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COMMERCIAL AIR TRANSPORT

FIXED WING

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SPORT AVIATION / BALLOONS

ADDENDUMS and CORRECTIONS

(ALL TIMES IN THIS BULLETIN ARE UTC)

INCIDENT

Aircraft Type and Registration:	Airbus A319-131, G-EUPF
No & Type of Engines:	2 IAE V2522-A5 turbofan engines
Year of Manufacture:	2000
Date & Time (UTC):	30 October 2005 at 1320 hrs
Location:	Aberdeen, Scotland
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 6 Passengers - 132
Injuries:	Crew - None Passengers - None
Nature of Damage:	Worn avionics vent fan bearing
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	53 years
Commander's Flying Experience:	11,000 hours (of which 2,000 were on type) Last 90 days - 105 hours Last 28 days - 35 hours
Information Source:	Aircraft Accident Report Form submitted by the commander

History of flight

Following takeoff from Aberdeen, failure messages related to the Instrument Landing System (ILS) and Ground Proximity Warning System (GPWS) illuminated and shortly after this the cabin crew became aware of a strange smell in the forward cabin area. The flight crew were informed of the smell and they asked the cabin crew to monitor the situation. The strange smell then became evident on the flight deck and there was an increase in cabin temperature. Initially it was thought that the smell emanated from the galley ovens but, as it was early in the flight, these had not yet been switched on.

The flight crew donned their oxygen masks, declared an emergency and then carried out an uneventful return to Aberdeen. After landing the smell had dissipated and, following a thorough inspection by the attending fire service, the aircraft was taxied onto the stand for a normal disembarkation of the passengers.

Previous flight

On the previous flight, ILS system 1 and the pressurisation system were not working correctly and after landing the 'AVIONICS VENT SYS FAULT' message appeared on the engine and warning display.

Engineering investigation

After the event, a thorough inspection of the engines, auxiliary power unit and air conditioning system did not reveal any problem that could have caused the strange smell. However, due to the ILS fault, GPWS fault and the earlier 'AVIONICS VENT SYS FAULT' message, it was suspected that the source of the problem lay with the avionics cooling system, so the avionics vent fan and filter were replaced. There was no repeat of the strange smell on subsequent flight sectors. The avionics vent fan was sent for repair, where examination revealed noisy and worn bearings.

There have been previous failures of the avionics vent fan on A319 and A320 aircraft and these have generally been related to the bearings. The symptoms of the bearing starting to fail are a low rumbling noise followed by the smell of burning in the cabin. The bearing failure can then reduce the amount of avionics cooling and produce warning messages such as 'AVIONICS VENT SYS FAULT'.

The avionics vent fan manufacturer has issued a Vendor Service Bulletin 3454-21-108, which replaces the current bearings, containing steel ball bearings, with an improved type utilising ceramic ball bearings. Consequently, the aircraft manufacturer has issued a service information letter (SIL 21-141) which notifies aircraft operators of the improvement.

INCIDENT

Aircraft Type and Registration:	Airbus A320, LZ-BHA
No & Type of Engines:	2 CFM56-5A turbofan engines
Year of Manufacture:	1989
Date & Time (UTC):	19 June 2005 at 0755 hrs
Location:	Stand 27, Belfast International Airport, Northern Ireland
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 6 Passengers - 20
Injuries:	Crew - None Passengers - None
Nature of Damage:	Wing tip damaged
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	39 years
Commander's Flying Experience:	10,900 hours (of which 780 were on type) Last 90 days - 200 hours Last 28 days - 40 hours
Information Source:	CAA Mandatory Occurrence Report 200504770 and subsequent AAIB investigation

Although most stands at the airport were marked with white boundary lines, Stand 27 was not. In preparation for the aircraft's arrival, a member of the ground crew used a small tug to position a set of mobile steps adjacent to the stand, in a position which he judged would be safe, and then adjusted their height to approximately that of the A320 doorway. Another member of ground crew switched on the AGNIS (Azimuth Guidance Nose-In Stands) which provides guidance to the commander for manoeuvring the aircraft onto the stand. The commander taxied the aircraft onto the stand normally, following the AGNIS indication, and brought the aircraft to a stop. As the aircraft came to a halt, the left wing collided with the mobile steps.

The handling agent's procedures required the ground crew to ensure that the stand was clear before activating the AGNIS equipment.

INTERIM REPORT AND SAFETY RECOMMENDATIONS

Aircraft Type and Registration:	Airbus A340-642, G-VATL
Manufacturer's Serial Number:	376
No & Type of Engines:	4 Rolls-Royce Trent 556-61 turbofan engines
Year of Manufacture:	2001
Date & Time (UTC):	8 February 2005 at 0330 hrs
Location:	En-route from Hong Kong to London Heathrow
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 18 Passengers - 293
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	43 years
Commander's Flying Experience:	7,000 hours (of which 3,100 were on type) Last 90 days -120 hours Last 28 days - 85 hours
Information Source:	AAIB Field Investigation

Synopsis

This report follows on from AAIB Special Bulletin S1 of 2005 which published the circumstances and facts established during the early part of the investigation. Investigative work continues and the final report will not be published before February 2006. This interim report contains safety recommendations addressed to the primary certification bodies for large transport category aircraft.

History of the flight

The flight was scheduled to depart Hong Kong at 1535 hrs (2335 local) on 7 February with a scheduled arrival time at London Heathrow of 0450 hrs the next day. There was one relevant entry in the technical log prior to departure; both Fuel Control Monitoring Computers (FCMCs) had been reset at separate times on the previous sector. During the pre-flight preparation period for this flight there was one FCMC 2 and one FCMC 1 failure; the crew were able to carry out successful resets on each occasion.

The aircraft took off from Hong Kong at 1621 hrs. Shortly after takeoff there was an Electronic Centralised Aircraft Monitor (ECAM) alert advisory 'FCMC2 FAULT' displayed. There were no ECAM actions associated with this fault and the commander decided to delay any attempt at a computer reset until the aircraft had reached its cruising level. When the aircraft reached its initial cruise level the crew attempted an FCMC2 reset using the computer reset procedure in the Quick Reference

Handbook (QRH). The reset attempt was unsuccessful. There were no further fuel system warnings, cautions or messages throughout the remainder of the flight.

The aircraft was cruising at FL380 in Dutch airspace when, at 0330 hrs, No 1 engine lost power. The flight crew secured the engine and the commander decided not to attempt to relight it but to continue towards Heathrow on three engines. The flight crew noticed that the fuel contents for the inner 1 fuel tank, which feeds engine No 1, was reading zero. Suspecting a possible fuel leak, a flight crew member was sent aft to inspect the engine area from the passenger cabin but nothing unusual was seen. However, soon afterwards, the crew observed the No 4 engine power fluctuate and noticed that the inner 4 fuel tank was also indicating zero fuel contents. The commander opened all the fuel crossfeed valves and the No 4 engine recovered. A 'MAYDAY' was declared and a diversion to Amsterdam Schipol Airport was initiated.

When the diversion commenced the total fuel on board was in excess of 25,000 kg but there were significant quantities of fuel located in the trim, centre and outer wing fuel tanks. Manual fuel transfer was started by the flight crew but they did not see immediately the expected indications of fuel transfer on the ECAM. Consequently, the flight crew remained uncertain of the exact fuel status. The diversion to Amsterdam continued and the aircraft landed there without further technical problems.

Investigative work in progress

To assist in the understanding of the events that surrounded the incident, the fuel system computers fitted to G-VATL have been installed onto a development A340-600 which will allow close monitoring and recording of the fuel system operation during all phases of flight. This, coupled with other investigative actions, may help to determine the root cause of the incident. Also, a detailed examination is underway into the presentation of fuel system data to the flight crew during a flight, especially following a FCMC failure, and also data used by the maintenance engineers for troubleshooting following a flight in which a fuel system anomaly was discovered.

Fuel system regulations

Large aeroplanes

A review of the current European EASA and US FAA regulations for large aeroplanes revealed that neither EASA CS-25 nor FAA FAR-25 contain a requirement for a low fuel level warning. The only specified requirement for fuel level is a fuel quantity indicator as quoted below:

CS 25.1305 Powerplant instruments

(a) For all aeroplanes

(2) A fuel quantity indicator for each fuel tank.

This basic requirement is amplified as follows*:*

'CS 25.1337 Powerplant instruments

(b) Fuel quantity indicator. There must be means to indicate to the flight-crew members, the quantity, in litres, (gallons), or equivalent units, of usable fuel in each tank during flight. In addition –

(1) Each fuel quantity indicator must be calibrated to read 'zero' during level flight when the quantity of fuel remaining in the tank is equal to the unusable fuel supply determined under CS-25.959;

(2) Tanks with interconnected outlets and airspaces may be treated as one tank and need not have separate indicators; and

(3) Each exposed sight gauge, used as a fuel quantity indicator, must be protected against damage…'

Despite this lack of a stated requirement for a low fuel level warning, EASA CS-25.1309 Equipment, systems and installations paragraph c) has a generic requirement for all aircraft systems, including fuel, which states:

> *"Information concerning unsafe operating conditions must be provided to the crew to enable them to take appropriate corrective action. A warning indication must be provided if immediate corrective action is required. Systems and controls, including indications and annunciations must be designed to minimise crew errors, which could create additional hazards."*

Normal, Utility, Aerobatic, and Commuter Category Aeroplanes

A review of similar regulations for other aircraft and rotorcraft reveals that there is a requirement for a low fuel level warning on some aircraft. The requirement is contained in EASA CS-23 Certification Specifications for Normal, Utility, Aerobatic, and Commuter Category Aeroplanes:

> *'CS-23.1305 Powerplant instruments…*
> *…(c) For turbine engine-powered aeroplanes In addition to the powerplant instruments required by sub-paragraph (a), the following powerplant instruments are required:*
> *(1) A gas temperature indicator for each engine.*
> *(2) A fuel flowmeter indicator for each engine.*
> *(3) A fuel low pressure warning means for each engine.*
> *(4) A fuel low level warning means for any fuel tank that should not be depleted of fuel in normal operations…'*

Small Rotorcraft

The EASA CS-27 Certification Specifications for Small Rotorcraft state:

> *'CS-27.1305 Powerplant instruments*
> *…(l) A low fuel warning device for each fuel tank which feeds an engine. This device must:*
> *(1) Provide a warning to the flight crew when approximately 10 minutes of usable fuel remains in the tank; and*
> *(2) Be independent of the normal fuel quantity indicating system…'*

Large Rotorcraft

The EASA CS-29 Certification Specifications for Large Rotorcraft state:

> *'CS-29.1305 Power plant instruments*
> *…(4) A low fuel warning device for each fuel tank which feeds an engine. This device must:*
> *(i) Provide a warning to the crew when approximately 10 minutes of usable fuel remains in the tank; and*
> *(ii) Be independent of the normal fuel quantity indicating system…'*

The FAA regulations FAR-23, 27 and 29 are similar to the EASA regulations above.

Discussion

Large aircraft, especially those equipped with glass cockpits and computerised management systems, are very complex and to that end the flight crew have to rely on the aircraft's systems warning them of problems. Although a low fuel level in the engine feeding fuel tanks should normally never occur (when the system is operating correctly) this investigation has shown that when the system fails to operate correctly and if the crew are not aware of the situation, they are unable to act in an appropriate manner and prevent engine fuel starvation. It could be argued that the need to indicate fuel system failures to the crew on complex aircraft is covered by EASA CS-25 1309 paragraph c. Indeed, when the fuel control system is operating normally on the A340-600 this is true, but this incident demonstrated a need for more specific requirements for certain warnings such as low fuel level in an engine feeder tank.

