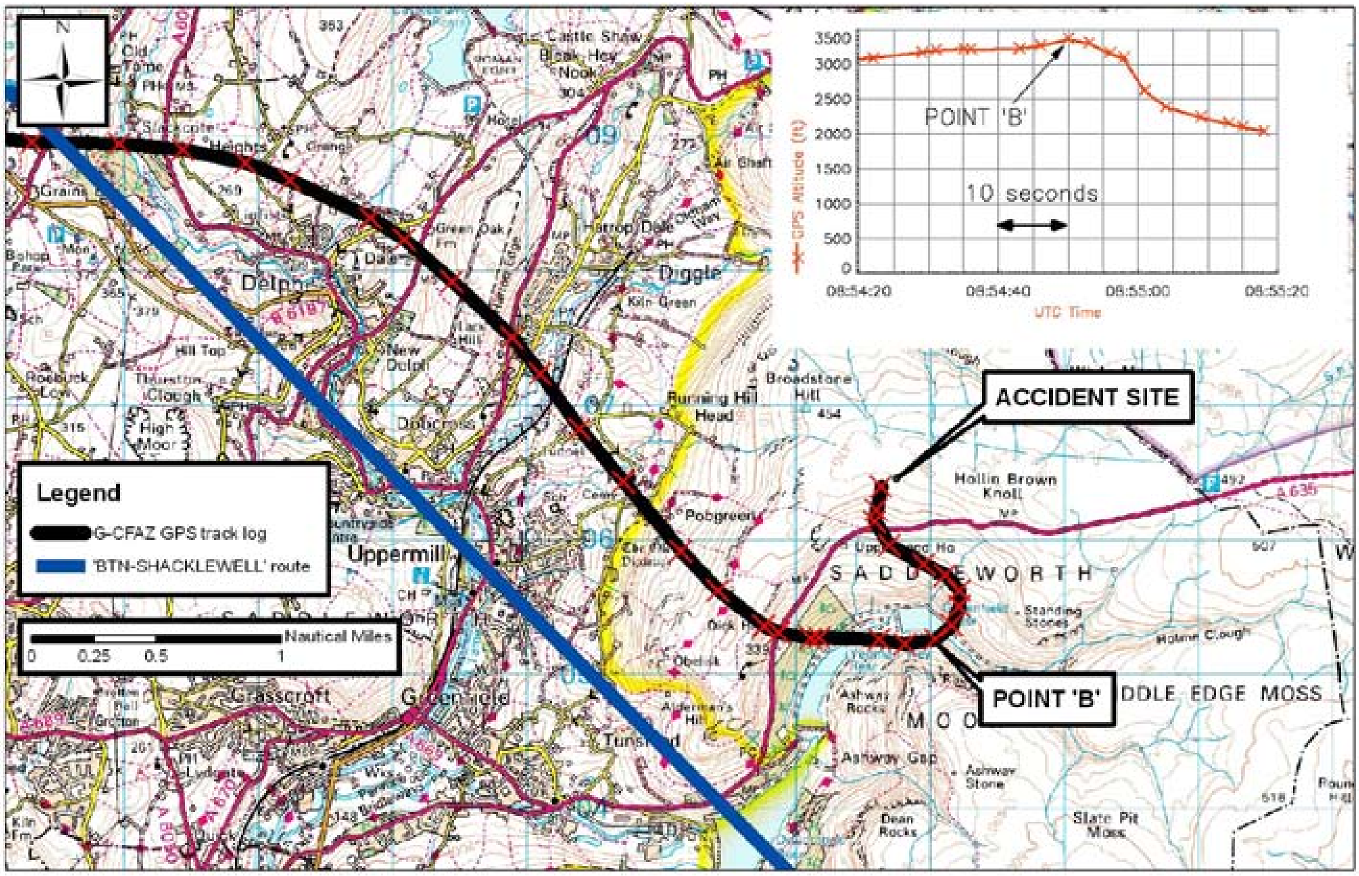

Figure 3

G-CFAZ GPS data – accident flight approaching Saddleworth Moor

Area Forecast (TAF) for Manchester International airport, some eight miles south-east of Barton, stated that between 0700 and 1600 hrs, the wind would be 270/10 kt, visibility would be 10 km or more, and there would be three or four octas of cloud base 2,500 ft above the airport.

The Met Office chart of forecast weather below 10,000 ft, issued at 0330 hrs and valid from 0800 hrs until 1700 hrs, indicated that low cloud in the area would consist of scattered or broken cumulus and stratocumulus with a base between 2,000 and 4,000 ft and tops at or above 7,000 ft. Isolated hill fog was also forecast.

The Met Office provided an aftercast describing the weather conditions at the time of the accident which broadly concurred with the forecast. It stated that a ridge of high pressure covered the area, with a moderate west to west-northwesterly flow, and that:

> *'Given the data from cloud observations, radiosonde ascents, and satellite data, patches of hill fog are possible above ~780 FT AMSL, particularly on the windward (west facing) slopes of the moors'*

and that visibility in this hill fog would be expected to be less than 200 m.

The aftercast described wind conditions in 'free air' away from the moors, and went on to state that the terrain may cause marked local variations in wind strength. The wind at 1,000 ft amsl was estimated to have been 290/15 kt in free air, but 290/30 kt at Dovestones Reservoir near the accident site. The wind at 2,000 ft amsl was estimated to have been generally 300/20 kt, but 300/40 kt at the Reservoir. The 0°C isotherm was at 6,000 ft amsl.

The farmer who found the wreckage of the aircraft recalled that when he had started work that morning, at about 0700 hrs, "a gale" was blowing up the valley, and that the weather was misty with thick fog on the top of the Moor. He estimated that the visibility in the fog was approximately 100 m. The top of the moor was not visible from part way up the valley until after lunchtime.

A flying instructor was travelling by car in the area at the foot of Saddleworth Moor's west side at between 0900 and 1000 hrs on the morning of the accident. He described that there was "a lot of low broken stratus" cloud in the area, some of it covering the hills.

Detailed wreckage examination

The engine's fuel, ignition and induction systems could not be tested but examination confirmed that the engine had not suffered internal failure, partly due to the 'slipper' clutch designed to protect the engine crankshaft in the event of a propeller strike. The engine controls had become disconnected from the engine in the impact and no witness marks were identified to indicate the throttle control setting.

Examination of the flight control circuits showed that all the damage was consistent with the aircraft's impact and no evidence of pre-impact defect or restriction was identified. The position of the flap actuator was found to correspond with the 'cruise' (-12°) position.

The possibility that the movement of the elevator had been restricted by one of the shotguns being carried was investigated, but no evidence of such obstruction was found. When the VHF radio recovered from the accident site was powered up, the primary frequency set was 118.575 (Manchester Approach) and the standby was 120.250 (Barton).

Pathology

A specialist aviation pathologist investigated the pilot's medical history and carried out a post-mortem examination of the pilot. No medical cause for the accident was identified Samples had been sent to a laboratory for toxicological analysis and the laboratory report stated that:

'Toxicology revealed the presence of tetrahydrocannabinoic acid (THC-COOH in [the pilot's] blood. This is an inactive metabolite of tetrahydrocannabinol (THC) which is the main active constituent of cannabis. THC concentrations generally fall below 5 mg/ml less than three hours after smoking cannabis, and are generally below the limits of quantitation within eight to twelve hours. In contrast, THC-COOH is excreted from the body over a period of days to weeks. Consequently, the results in this case indicate that cannabis had been consumed at some stage prior to the flight, but the absence of THC indicates that this would not have been within the few hours immediately preceding the flight.

'While THC was not detected, this does not necessarily mean that the pilot would have been unaffected by cannabis. Effects have been demonstrated on attention, psychomotor tasks and short term memory during the 12 to 24 hours

> *following cannabis use, and an adverse affect on performance of complex cognitive tasks has been demonstrated for up to 24 hours after smoking cannabis.'*

The toxicologist added that:

> *'whilst the possibility that the [TCH-COOH] findings are as a result of passive inhalation due to smoking by others in close proximity can not be entirely excluded it is unlikely that they have arisen from this route', and that 'the drug can have a detrimental effect on psychomotor control long after it has ceased to exert any of the euphoric effects for which it is taken and long after the user perceives that there is any effect.'*

It was not possible to determine when the pilot might have consumed (or been exposed to) cannabis, in the days before the accident.

Airspace

The Manchester Control Zone (CTR) is Class D airspace around Manchester Airport from the surface to 3,500 ft amsl. Further Class D controlled airspace exists in the area of the accident site, with a base of 3,000 ft. A Low Level Route is also established, running north/south, to the west of Manchester Airport, to facilitate aircraft transiting through the CTR. Barton is on the east side of the Low Level Route, near its northern end.

Flight planning

In planning his flight south, the pilot had two primary options: to depart Barton to the north-east and fly to the north and east of the Manchester CTR, or to depart Barton to the west and fly south through the Low Level Route. The former route would involve flying south down the east side of the control zone, where the base of controlled airspace above is 3,000 ft, with high ground to the east and controlled airspace existing down to the surface to the west. The latter would demand accurate navigation down the low level route but would avoid high ground.