Another argument for not having the requirement for a low level fuel warning could be that aircraft certified to EASA CS-25 are operated by a minimum of two flight crew and therefore at least one of these would be monitoring the fuel status. However, the flight crew have to monitor several systems at once placing more reliance on warning systems and flags to identify an impending problem. Also, with the larger aircraft, the fuel system may be used for centre of gravity control. Fuel tank feeding sequences may be complicated and some fuel tanks may be depleted and replenished frequently during a long flight. Consequently, although fuel sequencing may be automated, deviations from the correct sequence due to automation failure may be difficult to determine simply by looking at the synoptic display. Moreover, the synoptic display of the fuel system may be 'congested' and the information difficult to assimilate unless the pilots' attention is drawn to the problem area by an automatic status or failure warning.

Finally, contemporary large rotorcraft are as complex as some large aeroplanes and they are operated by a minimum of two flight crew, yet there is a requirement, in EASA CS-29, for a low fuel level warning system.

Findings

From the above regulations it is clear that there is currently no requirement within EASA CS-25 or JAR-25 for a low fuel level warning on large aircraft. This is at variance to the smaller aircraft and to all rotorcraft which, under European regulations, require such a system as defined by the relevant EASA Certification Specifications CS-23, CS-27 and CS-29. Despite the lack of a regulation to install a low level fuel warning, most large aircraft certified to FAR-25, JAR-25 or EASA CS-25 do have an independent low fuel level warning system installed.

Safety Recommendations

If the low fuel level warning system is not independent, it can be inhibited by a failing fuel control system. An independent low level fuel warning system would enable the flight crew to be made aware of a failure of the automatic fuel control system and enable them to act accordingly, either by taking control of the fuel system or by landing prematurely. There are two main certification agencies for very large aircraft: the European Aviation Safety Agency which has taken over responsibility for certification of large aircraft from the Joint Aviation Authorities, and the US Federal Aviation Administration. Consequently, each of two safety recommendations is addressed to both bodies.

Safety Recommendation 2005-108

It is recommended that the European Aviation Safety Agency introduces into CS-25 the requirement for a low fuel warning system for each engine feed fuel tank. This low fuel warning system should be independent of the fuel control and quantity indication system(s).

Safety Recommendation 2005-109

It is recommended that the European Aviation Safety Agency should review all aircraft currently certified to

EASA CS-25 and JAR-25 to ensure that if an engine fuel feed low fuel warning system is installed, it is independent of the fuel control and quantity indication system(s).

Safety Recommendation 2005-110

It is recommended that the USA's Federal Aviation Administration should introduce into FAR-25 a requirement for a low fuel warning system for each engine feed fuel tank. This low fuel warning system should be independent to the fuel control and quantity indication system(s).

Safety Recommendation 2005-111

The Federal Aviation Administration should review all aircraft currently certified to FAR-25 to ensure that if an engine fuel feed low fuel warning system is installed, it is independent of the fuel control and quantity indication system(s).

ACCIDENT

Aircraft Type and Registration:	BAe 146-RJ100, G-BZAT
No & Type of Engines:	4 Lycoming LF507-1F turbofan engines
Year of Manufacture:	1997
Date & Time (UTC):	7 October 2005 at 1300 hrs
Location:	Stand 3, Birmingham Airport, West Midlands
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - None Passengers - None
Injuries:	Crew - N/A Passengers - N/A
Nature of Damage:	Skin pulled from door frame structure, skin torn in two places
Commander's Licence:	Air Transport Pilot's Licence
Commander's Age:	37 years
Commander's Flying Experience:	8,338 hours (of which 1,191 were on type) Last 90 days - 85 hours Last 28 days - 39 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

On completion of loading the rear baggage hold, prior to the aircraft's departure, the motorised baggage loading belt struck the forward edge of the hold aperture whilst reversing from the aircraft. The impact pulled the aircraft skin from the door fame structure and tore it in two places. Repairs to the aircraft were necessary prior to the aircraft returning to service. An examination of the loading belt showed that it was fully serviceable at the time of the incident.

INCIDENT

Aircraft Type and Registration:	Boeing 757-200APF, TF-FIE
No & Type of Engines:	2 Rolls-Royce RB211-535E4 turbofan engines
Year of Manufacture:	1987
Date & Time (UTC):	18 August 2005 at 2239 hrs
Location:	London Stansted Airport, Essex
Type of Flight:	Public Transport (Cargo)
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Main bearing in engine
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	40 years
Commander's Flying Experience:	6,924 hours (of which 4,488 were on type) Last 90 days - 246 hours Last 28 days - 58 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further inquiries by AAIB

The aircraft was taking off from Runway 23 for a short night flight to Liege, Belgium; the first officer was the handling pilot. The takeoff was uneventful until, at about 5-10 kt below V_1, the captain thought he might have seen some smoke in the cockpit. At this time the first officer was unable to confirm the presence of smoke.

At approximately 500 ft, the captain turned-up his reading light and called that he could see smoke and the first officer confirmed that he could smell it. They called the control tower, explaining the circumstances and requesting a turn-back and landing. The controller asked if they were declaring an emergency but the captain declined, saying that the smoke had cleared however he still preferred to return. They were given radar vectors to 5 to 6 miles finals and the aircraft landed on Runway 23 without any difficulties after a total airborne time of 11 minutes. The Airport Fire Service attended and, after a brief inspection, the aircraft was taxied back to the gate with everything appearing normal.

A technician from the maintenance provider attended and agreed that he could also smell an odour of hot oil, apparently emanating from the air conditioning system. Subsequent inspection suggested that an oil leak, apparently from the No 1 bearing in the left engine, had been ingested into the intermediate pressure compressor and thence into the air conditioning bleed air. Initial actions were to change and inspect the pressure and scavenge oil filters but the operator subsequently opted to change the left engine. After this the aircraft was released to service with no further reports of air contamination.

A subsequent strip examination of the engine showed that a cracked No 1 bearing front ring seal had been responsible for the oil leak.

INCIDENT

Aircraft Type and Registration:	Boeing 757-204, G-BYAO
No & Type of Engines:	2 Rolls-Royce RB211-535E4-37 turbofan engines
Year of Manufacture:	1994
Date & Time (UTC):	12 May 2005 at 1648 hrs
Location:	Manchester Airport, Manchester
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 8 Passengers - 234
Injuries:	Crew - None Passengers - None
Nature of Damage:	Scrapes and wear to the rear of aircraft in vicinity of the tail scrape limiting device and auxiliary power unit access doors
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	48 years
Commander's Flying Experience:	10,630 hours (of which 4,030 were on type) Last 90 days - 143 hours Last 28 days - 64 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft was departing on a flight to Gran Canaria with the co-pilot handling the flight controls. During the takeoff, staff in the airfield's ATC tower and the crew of another aircraft, which was stationary at a holding point on the aerodrome, saw a significant amount of smoke emanate from the rear of the aircraft as it lifted off the runway. At the same time the crew in the aircraft heard a noise and felt a slight bump. The commander advised ATC that they thought that they had suffered a tailstrike and intended to return to the airfield. The aircraft made a gentle, uneventful landing back at Manchester, 12 tonnes over the maximum landing weight, and used the full length of the runway to minimise the load on the brakes.

The tailstrike was the result of an excessive rate of rotation during the takeoff. This was exacerbated by a variable headwind component which contributed to a lift off speed that was lower than intended by the manufacturer and compounded the loss of tail clearance. The operator has since amended its procedures to ensure better flying continuity and guidance for newly trained co-pilots, and the inclusion in he company operations manual of the advice given in the Boeing 757 Flight Crew Training Manual on the subject of takeoffs in Gusty Wind and Strong Crosswind Conditions.

History of the flight

The aircraft was departing from Runway 06L at Manchester Airport, on a flight to Las Palmas in Gran Canaria. The co-pilot was the pilot flying (PF) and during the take-off roll the commander noticed that he had introduced what he considered to be an excessive amount of into wind aileron for the prevailing conditions. The commander stated that, initially, the co-pilot set about half of the full control wheel roll deflection to the right but he reduced this as the aircraft's speed increased. On the commencement of rotation the commander watched for any signs of roll but the aircraft appeared to remain wings level. He considered that the rate of rotation was normal until the aircraft had reached 8º nose up but, thereafter, it increased rapidly and he was unable to check the control input. The co-pilot felt that the aircraft was a little 'nose light' and that the rate of rotation was too high up to 10º nose up. Passing the 10º pitch up attitude he continued to pull the control column back at a rate that he considered was about 2.5º of pitch/second.

The staff in the Visual Control Room (VCR) of the airfield's Air Traffic Control tower observed that the rate of rotation was somewhat sharper than usual for a Boeing 757-200. They also saw a significant amount of smoke emanate from the rear of the aircraft as it lifted off the runway. At the same time the commander heard a loud bang from the back of the aircraft and the co-pilot stated that he felt a slight bump as the aircraft rotated through an attitude of 12º nose up. The noise was also heard by the cabin crew. The crew of another aircraft, which was stationary at holding point DZ1 adjacent to the mid point of the runway, reported over the radio that they too had seen smoke coming from G-BYAO'S tail, which had seemed close to the runway surface as the aircraft took off.

ATC enquired of the crew as to whether all was well. The commander replied that they thought that the aircraft had suffered a tailstrike and that they intended to return to the airfield. He requested radar vectors and advised ATC that they did not wish to fly above 10,000 ft amsl. The crew completed the Abnormal Procedure for a tailstrike and, as part of that drill, depressurised the cabin. By this stage the aircraft was flying level at 5,000 ft amsl. The commander informed the cabin crew of the nature of the problem and of the decision to return to Manchester. He instructed them to prepare for a precautionary landing and told the passengers that they were returning to the airfield because the cabin could not be pressurised.

Meanwhile, the airport authority organised an inspection of Runway 06L. No marks, damage or debris were found and over the course of the next 24 hours three more inspections were carried out by different personnel, with the same result.

The flight crew made preparations for an overweight landing and transmitted a PAN call. They decided to use radar vectors, rather than enter a hold (at MIRSI), and the commander commented later that this had been a great help in reducing their workload. The aircraft landed on Runway 06R at a weight which was 12 tonnes above the normal maximum landing weight of 89,811 kg. The aircraft touched down gently and the commander, who had taken over the role of PF, was able to use the full length of the runway and minimum braking in order to reduce the load on the brakes.

After the aircraft had vacated the runway, the AFRS assessed the state of the brakes, which might have overheated, and advised the flight crew that they appeared to be safe. The commander told the passengers that it was normal for the AFRS to be present following an overweight landing and the aircraft was taxied on to a stand. The AFRS then inspected the brakes again and confirmed that they were still safe. Following that confirmation, the commander instructed the cabin crew to disembark the passengers.

The commander stated that the aircraft had behaved normally during all phases of flight after the takeoff.

Other aircraft departures and arrivals

An Airbus A320 had departed from Runway 06L four minutes before G-BYAO took off. This was sufficient time for its wake turbulence to have dissipated before the Boeing 757 departed. A Britten Norman Islander took off after the A320 but its wake turbulence would not have affected G-BYAO. Aircraft were landing on Runway 06R, but the displacement of the two runways, with the threshold on 06R downwind of the threshold on 06L, did not suggest that landing aircraft could have affected the departing aircraft. In addition, none of the departing aircraft reported any instances of turbulence or windshear.