Analysis

The purpose of the flight was routine and no technical cause of the accident was identified. The evidence from the accident site showed that the aircraft first struck the ground in a bank of 45° to 55° to the right and the degree of structural breakup, and the spread of the wreckage, indicated that the impact was at high speed and was not survivable. There was evidence of fuel on board and no evidence of failure within the engine, and the ground marks confirmed that the propeller was rotating at impact although the level of engine power at impact could not be determined. There was no evidence of pre-impact failure or restriction in the flying control circuits.

The visibility was good enough that the weather conditions over the Moors would probably have been apparent to the pilot before he took off from Barton, and certainly once he was flying towards the Moors. His choice of route necessarily involved flying towards high ground, and any cloud covering it. A decision to follow the Low Level Route southwards through the Manchester CTR would have enabled the pilot to avoid the combination of poor weather, rising ground, and adjacent airspace which the route over the Moors entailed.

The GPS evidence showed that the flight progressed unremarkably until shortly after the pilot began a climb above 3,000 ft just north of Delph. Once above 3,000 ft, the aircraft was in Class D controlled airspace, but although the aircraft's radio was tuned to the relevant frequency, the pilot did not make contact with the Manchester Approach controller. The absence of a request to enter the airspace may indicate that the pilot was already in difficulties. The aircraft then entered a series of manoeuvres, the first of which was a tight turn to the left towards a reciprocal course. During this turn, the aircraft began a descent which ended when it struck the ground.

Although the controlled airspace may have been a concern for the pilot, an appropriate distress (MAYDAY) call to the Manchester Approach controller, whose frequency the pilot was monitoring, would probably have resulted in clearance being given to the pilot to head west into the controlled airspace, at least far enough to avoid the high ground and cloud. Therefore, although the controlled airspace was a factor in the pilot's choice of route, it is not considered causal.

Witness evidence, and the Met Office aftercast, showed that cloud was present over the moors, with strong winds and very poor visibility at the surface. This weather had been accurately forecast. It is likely that the aircraft entered this poor weather, and that control was then lost. Whether the initial turn to the left was intentional, and the pilot was attempting to manoeuvre out of the poor weather, or whether the turn was a result of loss of control, cannot be determined.

The accelerated wind over the rising ground of the edge of the moors, and rising air with it, may have had some effect. It is possible that the pilot flew into conditions where the aircraft was, to some extent, carried upwards towards cloud by the rising air, and this contributed to its entry into cloud, simultaneously drifting the aircraft towards the high ground.

The pilot's behaviour, particularly with respect to his judgement of suitable weather conditions for VFR flight, had previously caused concern to the CFI and others. The pilot's lapsed licence, and the fact that he did not hold a radiotelephony licence, does not appear to have played a causal role in the accident.

The presence of THC-COOH in the pilot's blood did not necessarily reflect consumption in the 24 hours before the accident, and it is possible that consumption, active or passive, took place before that and the pilot's judgement was not affected by the drug at the time. However, without evidence to the contrary, the possibility remains that the pilot was under the influence of the drug at the time of the accident, and that his judgement may have been sufficiently impaired for this to have been a factor in the accident.

Safety Recommendation

The 'open monocoque' structural design of the rear fuselage in this aircraft would allow an unsecured item a significant range of movement, possibly to restrict aileron or elevator movement. While bungee nets may provide sufficient restraint of larger item they will not provide the same level of retention to thin objects. The following Safety Recommendation is made:

Safety Recommendation 2009-101

It is recommended that P&M Aviation/Flight Design review the design of the current baggage restraints in the CTSW design, to ensure that it provides effective restraint of all stowed baggage.

ACCIDENT

Aircraft Type and Registration:	Gemini Flash IIA, G-MWZC
No & Type of Engines:	1 Rotax 503 piston engine
Year of Manufacture:	1992
Date & Time (UTC):	1 May 2009 at 1230 hrs
Location:	Chirk, Clwyd
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - None
Nature of Damage:	Extensive damage
Commander's Licence:	National Private Pilot's Licence (expired)
Commander's Age:	61 years
Commander's Flying Experience:	99 hours (of which 99 were on type) Last 90 days - 4 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

On approach to Chirk Airfield, the aircraft struck trees adjacent to the runway. The pilot had become distracted in trying to assess the condition of the runway surface and had made insufficient allowance for wind effects.

History of the flight

The pilot had planned a flight from Otherton, Staffordshire, to Chirk, which has two grass landing strips designated Runway 01/19 and Runway 15/33. A row of trees run parallel to Runway 01/19 along its eastern edge. The runways are not marked but ground tracks 3 m wide, associated with car boot sales held on the site, are present on the airfield.

The weather was good and the wind was 210° at 10 to 15 kt. The pilot reported that the wind had increased while en-route and, on approach, he had difficulty in tracking the centreline of Runway 19. He continued the approach but was distracted as he concentrated on assessing the condition of the runway surface. At about 50 ft, the pilot reported that he felt a movement to the left from what he later described as a violent gust and, suddenly, his view was obscured by trees. He attempted to climb the aircraft but it struck the trees in a level attitude, and became trapped. A power line which ran through the trees was damaged, and the pilot thought that this may have assisted in stopping the aircraft. He was later assisted from the trees by the North Wales Fire Service.

He subsequently considered that he had made insufficient allowance for the wind effects and that, given the obstructions, an earlier go-around decision should have been made.

The pilot's licence had expired on 17 November 2008, as he had wrongly interpreted a recent change to the re-validation requirements.

ACCIDENT

Aircraft Type and Registration:	Ikarus C42 FB80 Ikarus, G-CDYT
No & Type of Engines:	1 Rotax 912-UL piston engine
Year of Manufacture:	2006
Date & Time (UTC):	29 April 2009 at 1107 hrs
Location:	Swansea Airport
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nose landing gear damage, propeller destroyed
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	70 years
Commander's Flying Experience:	200 hours total (approximate) Last 90 days - 10 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The aircraft was approaching to land on Runway 22 at Swansea Airport when a "strong crosswind component" from the left caught the pilot off-guard. While he was trying to correct the drift in the landing flare the aircraft stalled, resulting in a heavy landing and damage to the nose landing gear and propeller. The pilot was uninjured.

ACCIDENT

Aircraft Type and Registration:	Jabiru UL-450 Jabiru, G-CEKM
No & Type of Engines:	1 Jabiru Aircraft PTY 2200A piston engine
Year of Manufacture:	2007
Date & Time (UTC):	29 March 2009 at 1600 hrs
Location:	Close to Headon, near Retford, Nottinghamshire
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Substantial damage
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	46 years
Commander's Flying Experience:	255 hours (of which 82 were on type) Last 90 days - 12 hours Last 28 days - 7 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft suffered an engine failure during a long final approach, due to suspected carburettor icing. The proximity of an operational power station and a broken electrical lead for the electric carburettor heat were considered to be significant factors.

History of the flight

The aircraft was being flown from Cromer to Headon. The pilot made a long final approach from 3 nm east of Headon. He commenced the descent from 1,500 ft QFE with the engine speed set at approximately 2,000 rpm. Both heater elements of the electric carburettor heat were selected on for the entire flight, and the pilot had selected the 'hot air' carburettor heat to ON for approximately 10 seconds at the start of the descent. During the descent the aircraft passed within 300 to 400 metres of an operational power station, located south-east of Headon, near the river Trent.

At approximately 300 ft QFE, the pilot increased the throttle setting, but the engine failed to respond. He selected the 'hot air' carburettor heat to ON and shortly thereafter, the engine stopped. The aircraft touched down short of the intended field and struck a hedge bordering the field. The nosewheel then entered a ditch, causing the aircraft to pitch over inverted. The pilot shut down the aircraft and switched the fuel off. Both he and the passenger were uninjured and exited the aircraft after kicking out the passenger window.

Atmospheric conditions – carburettor icing

The aftercast supplied by the Met Office is included in Table 1.

From the chart in Figure 1 it can be seen that the general conditions were favourable for 'light icing - cruise or descent power'.

As reported in AAIB Bulletin 4/2003, in which a Jabiru UL-450 G-TYKE suffered a loss of power after being flown close to a power station, the humidity of the air can be significantly raised over a considerable distance (possibly some miles) from cooling towers, depending on the wind speed and level of turbulence. This can create local conditions more favourable for serious carburettor icing.

Aircraft examination

The pilot inspected the aircraft and found no anomalies with the fuel system. However a wire to the electric carburettor heat system was found to be broken, rendering it inoperative. He considered that it was unlikely to have broken in the forced landing. He concluded that the electrical carburettor heat was probably not working during the latter stages, and possibly all, of the accident flight.