Performance

The aircraft's gross weight at takeoff was calculated on the computerised loadsheet as 100,410 kg, with the CG at 22.5% mean aerodynamic chord (MAC). This was within the maximum take-off weight for the aircraft, which was 103,699 kg, and towards the centre of the CG range for that weight. A witness, who was present when the baggage was loaded before the flight and unloaded after it, stated that the baggage, which had been loaded in holds two, three and four, had not moved during the flight. Another witness who was involved with off-loading the baggage also confirmed that the baggage nets were still in place and that there was no sign that the baggage had moved.

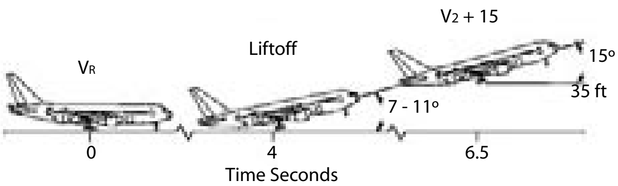
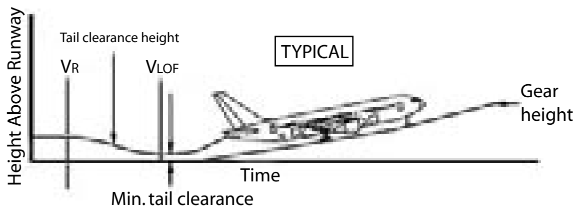
The flight crew calculated the take-off speeds for a departure with 15º of flap as: V_1 = 141 kt, V_R = 144 kt and V_2 = 148 kt. They selected the stabiliser trim to 4.7 units and used Derate One thrust, which gave an engine pressure ration (EPR) of 1.63. The manufacturer stated that the Flight Data Recorder (FDR) data showed a stabiliser setting of 4.5 units.

For the reported conditions, the manufacturer's recommended take-off parameters were; V_1 = 141 kt, V_R = 143 kt, V_2 = 148 kt, stabiliser setting 4.55 units and an EPR of 1.64.

Procedures

The manufacturer's guidance on *Rotation and Liftoff - All Engines* in its 757 Flight Crew Training Manual (FCTM) includes the following:

> *…When a smooth continuous rotation is initiated at VR, tail clearance margin is assured…..*
>
> *Above 80 knots, relax the forward control column pressure to the neutral position. For optimum takeoff and initial climb performance, initiate a smooth continuous rotation at V_R toward 15° of pitch attitude. The use of stabilizer trim during rotation is not recommended….*
>
> ***Note:*** *Do not adjust takeoff speeds or rotation rates to compensate for increased body length.*
>
> *With a consistent rotation technique, where the pilot uses approximately equal control forces and similar visual cues, the resultant rotation rate differs slightly depending upon airplane body length.*
>
> *Using the technique above, liftoff attitude is achieved in approximately 4 seconds. Resultant rotation rates vary from 2 to 2.5 degrees/second with rates being lowest on longer airplanes.*

> ***Note:*** *The flight director pitch command is not used for rotation.*
>
> ***Typical Rotation, All Engines***
>
> *The following figure shows typical rotation with all engines operating.*
>
> 
>
>
> ***…….Typical Takeoff Tail Clearance***
>
> *The following diagram and table show the effect of flap position on liftoff pitch attitude and aft fuselage clearance during takeoff. Additionally, the last column shows the pitch attitude for aft fuselage contact with wheels on runway and landing gear struts extended….*
>
> 
>

Model	Flap	Liftoff Attitude	Minimum Tail Clearance inches (cm)	Tail Strike Pitch Attitude degrees)
757-200	1 5 15 20	10.3 10.0 9.5 8.5	30 (76) 33 (84) 38 (97) 47 (119)	12.3
757-300	5, 15, 20	7.5	26 (66)	9.5

> ***……..Effect of Rotation Speed and Pitch Rate on Liftoff***
>
> *Takeoff and initial climb performance depend on rotating at the correct airspeed and proper rate to the rotation target attitude. Early or rapid rotation may cause a tail strike…..*

The FDR data was checked for any stabiliser trim inputs before or during the aircraft's rotation, before the landing gear was retracted. None were recorded.

Under the heading of ***Gusty Wind and Strong Crosswind Conditions*** the FCTM's advice is to:

> *avoid rotation during a gust. If a gust is experienced near V_R, as indicated by stagnant airspeed or rapid airspeed acceleration, momentarily delay rotation. This slight delay allows the airplane additional time to accelerate through the gust and the resulting additional airspeed improves the tail clearance margin. Do not rotate early or use a higher than normal rotation rate in an attempt to clear the ground and reduce the gust effect because this reduces tail clearance margins. Limit control wheel input to that required to keep the wings level. Use of excessive control wheel may cause spoilers to rise which has the effect of reducing tail clearance. All of these factors provide maximum energy to accelerate through gusts while maintaining tail clearance margins at liftoff.*

This advice does not appear in the operator's Operations Manual.

The operator's Operations Manual Part B for the B757/767 states, in relation to the takeoff:

> *At "Rotate" the aircraft should be rotated smoothly to 15º pitch attitude at an average rate of 2.5º/sec. Having achieved 15º pitch, and when airborne, but not before, follow the flight director pitch commands with an upper limit of 20º.*

Personnel information

Initially the co-pilot had been employed by the operator on a temporary basis, as part of a partnership training programme with an approved flying training organisation. He completed his line training on 16 February 2005 and his temporary contract ended on 22 April 2005. He last flew on that contract on 19 April 2005. On 1 May 2005 he restarted his employment with the operator on a permanent contract but was unable to operate on the line until he had completed an Operator Proficiency Check (OPC) in the simulator on 6 and 7 May. The accident flight was his first since that OPC and came 23 days after his previous flight. He had accrued a total of 576 flying hours on all types of aircraft and 323 hours on the B757-200. His performance during training had been commensurate with that expected of a capable pilot with low hours and limited experience. The operator stated that there had been no sign of any particular trend in the co-pilot's flying during his training.

The commander had significantly more experience, both in terms of total flying hours and hours on type. As both the aircraft commander and the non flying pilot (PNF), his role was to monitor PF and his actions. The two pilots had not flown together before so their pre-flight preparation included introducing themselves to each other. All their preparation was completed in good time and neither felt rushed at any stage. The aircraft pushed back off stand three minutes ahead of schedule.

During the investigation it became apparent that, despite never having flown together, the crew co-operated well together and with the cabin crew, both before and after the tailstrike. Their response to the event was clear and decisive, included the relevant procedures and was well communicated.

Meteorology

An observation taken at the airport at the time of the accident recorded the surface wind as 070º/14 kt, visibility greater than 10 km, no cloud below 5,000 ft above airfield level (aal), outside air temperature 14ºC, dew point 1ºC and the QNH pressure was 1022 hPa.

When cleared for takeoff the surface wind was 070º/15 kt. This contrasted with a surface wind of 100º/14 kt which the crew had recorded on the operator's 'take-off form', on which they had also annotated the speeds for V_1, V_R and V_2, as well as the thrust and configuration for takeoff.

The Terminal Area Forecast (TAF) for Manchester between 1600 hrs and 0100 hrs predicted a surface wind of 110º at 11 kt, visibility in excess of 10 km, one to two octas of cloud at 4,000 ft agl and the visibility temporarily reducing to 8,000 m between 2200 hrs and 0100 hrs.

Aircraft examination

Following the incident, the aircraft was taken to a local maintenance facility, where it was later examined by the AAIB. G-BYAO had been fitted with a Tail Scrape Limiting Device (TSLD) which consisted of an inverted section made of nickel alloy, enclosed and sitting proud of a composite fairing. The TSLD was mounted underneath the aircraft, on its centreline, at structural frame 1743.85 (the first frame aft of the rear pressure bulkhead) and deliberately located so that it would be the first point of contact during a tail scrape.

The TSLD had extensive contact damage, with the inverted section worn down so that it was flush with its fairing. Around the device, the airframe skin had buckled and rivets, attached to the frame, had pulled away from the external skin. Internally, frame 1743.85 had been buckled in two diametrically opposite areas where stringer 29L and stringer 29R were attached to the frame. This buckling was consistent with an extensive upward force on the TSLD with the load being transferred into the frame, pushing this upward and causing the plastic deformation of the frame and aircraft skin.

Moving aft from the TSLD, the next contact point was at the APU fire extinguisher access door located between frames 1862 and 1885. Light scrapes were evident 150 mm aft of frame 1862, with these worsening toward the rear of the aircraft. 420 mm aft of the frame, the paint on the access door was worn away in line with the centreline of the aircraft and over an area measuring 160 mm wide and 90 mm in length. The APU access doors were mounted just aft of frame 1885, with a deflector strip mounted on the frame. The centre of the deflector strip was totally worn away, with scuffing of the airframe skin underneath over a width of about 100 mm either side of the aircraft centre line. The scrape damage continued onto the two APU access doors up to a point 470 mm aft of frame 1885. The APU doors contained several proud roundhead rivets and those along either side of the centre line had been completely worn down; coupled with additional wear of the door down to its metal skin. This damage was worse on the right hand door, with the damage at its widest point some 65 mm to the right of the centre line. The left door also suffered similar damage but this only extended 20 mm to the left of the centreline.

Various aircraft systems were checked for serviceability. This included the airspeed indication system stabiliser trim, elevator, flaps and a visual examination of the forward and aft bulk cargo holds. No problems were identified that could have contributed to the tail scrape.

The airframe damage was limited to the un-pressurised area of the aircraft. The aft pressure bulkhead remained undamaged, which was mainly as a result of the TSLD. The aircraft was later flown to its home base for repair. The frame and the skin damage repairs at frame 1885 were carried out in accordance with prescribed manufacturer structural repair manual instructions and a bespoke doubler repair was carried out to the skin surrounding the TSLD. The APU fire extinguisher doors, the two APU access doors and the deflector strip were all replaced with new parts. (See Figure 1)

Flight Recorders

General

The aircraft was equipped with a 25-hour duration FDR, a 30-minute cockpit voice recorder (CVR) and a quick access recorder (QAR), which was utilised by the operator to support its flight data monitoring (FDM) program. When the CVR was replayed the takeoff, approach and landing phases were found to have been overwritten as the CVR power had not been isolated in sufficient time to preserve information relating to the incident. The FDR was downloaded and data for the entire flight was successfully recovered. Data from the QAR was also recovered.