Piston engine icing

The CAA's Safety Sense Leaflet 14 General Aviation '*Piston Engine Icing*' (see LASORS published by the Stationary Office or www.caa.co.uk/safetysense) provides much useful information regarding engine icing. In section 7 'Pilot Procedures' sub-section j it states:

> *'Descent and Approach*
>
> *Carb icing is much more likely at reduced power, so select carb heat before, rather than after, power is reduced for the descent, and especially for practice forced landing or a helicopter autorotation, i.e. before the exhaust start to cool. (A full carb heat check just before selecting hot air for the descent is advisable). Maintain FULL heat during long periods of flight with reduced power settings. At intervals of about 500ft, or more frequently if conditions require, increase power to cruise setting to warm the engine and to provide sufficient heat to melt any ice.'*

Discussion

The most likely reason for the engine failure was carburettor icing. The failure of the electrical lead to

Height AGL	Wind Direction & Speed	Temperature (Celsius)	Dew Point (Celsius)	Humidity (%)
Surface	210°-220° 02-05	8.3	-6.3	35
500 ft	220° 06 kt	5.4	-6.8	41
1000 ft	230° 08 kt	3.9	-7.0	45
1500 ft	240° 10 kt	2.4	-7.3	49
2000 ft	240° 10 kt	0.9	-7.6	53

Table 1

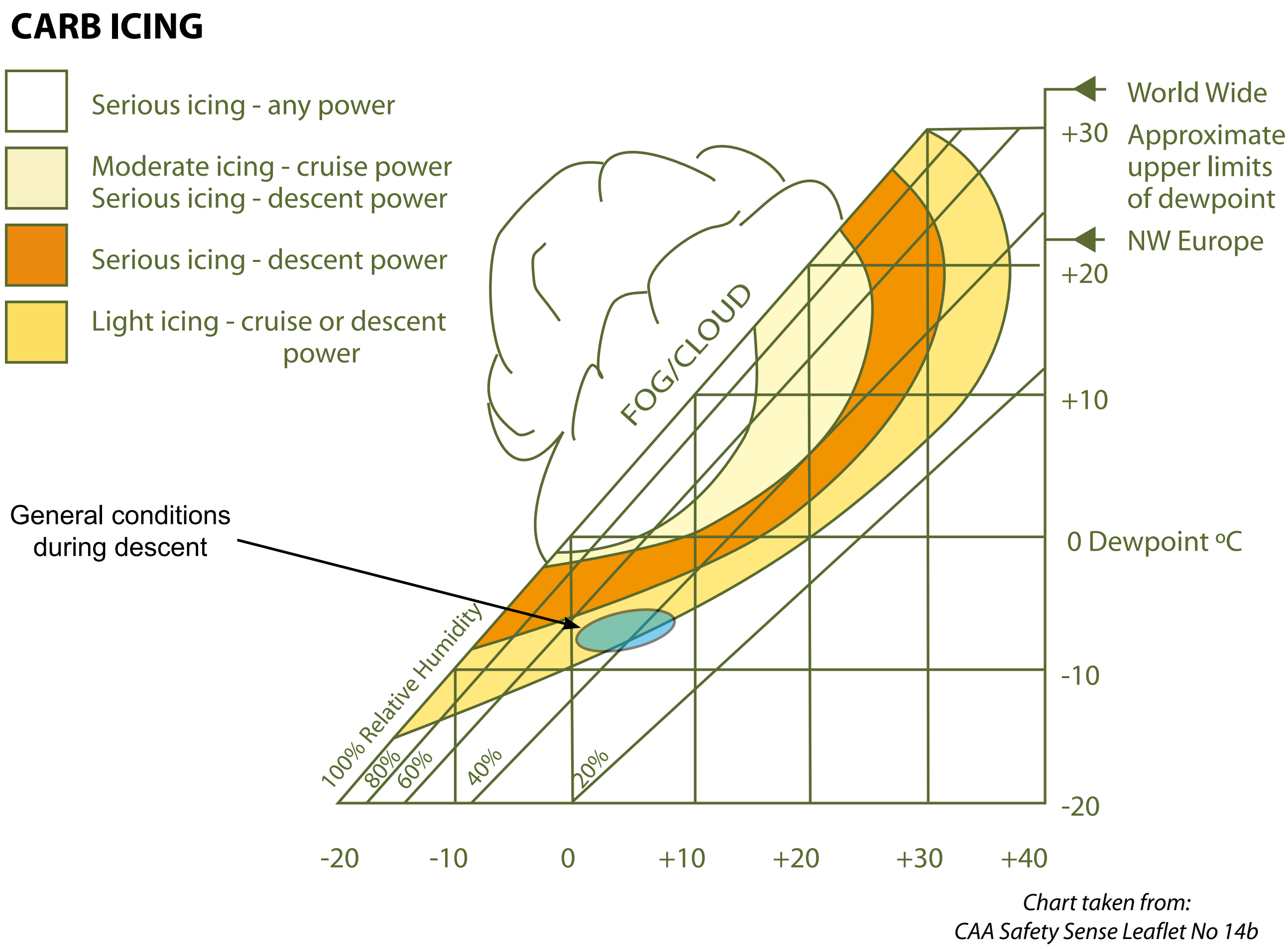

Figure 1

the electric carburettor heat and the proximity of the power station were considered to be significant factors. The pilot routinely flew with the electrical heat on at all times. If it had failed, his brief use of the 'hot air' carburettor heat may not have been effective in preventing carburettor icing.

ACCIDENT

Aircraft Type and Registration:	MW6-S (Modified) Fat Boy Flyer, G-MZDL
No & Type of Engines:	1 Rotax 582 piston engine
Year of Manufacture:	1999
Date & Time (UTC):	4 July 2009 at 2125 hrs
Location:	Rayne, near Braintree, Essex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Minor damage to pod, top of rudder and propellor blades
Commander's Licence:	Private Pilot's Licence
Commander's Age:	50 years
Commander's Flying Experience:	15 hours (of which 5 were on type) Last 90 days - 9 hours Last 28 days - 6 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

During landing the aircraft bounced and touched down again on its nosewheel, before veering to the left. It then departed the runway and entered an area of standing crops, where it overturned. The pilot was uninjured and the aircraft sustained minor damage. The pilot, who had only recently begun flying the aircraft, considered that his approach to the unfamiliar runway was slightly fast and that his landing flare judgement may have been affected by the low position of the sun in front of him. He is planning further training with an instructor to increase his proficiency.

ACCIDENT

Aircraft Type and Registration:	Pegasus Quantum 15, G-MZOV
No & Type of Engines:	1 Rotax 503-2V piston engine
Year of Manufacture:	1999
Date & Time (UTC):	23 June 2009 at 1850 hrs
Location:	Quarter-mile north-west of Runway 08 threshold, Enstone Aerodrome, Oxfordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Front steering fork bent, damage to glass-fibre cockpit fairing
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	32 years
Commander's Flying Experience:	71 hours (of which 69 were on type) Last 90 days - 2 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

During the first operation following routine engine maintenance, the pilot flew a number of touch-and-go circuits before conducting a local flight in the vicinity of the airfield. On his return, he completed a standard overhead join and commenced his descent to circuit height on the dead side of the runway. Halfway through the descent, the pilot applied power to warm the engine. On reaching the required height of 600 ft he levelled out but noted the engine was slow to accelerate again. As there was other traffic in the circuit the pilot elected to continue but, on base leg, the engine started to fade and then stopped. The landing site options were limited so the pilot chose the field with the least dense crop cover. He manoeuvred into the flare as slowly as possible but the vegetation caused the trike to pitch forward onto the nose gear, bending it at a welded joint. The aircraft came to rest without injury to the pilot. No causal defects were identified during repair of the aircraft. The pilot reported that the atmospheric conditions were conducive to carburettor icing but added that this engine and installation were not particularly prone to the problem.

ACCIDENT

Aircraft Type and Registration:	Pegasus Quik, G-CDMZ
No & Type of Engines:	1 Rotax 912-UL piston engine
Year of Manufacture:	2005
Date & Time (UTC):	5 July 2009 at 1700 hrs
Location:	Herridge Court Farmstrip, Kent
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nose landing gear, fuselage pod and wing
Commander's Licence:	Private Pilot's Licence
Commander's Age:	64 years
Commander's Flying Experience:	232 hours (of which 67 were on type) Last 90 days - 4 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

During the final stages of the approach, in mildly turbulent conditions, the pilot moved the wing to initiate the flare. The aircraft failed to respond to the change in attitude of the wing and landed heavily. It became briefly airborne again before landing on its nosewheel, which collapsed, causing the aircraft to become inverted. The pilot was uninjured. The pilot attributed the accident to encountering turbulence or wind shear during the later stages of the approach.