Flight Data

All times quoted were recorded from the commander's clock. At 1644 hrs the aircraft taxied onto a magnetic heading of about 061° and came to a stop with the engines at idle, flaps were at 15° and the horizontal stabiliser position was at about 4.6 units, where it remained until after the aircraft was airborne. The recorded gross weight was 100,624 kg at the time. The aircraft remained stationary for about two minutes before the engine thrust was gradually increased. EPR for both engines stabilised at about 1.63 and the aircraft started to accelerate. During the majority of the take-off roll the

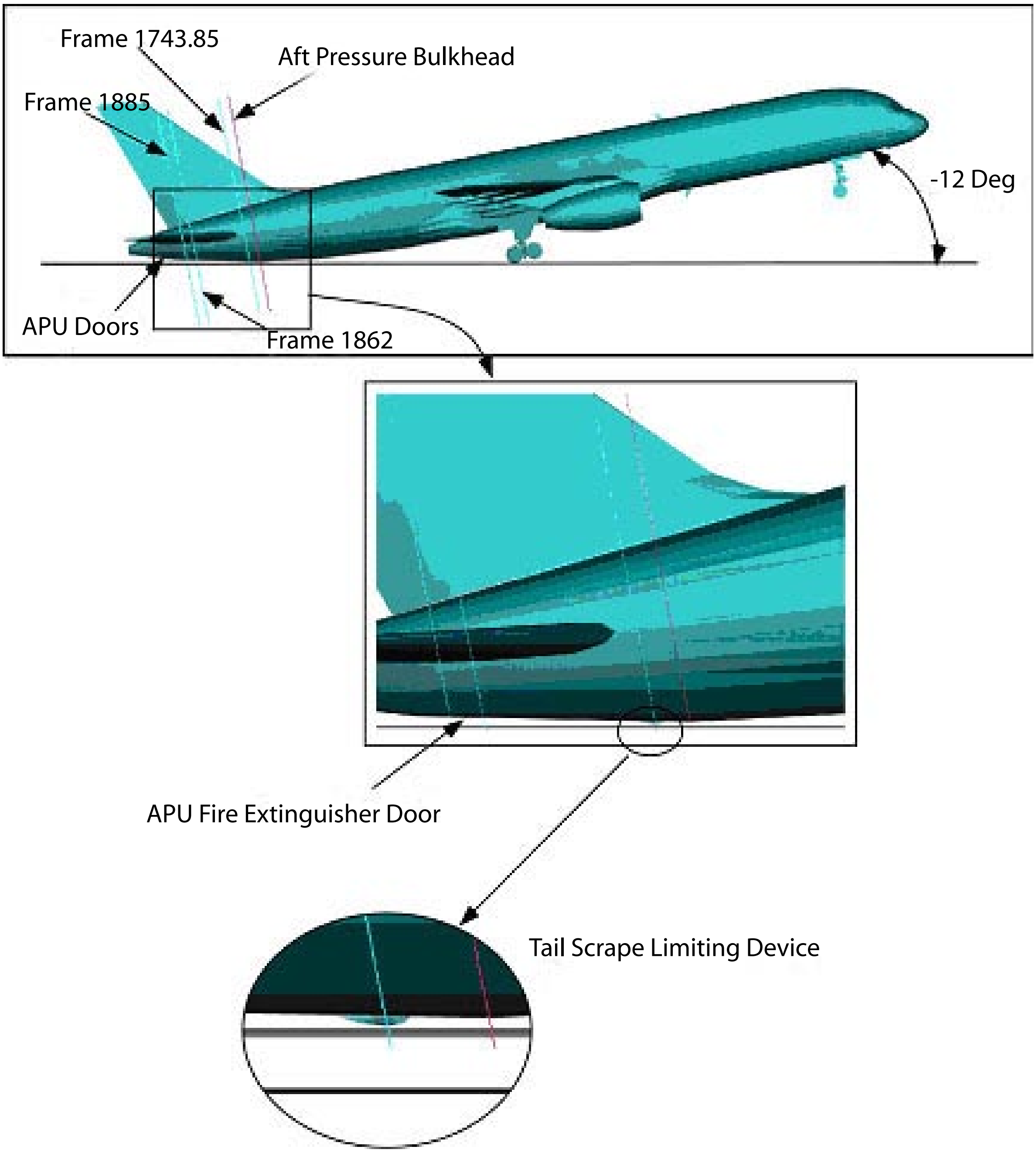


Figure 1

control wheel position was about 18º to the right and a small amount of left rudder was also applied. During the takeoff the airspeed was between 10 kt and 30 kt greater than the groundspeed.

Figure 2 details the salient parameters during the takeoff phase. At 1647:18 hrs, at an airspeed of about 144 kt and a groundspeed of about 120 kt, the control column started to move aft (Figure 2, Point A) and about two seconds later the nose squat switch indicated that the nose gear was no longer compressed (Figure 2, Point B).

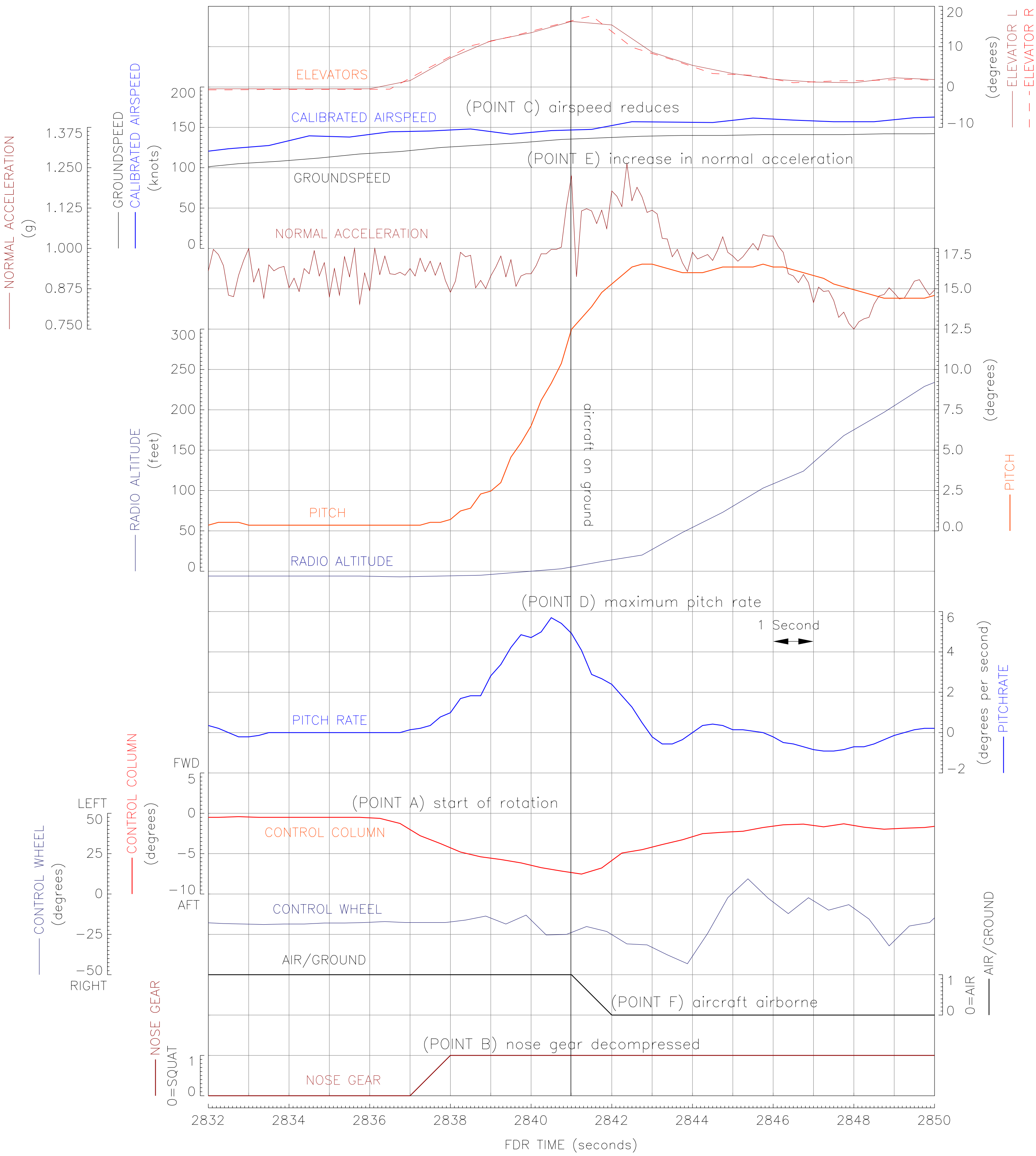


Figure 2

Salient FDR Paramenters

About one second later the airspeed reduced to about 142 kt (Figure 2, Point C), however the groundspeed continued to increase.

About four seconds after the control column had started to move aft the pitch attitude was at about 10º nose up and the airspeed was about 146 kt; at that time the pitch rate was about 5.7º per second (Figure 2, Point D). The control column continued to move aft and the pitch attitude continued to increase. When the pitch attitude was at about 12.5º nose up, a normal acceleration of 1.22 g was recorded (Figure 2, Point E). At that time the main undercarriage truck tilt parameters indicated that the aircraft was on the ground and the elevators were at about 16º trailing edge up. For a short duration the control column continued to move aft and the elevators moved to about 17.6º trailing edge up, before the control column was then moved forward. About half a second later the air ground parameter indicated that the aircraft was airborne[1] (Figure 2, Point F), airspeed was about 148 kt and the groundspeed was about 137 kt. During the take-off roll and rotation phase the aircraft had remained predominantly wings level.

The aircraft continued to climb until it reached FL047, where it remained until about 1704 hrs when the aircraft started to descend and was then configured for landing. The approach and landing were uneventful with touchdown occurring at about 1711 hrs.

Operators Flight Data Monitoring (FDM) program

Overview

The operator utilised a FDM program to monitor the operation of aircraft across the fleet. The FDM program analysed QAR data and identified if operational and/or aircraft performance limits, which had been set by the operator, had been exceeded. The QAR data was typically available for up to six months following analysis.

FDM high pitch attitude and high pitch rate at takeoff detection

The operators FDM program included the capability to identify if pitch rate and/or pitch attitude had exceeded FDM limits. The program had been configured to identify if the pitch attitude at takeoff had exceeded 10º for half a second or more and if the average pitch rate[2] was greater or equal to 3.5º per second during take-off rotation.

The FDM program utilised the normal acceleration and air/ground parameters in its calculation of the take-off point. When the airspeed had exceeded a preset limit the FDM program monitored for an increase in the normal acceleration parameter values or a change of state of the air/ground parameter to identify the take-off point.

FDM historic and incident data

The operator made available FDM data for the handling pilot's previous takeoffs and the incident flight. The FDM program did not identify any events associated with either a high pitch attitude or high pitch rate for any of the takeoffs prior to the incident. This was confirmed by visual analysis of the flight data.

When the FDM program analysed the incident flight it identified that both the pitch attitude and pitch rate at takeoff had exceeded the limits set by the operator during takeoff. The FDM program identified that the

Footnote

[1] The FDR air/ground is recorded in the air mode when the main undercarriage gear trucks are tilted and the nose gear shock strut is extended and the truck positioner hydraulic actuator inlet pressure switches are closed.

Footnote

[2] The average pitch rate was calculated by determining the time difference between when the aircraft pitch attitude had reached two degrees or more and the sample of pitch prior to being greater then twelve degrees; the difference in pitch attitude between the two points was then calculated and divided by the time difference.

maximum pitch attitude at takeoff was 13.2º. This value was consistent with the period when the tail would have been in contact with the runway surface during the takeoff.

Elevator position at takeoff

The manufacturer calculated that for the aircraft configuration an elevator position of between about 10º to 12º would have been required to have maintained an average pitch rate of about 2.5º per second.

Aircraft lift off speed (V_{LOF})

The manufacturer advised that the typical airspeed increase from V_R to V_{LOF} would have been about 13 kt based on the aircraft configuration. V_R was 143 kt and V_{LOF} would have been about 156 kt based on an average pitch rate of about 2.5º per second.

FDR Analysis

About four seconds after rotation had been initiated the pitch attitude had reached 10º, this was in accordance with the manufacturer's recommended average rotation rate of 2.5º per second over a four second period, however the pitch rate at the commencement of the rotation had initially been low and had then rapidly increased. During the rotation the elevator had moved to about 17.6º, about 5.6º beyond the maximum position that the manufacturer advised would have been necessary to have maintained an average pitch rate of about 2.5º per second. The control column position and coincident elevator movement indicated that the rapidly increasing pitch rate had been due to an increase in the aft column position.

During the take-off roll the aircraft had been experiencing a headwind component, which had been varying between 10 kt and 30 kt (as indicated by the difference between the airspeed and groundspeed). As the aircraft had started to rotate the headwind component started to reduce which, as the aircraft had approached 10º of pitch attitude, resulted in an airspeed that was about 10 kt below V_{LOF}. The pitch attitude continued to increase while the aircraft's landing gear was still in contact with the runway and it was most likely that at about 12.5º pitch attitude the aft body made initial contact with the runway as indicated by the coincident recording of 1.22 g.

Operator's actions

The operator implemented the following changes to their procedures:

1. In the first three months following their final line check, new co-pilots are to be rostered for sufficient sectors to ensure consolidation of their training and to allow for close monitoring.
2. Commanders are to be encouraged to give feedback and appropriate advice to new co-pilots.
3. During training, training pilots are to explain the rotation self timing technique and encourage its use.
4. Examine the possibility of obtaining trends from flight data monitoring recordings and providing continuation training for pilots where necessary.
5. The operator has amended his operations manual to include the advice given in the Boeing 757 Flight Crew Training Manual on the subject of takeoffs in Gusty Wind and Strong Crosswind Conditions.

Previous studies

Tail strike accidents in the past have prompted a number of studies. One such, initiated by the manufacturer, listed four take-off risk factors. Namely:

- Mistrimmed stabiliser
- Rotation at improper speed
- Excessive rotation rate
- Improper use of the flight director

Discussion

The results of the investigation indicate that the tailstrike was a result of the excessive rate of rotation during the takeoff; one of the four take-off risk factors for a tailstrike that have been identified by the manufacturer. Rotation was initiated at the correct airspeed but at a low rate. Then it increased rapidly, so that four seconds after the control column had started to move aft the pitch rate peaked at about 5.7º per second. At that point the aircraft's pitch attitude was about 10º nose up and its airspeed was about 146 kt. This compared with the recommended rotation rate of 2.5º per second over a four second period and a lift off pitch attitude of 9.5º nose up. However, having exceeded the recommended pitch rate, the aircraft continued to rotate faster than the manufacturer's and operator's manuals advised. Also G-BYAO's airspeed was less than would be expected at that stage of the takeoff, by some 10 kt. The FDR data indicated that this was because of changes in the headwind component which varied between 10 kt and 30 kt and caused a non-uniform airspeed acceleration. The manufacturer gives guidance, in his Boeing 757 Flight Crew Training Manual, on the procedure to use during takeoffs in gusty wind and strong crosswind conditions to cater for this situation. At the time, the operator did not include this advice in his procedures but this has been addressed and that guidance has since been added to the operator's Operations Manual.

Although the FDR data gave indications of a variation between the airspeed and groundspeed of between 10 and 30 kt, it is of note that neither the meteorological forecast nor observations mentioned wind gusts and no crews in any of the aircraft which were taking off around the time of the accident reported gusty or windshear conditions.

The aircraft lifted off with a nose up pitch attitude of 13.2º and an airspeed of 148 kt, 8 kt slower than the manufacturer's expected lift off speed. The tailstrike occurred before that, when the aircraft's pitch attitude was 12.5º nose up. The data indicated that the pitch attitude and rate of rotation were related to the rearwards movement of the control column. It eventually gave an elevator position which was 5.6º beyond the maximum trailing edge up angle that the manufacturer advised would have been necessary to have maintained an average pitch up rate of about 2.5º per second.

The co-pilot was the handling pilot and there had been no sign of any particular trend during his recent training. His performance during that training had been commensurate with that expected of a capable pilot with low hours and limited experience. However, he had not flown for over three weeks before the tailstrike flight, apart from a two day session in the simulator. The operator has since amended his procedures to ensure that newly trained co-pilots receive better flying continuity and that training and line captains are encouraged to give co-pilots feedback on their handling technique.

The commander had been unable to intervene in time to prevent the tailstrike when he noticed the rate of rotation increase. The recorded flight data indicated that there had been a cue from the stagnating airspeed in the last few seconds before lift off, which might also have alerted PNF to the gusty conditions, albeit at a very late stage in the take-off run. The operator subsequently arranged for him to receive some simulator training to address the situation that he had been faced with. The co-pilot also received further training.

The crew's reaction to the tailstrike reflected well on their ability to handle the consequences of the event and, having never flown together before, to co-operate together and with the cabin crew. The aircraft returned to the airport for an uneventful, overweight landing. Appropriate precautions were taken by the crew and airport authorities to guard against the possible danger of overheated brakes before the passengers disembarked from the aircraft.

INCIDENT

Aircraft Type and Registration:	DHC-8-311, G-BRYU
No & Type of Engines:	2 Pratt & Whitney Canada PW123 turboprop engines
Year of Manufacture:	1997
Date & Time (UTC):	20 June 2005 at 1340 hrs
Location:	Aberdeen Airport, Scotland
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 4 Passengers - 28
Injuries:	Crew - None Passengers - None
Nature of Damage:	Hydraulic pipe leak
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	43 years
Commander's Flying Experience:	4,452 hours (of which 853 were on type) Last 90 days - 190 hours Last 28 days - 57 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot. Additional information supplied by National Air Traffic Services and by the Safety Services Department of the Operator

The aircraft commander reported that the passengers were disembarking on arrival at Aberdeen when a member of ground staff was observed making gestures indicating an abnormality in the nose area. On leaving the aircraft to investigate the problem, the commander observed what appeared to be smoke coming from a vent under the right hand side of the nose. He returned to the aircraft, by which time all passengers had disembarked. On re-entering the cockpit, he told the First Officer to alert the AFRS and then to evacuate the aircraft. He entered the cabin and advised the cabin crew to evacuate via the forward exit; he then made sure that all power had been removed from the aircraft before he left.

On arrival at the aircraft the AFRS determined that the smoke had ceased so no extinguishant was used. An engineer then carried out an investigation with the fire services present. Examination revealed that a very small hole in a hydraulic pipe had sprayed fluid into the hot area of the weather radar, producing a fluid vapour similar to smoke. It is understood that the hole was presumed to have resulted from chaffing/fretting as a result of contact with adjacent structure or piping.

At about the time of this incident, a high occurrence rate of hydraulic leaks on the operator's Dash-8 fleet was identified. It was thus decided to issue an Engineering Technical Requirement calling for "Inspection of Rigid and Flexible Hydraulic Tube Installation". The specific work requirement was as follows:

> *"Inspect installation of all rigid hydraulic tubes in the NLG bay, LH and RH nacelles, wing roots and rear fuselage for adequate clearance between pipe-to-pipe and pipe-to-structure".*
>
> *"Inspect installation of MLG brake unit flexible hydraulic tubes"*

This was a repetitive inspection to be carried out at 'A' and 'C' checks. During the six months since these inspections were implemented, only one further hydraulic leak has been reported on the operator's Dash 8 fleet; a total of eight aircraft. This represents a substantial reduction in the previous rate of occurrence.

INCIDENT

Aircraft Type and Registration:	Dornier 328-100, G-BWIR
No & Type of Engines:	2 Pratt & Whitney PW119B turboprop engines
Year of Manufacture:	1995
Date & Time (UTC):	20 February 2005 at 1536 hrs
Location:	London City Airport, London
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 3 Passengers - 26
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	38 years
Commander's Flying Experience:	3,520 hours (of which 3,130 were on type) Last 90 days - 180 hours Last 28 days - 57 hours
Information Source:	AAIB Field Investigation

Synopsis

Shortly after touchdown at London City Airport (LCY), the aircraft veered to the right and departed the runway before the flight crew were able to bring it under directional control. The investigation revealed that a combination of crosswind and asymmetric reverse thrust caused the initial divergence. Because the aircraft was held in a slightly more nose-up attitude than normal, the nose wheel steering (NWS) system did not become enabled. The consequent unavailability of nose wheel steering resulted in the crew not acquiring directional control immediately. Directional control was only gained after the aircraft had departed the runway when differential braking and asymmetric reverse thrust were applied.

History of flight

The crew departed Edinburgh at 1423 hrs to operate the first of a series of four sectors between Edinburgh and LCY. After an uneventful cruise they flew an ILS approach to Runway 28 at LCY with the commander as the handling pilot. Runway 28 has an asphalt surface (which was dry), an LDA of 1,319 m and the ILS glidepath is set at 5.5º. During the final stages of the approach, the tower controller transmitted two consecutive wind checks of 330º/13 kt. Shortly after touching down on the centreline, the aircraft started a veer to the right which the commander could not correct, even with the application of full left rudder pedal. The aircraft departed the runway onto the grass before control was regained, using asymmetric braking and asymmetric reverse thrust. As the speed decayed, the aircraft was steered back onto the runway and taxied to its parking stand. The crew did not notice any Engine Indicating and Crew Alerting System (EICAS) status messages or warnings during the incident.

Following this excursion incident the aircraft was taken out of passenger service for inspection and functional tests. These included ground inspections and, on the following day, a number of crew training flights with particular attention being paid to the propeller controls and the nosewheel steering. Interrogation of the Integrated Avionics Computers showed a transient 'NWS' message but this did not appear to be linked to any mechanical or system failure.

No faults were found and the aircraft was returned to passenger service.

Flight data recorders

The aircraft was fitted with a Solid State Cockpit Voice Recorder (SSCVR) which recorded the last 30 minutes of flight crew speech and cockpit area microphone sounds. Unfortunately the CVR circuit breaker was not pulled after the landing so the CVR recording contained only post-landing cockpit sounds and crew speech.

The aircraft was also fitted with a Solid State Flight Data Recorder (SSFDR) which recorded a large number of flight data parameters and discretes. These included air data and engine parameters and control surface positions but no parameters related to the braking system or nosewheel steering. All of the available flight data was recovered successfully. Over 50 hours of data was recorded.

A time history of relevant flight data parameters for the landing at LCY is shown in Figure 1. The weight-on-mainwheels discretes (there was no weight-on wheels discrete for the nose wheel) were activated when the airspeed was about 93 kt, although it is possible that the aircraft may have touched down momentarily 4 seconds earlier, when there was a large increment in normal acceleration at an airspeed of about 102 kt.

There was a difference in engine torque of the order of 2% (right torque greater than left torque) just after touch-down. As soon as the aircraft touched down, the aircraft started to diverge to the right at a calculated rate of about 1º/sec. Despite the application of full left rudder 1 second after touch-down, the aircraft continued to diverge to the right. It is inferred from the normal acceleration and pitch attitude data that the aircraft left the paved runway about 9 seconds after touch-down. The airspeed at this time was about 48 kt. About 1 second later the turn to the right was arrested and the aircraft started to turn to the left. It is inferred, again from the normal acceleration and the pitch attitude data, that the aircraft regained the paved runway about 18 seconds after touch-down.