ACCIDENT

Aircraft Type and Registration:	QUIKR, G-LPIN
No & Type of Engines:	1 Rotax 912ULS piston engine
Year of Manufacture:	2009
Date & Time (UTC):	28 May 2009 at 0816 hrs
Location:	Popham Airfield, Hampshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to wing and trike
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	60 years
Commander's Flying Experience:	105 hours (of which 14 were on type) Last 90 days - 13 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Following an uneventful flight from Sandy, Bedfordshire, the aircraft touched down normally on Runway 26 at Popham. During the roll-out, at approximately 30-35 mph, the right wing suddenly lifted and the aircraft rolled onto its left side. The wind speed was 6 kt from a direction of 300°. The airfield is bounded by tall trees and it is known that undesirable wind effects can be experienced when the runway is downwind of the trees, as was the case in this accident.

ACCIDENT

Aircraft Type and Registration:	Rans S6-ES Coyote II, G-CCLH
No & Type of Engines:	1 Rotax 582-48 piston engine
Year of Manufacture:	2003
Date & Time (UTC):	21 June 2009 at 1410 hrs
Location:	Sandwood Beach, Cape Wrath, Sutherland, Scotland
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Broken propeller and noseleg, salt water damage to engine and forward fuselage
Commander's Licence:	Private Pilot's Licence
Commander's Age:	55 years
Commander's Flying Experience:	592 hours (of which 399 were on type) Last 90 days - 33 hours Last 28 days - 21 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Intending to land on a beach, the pilot first tested the surface by performing a low pass during which he allowed the aircraft's wheels to touch the surface. The wheels hit a drift of sand which caused the nosewheel to collapse and the nose of the aircraft to become buried in the sand, bringing the aircraft to an abrupt halt.

INCIDENT

Aircraft Type and Registration:	X-Air Hawk, G-CEEC
No & Type of Engines:	1 Jabiru Aircraft PTY 2200A piston engine
Year of Manufacture:	2006
Date & Time (UTC):	28 May 2009 at 0730 hrs
Location:	Halwell, near Dartmouth, Devon
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nose gear, right main gear and engine cowling damaged
Commander's Licence:	Private Pilot's Licence (Microlights)
Commander's Age:	85 years
Commander's Flying Experience:	100 hours (of which 2 hours were on type) Last 90 days - 3 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot was making his third flight on this aircraft type. On his third approach to the 480 metre grass strip at Halwell in calm conditions, he landed fast and long. Realising that he was going to overrun, he steered the aircraft to the left, but was unable to prevent it from striking a hedge, damaging the landing gear and engine cowling. The pilot, who was wearing a full harness, was uninjured. He attributed the accident to his lack of experience on type.

AIRCRAFT ACCIDENT REPORT No 6/2009

This report was published on 20 October 2009 and is available on the AAIB Website www.aaib.gov.uk

REPORT ON THE ACCIDENT TO HAWKER HURRICANE MK XII (IIB), G-HURR 1 NM NORTH-WEST OF SHOREHAM AIRPORT, WEST SUSSEX ON 15 SEPTEMBER 2007

Registered Owner and Operator:	Spitfire Ltd
Aircraft Type:	Hawker Hurricane Mk XII (IIb)
Registration:	G-HURR
Manufacturer's Serial Number:	52024
Place of Accident:	1 nm north-west of Shoreham Airport, Sussex
Date and Time:	15 September 2007 at 1422 hrs (All times in this report are UTC, unless otherwise stated)

Synopsis

The accident was notified to the Air Accidents Investigation Branch (AAIB) by Shoreham Airport Air Traffic Control (ATC) shortly after it occurred; an AAIB field investigation was commenced immediately.

The Hurricane aircraft, G-HURR, was taking part in a flying display and was following another Hurricane in a tail chase. Both aircraft flew past the spectators along the display line at a height of approximately 200 ft before tracking to the north-west and climbing. The lead Hurricane climbed to approximately 1,100 ft above ground level (agl), pitched nose-up about 45º and rolled to the left through 270º, before pulling into a right turn to rejoin the display line. The second Hurricane, which was approximately 700 ft agl, pitched nose-up about 15º, before rolling to the left. As it reached the inverted position, the roll stopped, the nose dropped and the aircraft entered a steep dive. It struck the ground, fatally injuring the pilot. The aircraft was destroyed by the ground impact and subsequent fire.

The pilot appeared to have attempted to follow the manoeuvre flown by the leading pilot. Although the airspeed was adequate, the aircraft had insufficient nose-up pitch attitude at the point of entry to ensure the safe execution of the manoeuvre in the height available. When the aircraft was inverted, the roll stopped, the nose dropped and insufficient height was available to recover from the dive.

The investigation identified the following causal factors:

1 The accident probably occurred as a result of the pilot attempting an unplanned rolling manoeuvre.

2 When the manoeuvre was commenced, the airspeed was adequate, but the nose-up pitch attitude was insufficient to enable the manoeuvre to be completed safely in the height available.