It can be seen from Figure 1 that, at about 5 seconds after touch-down, the difference in torque between the left and right engines was reversed (left torque greater than right torque). This difference was of the order of 4% and lasted for about 9 seconds. This is consistent with the crew attempting to control the yawing motion with differential propeller settings. Also, it can be seen that the pitch attitude remained at about 1º nose up during this part of the landing run and that the elevators remained slightly in the nose up sense until the turn to the right was arrested.

A comparison of the pitch parameters during the incident and during the previous landing is shown in Figure 2. It can be seen that the pitch attitude is about 0º during the previous landing and this was also the case for the other previous recorded landings.

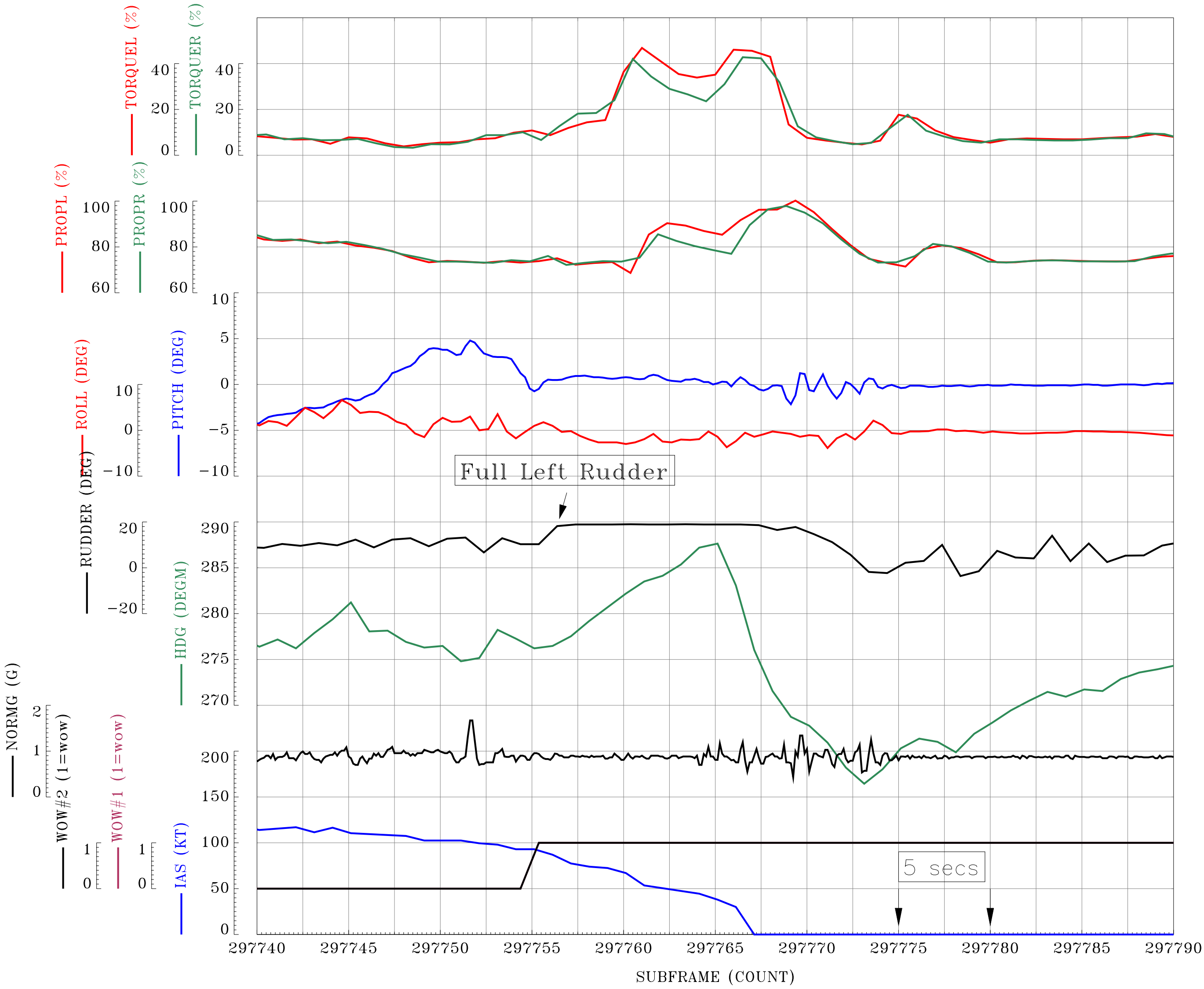


Figure 1

Salient Flight Data Parameters
Serious Incident to Dornier 328, G-BWIR, at London City Airport on 20 February 2005

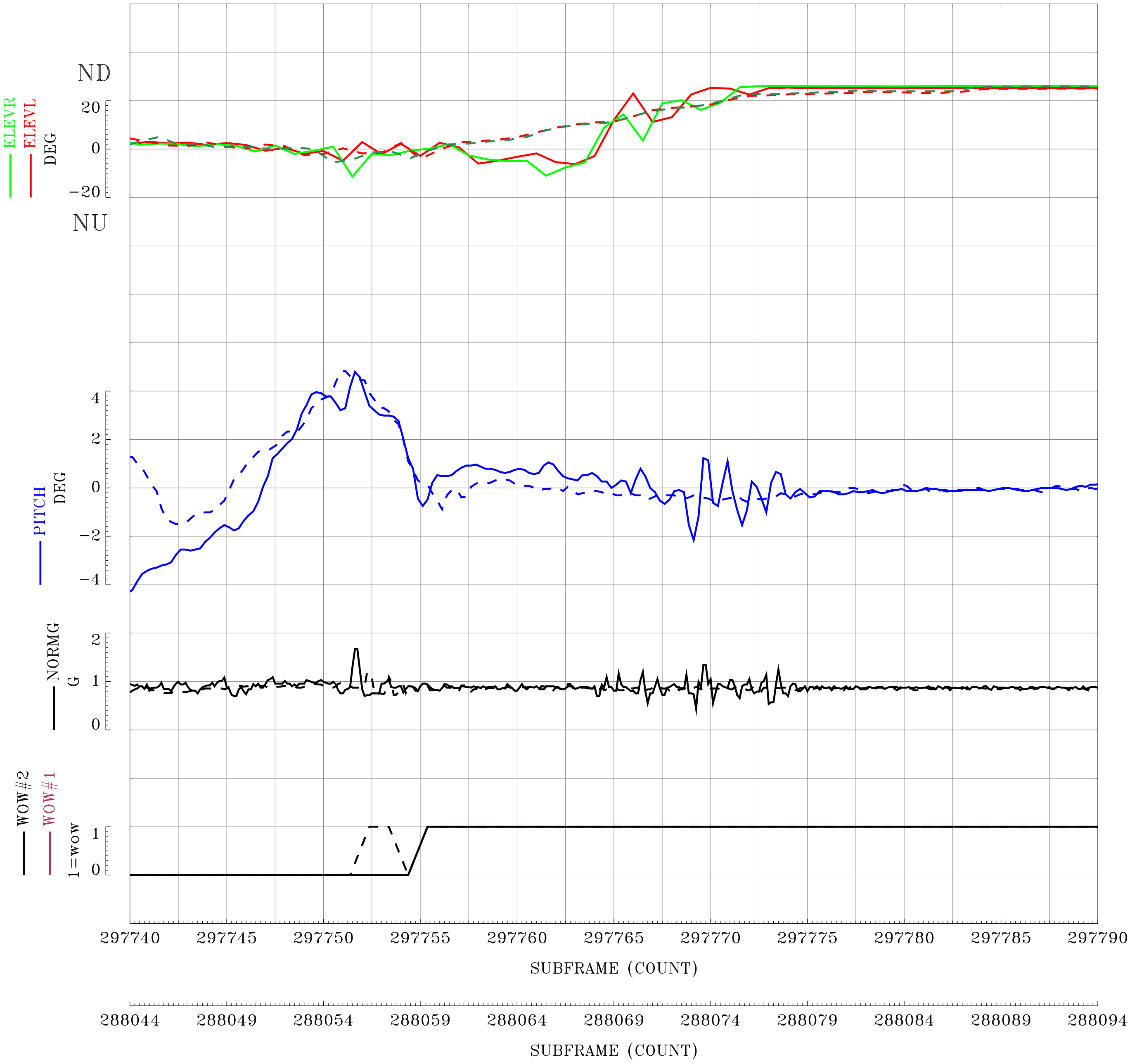


Figure 2

Comparison of Accident Pitch Parameters (solid) with Previous Landing (dotted)
Accident to Dornier 328, G-BWIR, at London City Airport on 20 February 2005

Systems description

On the ground, the Dornier 328 may be steered by a combination of differential braking, aerodynamic yaw control from the rudder and hydraulically actuated nosewheel steering.

Nose wheel steering commands are provided by a combination of pedal input, where full pedal deflections can provide ±10º of steering, and a hand control unit (tiller) located on the left-hand side console. Full deflection of this hand control unit can provide commands of ±60º to the nosewheel steering actuator but this requires the engine condition levers to be at or below the intermediate HIGH TAXI position. With the engine condition levers fully forward, the usual position immediately after landing, there should be no input to the steering actuator from the hand control unit.

The nosewheel steering system has a built-in monitoring function and steering is disabled when the landing gear is retracted after takeoff or if any of the components in the system fail. The system also provides status and failure messages for the crew on the EICAS system. At landing, nose wheel steering is enabled by a timing function 0.5 seconds after the nose leg weight-on-wheels (WOW) switch is closed. This delay of 0.5 seconds is reset each time the nose leg WOW switch becomes open, for instance during a bounce on touchdown.

In common with other turboprop types, the propellers may be operated on the ground in the Beta range, giving reverse thrust and enhanced retardation. Asymmetric application of Beta torque will produce a yawing moment. The effect of this was examined by the aircraft manufacturer during the original type certification tests, with full asymmetry (maximum Beta torque on one propeller and 'ground fine' pitch on the other) at 40 kt and 100 kt. In both tests the data shows that the test crew handled the asymmetry, with a brief yaw excursion of less than 10º, principally with prompt and effective input from the nosewheel steering system up to the 10º available on the pedals.

The primary flying controls of the Dornier 328 for pitch and yaw are simple mechanical systems with direct, unpowered linkages from the control columns to the elevators and from the pedals to the rudder (with assistance, at low speed, from a spring tab). For roll control, the control columns are linked directly to the ailerons and to hydraulically-powered roll spoiler panels outboard on the wing. One effect of the roll spoilers is, with large roll control inputs on the ground, to add a yaw effect in that direction.

Ground marks and tests

The marks from all three landing gears could be traced back to their initial departure from near the runway centreline. The marks showed a progressive departure from the runway heading which was not corrected until the aircraft had left the runway and there were no rubber deposits either to denote heavy differential braking or cycling of the anti-skid system. There were also no indications of nose wheel steering inputs to the left, which would have been expected with the full left pedal deflection shown on the FDR.

As a result of the lack of evidence of nose wheel steering on the runway and the FDR data showing a slight nose-up pitch attitude after touchdown, the AAIB and the operator conducted a series of tests on G-BWIR to examine the sensitivity and ranges of the WOW sensors on all three landing gear legs. This involved jacking the aircraft to unload the landing gear legs, while electronically monitoring the WOW sensors and measuring the pitch attitude with an accurate inclinometer.

The most significant result was that, with the main landing gear legs bearing their normal load, the nose leg WOW sensors became open at 0.6º nose-up. With the main landing gear legs progressively unloaded, the nose-up pitch attitude required to open the nose leg WOW sensors was reduced. The results of these tests fully supported the hypothesis that the lack of nosewheel steering effect during G-BWIR's runway excursion was due to the nose wheel steering system being disabled during this period because of the unloading of the noseleg, by aft control movement, to the extent that the WOW sensors did not detect that the nosewheel was in contact with the runway.

As part of the engineering investigation, the oleo strut from the nose leg assembly was removed and taken to an approved overhaul facility for test and examination. Before disassembly, the oleo strut was subjected to the functional testing normally performed as part of the post-maintenance acceptance test procedure. This showed it to perform within the specified values for a newly-overhauled unit and a strip examination showed no evidence of any unusual wear or other defect.

Company Standard Operational Procedures (SOPs)

The company Operations Manual Part B section 2.19.1 entitled 'Landing Technique' states

> *'When established on final the aircraft should be crabbed into wind as necessary to maintain the runway centreline. Crossing the threshold a transition to the wing down method should be made, touching down on the main wheel on the windward side, keeping the aircraft aligned with the runway centreline. The controls should be displaced to allow smooth contact with the runway as the speed decreases.*
>
> *When landing on a minimum length runway, strict adherence to the correct Vref speed and profile should be observed. Additionally, landing with minimum flare is recommended to make use of the available runway. Apply smooth constant brake pressure after touchdown to achieve the best performance. On slippery runways with the anti-skid functioning use full brake pedal after touchdown –DO NOT ATTEMPT TO MODULATE BRAKING ACTION THROUGH THE PEDALS.*
>
> *Judicious use of reverse thrust will improve landing distance performance. Use reverse carefully on wet or slippery surface. Max thrust reverse should not be used below 60 kt to avoid ingestion. After the handling pilot has selected ground idle, the non-handling pilot should look for the beta lights and call '2 betas' once seen and '60 kt' at which point the handling pilot will call for 'condition levers minimum'.*

Significant aileron inputs are required in a crosswind even with the aircraft on the ground, due to the relatively narrow wheel track of this aircraft. Into-wind aileron activates the roll spoilers on the upwind wing which will aggravate the aircraft's potential to weathercock. After touchdown the nosewheel is lowered and symmetric reverse thrust applied, using the rudder pedals to keep straight. At 60 kt, reducing the condition levers to the HIGH TAXI position activates the tiller (positioned on the commander's side only) which may then be used to steer the aircraft. Although the commander was relatively new in the left-hand seat, he had flown many landings into LCY from the right-hand seat. The company regards both runways at LCY as 'minimum length runways'.

Analysis

The investigation identified four means of directional control on the ground available to pilots on this aircraft; asymmetric thrust, differential braking, nose wheel steering and rudder and these are discussed in turn.

1. The investigation initially focussed on the asymmetric application of torque in the Beta range, there being slightly more reverse torque on the right-hand engine. However, analysis of the FDR data showed that the initial yaw to the right ***preceded*** this application and the manufacturer's certification tests had shown that this asymmetry could be countered by the nosewheel steering system. At about the time that the aircraft left the runway, the commander deliberately set opposite asymmetric power to assist with regaining directional control (more left reverse thrust than right) and this is reflected by the aircraft regaining runway heading. Therefore, whilst the initial reverse thrust asymmetry would have exacerbated the heading divergence, it should not by itself have led to loss of directional control.
2. Differential braking was reportedly used by the commander after the aircraft had departed from the runway and enabled directional control to be established with the aircraft on the grass. It would only be usual to use differential braking after having applied full rudder pedal deflection. At high speeds, differential braking would normally be used only when other directional control means had been exhausted as it can lead to steering overcontrol and can generate high lateral forces.
3. Data from the manufacturer's certification tests show that the initial asymmetric torque could be countered by an effective nosewheel steering system. Therefore a serviceable nose wheel steering system should have enabled directional control, even taking into account the weathercocking effect of the crosswind. That full rudder pedal deflection (and therefore an expected 10º of nose wheel steering) was applied without any consequent directional correction, suggested that the nose wheel steering system had not been activated. This was almost certainly as a result of the noseleg WOW switch not being closed. The results of the WOW sensor test support this conclusion and the recorded flight data suggests that the unusual aircraft nose-up elevator input led to the nose wheel steering not being available.
4. Although full left rudder pedal deflection was attained almost immediately after the aircraft began its right swing, it had no effect on the rate of change of the aircraft's heading for a further 7 seconds. Notwithstanding the ineffectiveness of the nose wheel steering, the lack of aerodynamic effect from the rudder was also surprising, particularly at initial application with the aircraft at relatively high speed. However, anecdotal evidence suggests that this is not uncommon with engines in reverse thrust, as the disrupted airflow across the rudder can significantly reduce its authority.

Although the manufacturer considers that the normal pilot action, after touchdown, would be to relax elevator control, thereby ensuring activation of the nose wheel steering, there is no guidance in the Dornier 328 operator's or manufacturer's literature concerning elevator handling after touchdown. The Bombardier DHC-8-400 uses a similar noseleg WOW switch to enable nose wheel steering activation and that aircraft's flight manual includes the following note in Section 4.4 entitled 'Landing Procedures', *'The nosewheel should be promptly brought into contact with the ground following mainwheel contact'.* Given the implications of the noseleg WOW switch not being closed, the AAIB recommends that similar guidance on post-touchdown elevator handling be promulgated to Dornier 328 operators.

Conclusion

This investigation concluded that, after touchdown, the aircraft veered to the right as a result of the weathercocking effect of the crosswind, exacerbated by a slight asymmetry of the reverse thrust which was initially applied. The failure to gain directional control, immediately, most likely occurred as a result of the non-availability of the nose wheel steering system. The nose-up elevator position during the landing rollout appears to have prevented the noseleg WOW switch being closed, which is a prerequisite for nose wheel steering activation. Directional control was only gained after the aircraft had departed the runway when differential braking and asymmetric reverse thrust were applied.

Safety Recommendation 2005-139

It is recommended that AvCraft, the Dornier 328 type certificate holder, produce guidance to all Dornier 328 operators regarding post-touchdown elevator handling and the implications of the noseleg weight-on-wheels switch not being activated.

INCIDENT

Aircraft Type and Registration:	(i) Embraer EMB-145EU, G-EMBE (ii) Two Mc Donnell Douglas F15E Eagle aircraft
Date & Time (UTC):	27 January 2005 at 1135 hrs
Location:	Between reporting points EBOTO & SIVDA (near Bedford) at FL210
Type of Flight:	(i) Public Transport (Passenger) (ii) Military
Persons on Board:	(i) Crew - 4 Passengers - 35 (ii) Crew - 4 Passengers - None
Injuries:	None
Nature of Damage:	None
Information Source:	AAIB Field Investigation

Synopsis

The aircraft commander reported seeing a military fighter aircraft pass close in front of him whilst his aircraft was cruising on Airway P155 at FL210. The conflicting aircraft was later identified as one of a pair of United States Air Force F15E 'Eagle' aircraft diverting from RAF Lakenheath to RAF Valley. The military aircraft were both low on fuel and were diverting due to poor weather and air traffic delays at Lakenheath. They had climbed above their cleared level and one aircraft passed within 0.53 nm of the aircraft on the airway. It has not been possible to determine the vertical separation during the 'Airprox' encounter.

History of flight

Two F15E 'Eagle' aircraft departed in formation from RAF Lakenheath, Suffolk at 0948 hrs for a close air support training sortie at Otterburn Range which is about 20 nm north-west of Newcastle. Each aircraft was crewed by a pilot and a weapons system officer. The formation commander had the allocated callsign Tahoe 51 and his wingman callsign Tahoe 52. The formation was to operate under the leader's callsign.

The sortie had been planned early that morning and fuel calculations took into account the Allocated Sortie Duration (ASD) of 1.3 hours and the nominated diversion of RAF Valley in Anglesey, Wales. "BINGO" fuel, the lowest fuel load required to return to base from the range and if necessary divert, was 10,000 lb.

On reaching the range the aircraft flew at altitudes between 10,000 and 12,000 ft being guided onto ground targets by ground based forward air controllers. About twenty-five minutes into the exercise Tahoe 52 informed the formation commander that he was approaching "BINGO" fuel. The formation commander decided to reduce "BINGO" fuel to 9,000 lb as he considered that under the prevailing conditions, both aircraft still had sufficient fuel remaining to complete one more run at 20,000 ft during the climb to their cruising altitude for their transit back to Lakenheath. About 10 nm from the target Tahoe 52 informed the formation commander that he was now at the new lower "BINGO" fuel level, but the formation commander decided to complete the run as he estimated that to do so would only burn an additional 200-300 lb in fuel.

Having completed this final run the two aircraft climbed to FL240 and flew in formation towards Lakenheath, at the normal transiting speed of 320 KCAS. Shortly after reaching FL240, Tahoe 52 requested they slow down in order to conserve fuel as his flight management system was indicating that his aircraft would arrive at Lakenheath with 5,800 lb of fuel; the calculated diversion fuel being 6,900 lb. The formation commander judged that fuel could be conserved by carrying out a minimum power descent from their cruising altitude which would result in the aircraft arriving at Lakenheath with sufficient fuel to divert.

Between 75 and 100 nm north of Lakenheath, at about 1105 hrs, the formation commander contacted the SOF[1] at Lakenheath for a weather update. He was informed that the weather was worse than that on departure and was continuing to worsen. The ATIS weather report obtained by the formation commander a few minutes later gave the main cloud base as 1,200 ft aal (above airfield level), but with some cloud at 800 ft aal. Shortly after this, about 50 nm north of the airfield, the aircraft began their minimum power descent at which time Tahoe 52 observed eight other aircraft on his datalink display operating in the Lakenheath area.

Initial contact with Lakenheath ATC was made at 1116 hrs when the aircraft were handed over from London Military Radar to the Lakenheath Approach controller. At this time the aircraft were maintaining their formation in VMC above a layer of cloud. The aircraft were given a radar information service and were cleared to descend to FL070. The formation commander requested an ILS approach in trail to the active runway, Runway 06, and the aircraft were given radar vectors to the east for sequencing. When the formation was given vectors back towards the west the formation commander realised the spacing between the formation and the aircraft ahead had now extended beyond the minimum 10 nm spacing normally required by Lakenheath ATC. The formation was also informed by ATC that: "Arrival is busy".

Concerned by their low fuel state, at 1121 hrs, the formation commander asked ATC what the expected delay would be. ATC replied that there would be "NEGATIVE DELAY" and that they were now being turned onto the downwind leg. Thinking they would shortly be vectored onto the approach the formation commander decided to continue with his intention of landing at Lakenheath, both aircraft then having less than their planned diversion fuel for RAF Valley.

In order to expedite the approach for Tahoe 52, who had less fuel remaining than Tahoe 51, Tahoe 52 took the lead as the formation turned to the west. Tahoe 51 took up a position in trail using his aircraft's radar to maintain a 2 nm separation. Tahoe 52 then took it upon himself, without discussion with the formation commander, to take over the formation's radio transmissions with ATC. As a result of the change in lead aircraft, ATC also instructed Tahoe 52 to take over the formation squawk of 0407 on his transponder, at the same time instructing the formation commander to turn his transponder to standby. These instructions were acknowledged by the two pilots.