3 When the roll stopped in the inverted position, the aircraft's nose dropped rapidly and there was insufficient height available for the recovery manoeuvre the pilot attempted.

As a result of this accident six Safety Recommendations are made.

Findings

1 The aircraft had a current Permit to Fly and was properly maintained.

2 No evidence was found of any defect or malfunction in the aircraft that could have caused or contributed to the accident.

3 The mass and centre of gravity of the aircraft were within the prescribed limits.

4 The pilot was properly licensed, held a current Class 2 medical certificate and was properly authorised to display the Hurricane.

5 There was no record of the pilot having completed the currency training requirements as specified in the operator's Organisational Control Manual.

6 The pilot appears to have attempted to perform a rolling manoeuvre with insufficient nose-up pitch attitude to ensure safe completion of the manoeuvre in the height available.

7 When the roll stopped at the inverted, the aircraft's nose dropped rapidly and insufficient height was available to recover from the dive.

8 The pilot had stated on a number of occasions prior to the display that he would not be rolling the aircraft, but in the event, did so.

9 Whilst the lead Hurricane pilot and the display sequence organisers were satisfied from the briefings and the pilot of G-HURR's comments that he was clear about the manoeuvres he would be performing, his action of attempting the rolling manoeuvre suggested otherwise.

10 The intended display sequence had not been practised.

11 The pilot had not demonstrated similar manoeuvres in an aircraft in the same category when his Display Authorisation was last renewed.

Safety Recommendations

Safety Recommendation 2009-052

It is recommended that the UK Civil Aviation Authority requires that the sequence of manoeuvres for a flying display is clearly specified in advance of the display and provided to the display organiser and that the sequence is practised prior to displaying to the public.

Safety Recommendation 2009-053

It is recommended that the UK Civil Aviation Authority amend the Display Authorisation process to identify the level of aerobatic manoeuvres a pilot is permitted to perform when leading or flying as a member of a tail chase.

Safety Recommendation 2009-054

It is recommended that the UK Civil Aviation Authority introduce a recurrent programme of Human Factors training for display pilots. The training should specifically address human performance and its limitations when undertaking display flying and should form part of the Display Authorisation process.

Safety Recommendation 2009-055

The UK Civil Aviation Authority should amend CAP 403 to require a pilot to demonstrate competence in each aircraft category to be flown and the level of aerobatic maneuvers to be performed in the specific flying display discipline (solo, formation, tail chase) for which the Display Authorisation is being sought.

Safety Recommendation 2009-056

It is recommended that the UK Civil Aviation Authority (CAA) remind CAP 632 aircraft operators of the need to clearly identify in the Organisational Control Manual the level of initial and recurrent training required and that the CAA should ensure compliance with those requirements.

Safety Recommendation 2009-057

It is recommended that the UK Civil Aviation Authority conduct periodic reviews of the current operating requirements to ensure that they provide adequate safety for display flying.

FORMAL AIRCRAFT ACCIDENT REPORTS ISSUED BY THE AIR ACCIDENTS INVESTIGATION BRANCH

2008

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

Published February 2008.

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

Published February 2008.

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

Published April 2008.

6/2008 Hawker Siddeley HS 748 Series 2A, G-BVOV
at Guernsey Airport, Channel Islands
on 8 March 2006.

Published August 2008.

7/2008 Aerospatiale SA365N, G-BLUN
near the North Morecambe gas platform, Morecambe Bay
on 27 December 2006.

Published October 2008.

2009

1/2009 Boeing 737-81Q, G-XLAC, Avions de Transport Regional ATR-72-202, G-BWDA, and Embraer EMB-145EU, G-EMBO
at Runway 27, Bristol International Airport
on 29 December 2006 and
on 3 January 2007.

Published January 2009.

2/2009 Boeing 777-222, N786UA
at London Heathrow Airport
on 26 February 2007.

Published April 2009.

3/2009 Boeing 737-3Q8, G-THOF
on approach to Runway 26
Bournemouth Airport, Hampshire
on 23 September 2007.

Published May 2009.

4/2009 Airbus A319-111, G-EZAC
near Nantes, France
on 15 September 2006.

Published August 2009.

5/2009 BAe 146-200, EI-CZO
at London City Airport
on 20 February 2007.

Published September 2009.

6/2009 Hawker Hurricane Mk XII (IIB), G-HURR
1nm north-west of Shoreham Airport, West Sussex
on 15 September 2007.

Published October 2009.

AAIB Reports are available on the Internet
http://www.aaib.gov.uk