At 1122 hrs the formation requested, and were given, a radar advisory service in anticipation of going IMC

Footnote

[1] Supervisor of Flying: a pilot or weapon system officer in the control tower passing operational information to crews on a different UHF frequency to ATC.

as they continued their descent towards the cloud layer covering the Lakenheath area. At about this time the formation commander also requested an update on the latest airfield weather conditions from the SOF who reported a pilot observed cloudbase of between 300 and 500 ft aal.

The formation commander had expected to be turned by ATC onto a closing heading for the ILS by the time the aircraft were 13 nm west of the airfield, however the vectors given took them about 30 nm west. As a result he again questioned the expected delay with ATC and at 1127 hrs mentioned for the first time the possibility of having to divert to RAF Valley. Approach replied that they would be turned in another 5 nm and handed them over to the Lakenheath Arrival frequency. The formation checked in with Lakenheath Arrival at 1128 hrs and were given a vector back towards the airfield and clearance to descend to an altitude of 3,000 ft. ATC now reported that the aircraft were under a radar information service, the aircraft having been under a radar advisory service at the time they were handed over. This change was not questioned by either aircraft.

Listening to the radio transmissions between ATC and other aircraft on the Arrival frequency the formation commander became aware that the aircraft ahead of them was an F15E. This aircraft was following an F15C which was on finals. The F15E was only 6 nm behind the F15C, which was less than the 10 nm minimum separation required by Lakenheath ATC. The formation commander was aware that the F15E has an approach speed of about 180 kt whereas the lighter F15C has an approach speed of about 150 kt and that the gap between them was therefore likely to close. He expected that it was likely that the following aircraft would have to go around and he was then also aware of a different aircraft going around due to the weather. He stated that all this indicated to him that ATC were under pressure. The formation commander called the SOF for another update and was advised that the cloudbase was now 300 ft aal and reducing; the SOF recommended that the formation divert to RAF Valley.

At 1129 hrs Tahoe 52, as instructed by the formation commander, advised ATC that the formation was diverting to RAF Valley and that it was turning onto a heading of 291º. The aircraft were now about 25 nm west of Lakenheath, passing an altitude of about 5,000 ft in the descent. Tahoe 52 had about 5,000 lb of fuel on board and the formation commander about 5,500 lb.

ATC asked for the call to be repeated. The formation commander informed Tahoe 52 that he, the formation commander, would now make the formation's ATC calls and informed ATC that the formation would be turning onto a heading of 300º. He also requested a hand over to London Military Radar. Although it was not discussed between the aircraft, Tahoe 52 maintained the formation squawk of 0407. The formation commander then used his auxiliary radio to instruct Tahoe 52 to carry out a climb at maximum 'dry' power to FL240. Seconds later Lakenheath Arrival instructed:

Arrival:	"TAHOE FIVE ONE CLIMB AND MAINTAIN FLIGHT LEVEL TWO THREE ZERO STAND-BY FOR CO-ORDINATION"
Tahoe 51:	"WILCO"

Then, using the auxiliary radio, the formation commander instructed Tahoe 52 to check his fuel load and requirements for the diversion. No mention was made of their cleared flight level nor his previous instruction to climb to FL240, although he did inform Tahoe 52 that he intended to request airways crossing clearance at FL300.

The formation commander also commenced climbing, at a rate of about 5,000 ft/min, and was aware of controlled airspace above his aircraft at FL195 from his avionic displays . He was increasingly concerned about the fuel state of Tahoe 52, who was by now about 5 nm ahead and to the west of his own position. The formation commander made several calls to Lakenheath Arrival to get a hand over to London Military Radar (callsign 'London Mil') for airways crossing clearance, which was more and more urgently needed due to their position. The first of these calls was at 1130 hrs:

Tahoe 51:	"ARRIVAL WOULD YOU PASS TO LONDON THAT WE'RE GONNA BE CLIMBING TO FLIGHT LEVEL THREE HUNDRED REQUESTING TO CROSS THE AMBERS AT FLIGHT LEVEL THREE HUNDRED"
Arrival:	"TAHOE FIVE ONE UH…. CORRECTION MAINTAIN FLIGHT LEVEL ONE FIVE ZERO EXPECT HIGHER WITH LONDON"
Tahoe 51:	"ROGER WOULD YOU PASS THAT MESSAGE TO LONDON PLEASE"
Arrival:	"TAHOE FIVE ONE WILCO"

The aircraft were by then climbing through FL 120.

At 1130:19 hrs the process of arranging a handover to London Military was begun through telephone conversations between the London Military allocator and the Lakenheath coordinator. Within 20 seconds, a London Military controller had been allocated to handle the "un-pre-noted UHF handover". The London Military controller asked the Lakenheath coordinator to instruct the formation to squawk 6143 for identification. This was acknowledged by the Lakenheath coordinator but the conversation about the formation's requests and intentions continued for about another 40 seconds, interspersed with and interrupted by several messages between aircraft and the Lakenheath Arrival controller. At 1131:33 hrs the Lakenheath Arrival controller informed the formation that their handover to London Military had been arranged. The formation was instructed to turn onto a heading of north and to call London Military on 254.825 MHz. The 6143 transponder code acknowledged by the Lakenheath coordinator was not communicated to the formation.

Radar records showed that by this time Tahoe 52 was in the climb passing FL160. The frequency change to 254.825 MHz was correctly read back by the formation commander and he instructed his wingman to change to that frequency. However, the wingman did not acknowledge the leader's instruction so a few seconds later, using the aircraft's auxiliary radio (on a private frequency), Tahoe 51 then transmitted "TAHOE FIVE TWO COME UP TWO FIVE FOUR **ZERO** TWO FIVE" (instead of 254.**8**25 Mhz). None of the crew in either aircraft noticed the mistake and the formation commander attempted to make contact with London Military on the incorrect frequency. Radar records show that at this time the Mode C squawk being transmitted by Tahoe 52 for the formation disappeared.

Unable to get a reply to his transmissions, the formation commander instructed Tahoe 52 to select a pre-set frequency and the formation made contact with London Military at 1132:20 hrs:

Tahoe 51:	"LONDON MIL TAHOE FIVE ONE"
London Mil:	"TAHOE FIVE ONE LONDON MIL PASS YOUR MESSAGE"
Tahoe 51:	"ROGER M'AM WE ARE FUEL DIVERT OFF OF LAKENHEATH DIRECT TO VALLEY I NEED CLIMB UP TO FLIGHT LEVEL THREE

	"HUNDRED OR THREE ONE ZERO DIRECT TO VALLEY FOR FUEL"
London Mil:	"TAHOE FIVE ONE CONFIRM YOUR LEVEL PASSING"
Tahoe 51:	"ROGER MA'AM I'M AT TWO ZERO SEVEN AND I'D LIKE TO CLIMB UP TO FLIGHT LEVEL THREE HUNDRED"
London Mil:	"TAHOE FIVE ONE AVOIDING ACTION TURN RIGHT HEADING NORTH TRAFFIC BELIEVED TO BE YOU...YOU HAVE TRAFFIC EAST THREE MILES AT FLIGHT LEVEL TWO ONE ZERO"
Tahoe 51:	"ROGER I BELIEVE...I'VE GOT MY WINGMAN WITH ME AS WELL YOU MIGHT SEE HIM"
London Mil:	"TAHOE FIVE ONE SQUAWK SIX ONE FOUR THREE WHAT TYPE OF RADAR SERVICE DO YOU REQUIRE"

At this time Tahoe 52 was approximately 5 nm north-west of Tahoe 51 at an unknown altitude. Also at this time London Area Control Centre received a radio transmission from the captain of a civil Embraer 145 flying at FL210 from west to east along Airway P155 in the area of the two military aircraft. The captain informed ATC that they had just seen an F15 aircraft pass the nose of their aircraft about one hundred feet below and "no more than about two hundred yards ahead, descending".

Meanwhile the formation commander of the military aircraft was still in conversation with the London Military controller:

Tahoe 51:	"SIX ONE FOUR THREE I WOULD LIKE RADAR CONTROL AND WE SAW CIVIL TRAFFIC OUR APOLOGIES THERE AND WE WOULD LIKE TO CLIMB UP TO FLIGHT LEVEL THREE ZERO ZERO"

London Mil:	"TAHOE FIVE ONE NEGATIVE MAINTAIN YOUR LEVEL UNTIL IDENTIFIED"
Tahoe 51:	"TAHOE FIVE ONE IS GOING TO SQUAWK EMERGENCY MA'AM WE HAVE EMERGENCY FUEL DIVERT FOR TAHOE FIVE TWO WHO IS WITH US WE NEED TO CLIMB TO THREE ZERO ZERO IF THAT WOULD HELP YOU BETTER WE WOULD LIKE TO GO AHEAD AND SQUAWK EMERGENCY NOW"
London Mil:	"TAHOE FIVE ONE AFFIRM SQUAWK EMERGENCY"

The time of this transmission corresponds with the re-appearance of secondary data on radar for both Tahoe 51 and Tahoe 52, the formation commander now positioned about 10 nm to the east of his wingman flying on a divergent track. Both aircraft levelled shortly afterwards at FL230.

The formation commander pressed ATC for a climb to FL300 which was denied due to conflicting traffic. The formation commander then asked London Military if there was a suitable airfield with good weather for them to divert to on the eastern side of the country, suggesting the military airfields at Cottesmore and Waddington. The controller was at this time on the telephone trying to arrange a hand over of the aircraft to Swanwick Military. Due to the loud volume of the telephone she misheard the transmission as a request to divert to Cottesmore. A further request by Tahoe 51 for the anticipated delay before they could climb was also misheard by the controller as a request to climb. Tahoe 51 made a further request for the weather at Cottesmore or Waddington but the request was not answered. Instead Tahoe 51 was asked to confirm he was the lead aircraft to which he replied that he was and that his wingman was to the west of him. London Military then gave clearance to climb:

London Mil:	"TAHOE FIVE ONE CLIMB NOT ABOVE FLIGHT LEVEL TWO FOUR ZERO MAINTAIN YOUR LEVEL TAHOE FIVE TWO MAINTAIN FLIGHT LEVEL TWO THREE ZERO YOU'RE CO-ORDINATED AGAINST CIVIL TRAFFIC ON THE AIRWAY"
Tahoe 52:	"TAHOE FIVE TWO FLIGHT LEVEL TWO THREE ZERO AND LOOKING FOR CLIMB AS SOON AS POSSIBLE"
London Mil:	"TAHOE FIVE ONE FLIGHT CONTACT SWANWICK MIL TWO SEVEN FIVE DECIMAL THREE FIVE"
Tahoe 51:	"TWO SEVEN FIVE DECIMAL THREE FIVE TAHOE FIVE ONE PUSH"

Both aircraft then switched frequency to Swanwick Military:

Tahoe 51:	"LONDON MIL TAHOE FIVE ONE EMERGENCY AIRCRAFT FOR FUEL REQUESTING THREE ZERO ZERO DIRECT VALLEY"
Swanwick Mil:	"TAHOE FIVE ONE SWANWICK MIL IDENTIFIED CLIMB FLIGHT LEVEL THREE ONE ZERO RADAR CONTROL REQUEST YOUR HEADING"
Tahoe 51:	"ROGER MA'AM THE HEADING WILL BE TWO NINE ZERO"
Swanwick Mil:	"TAHOE FIVE ONE COPIED TAHOE FIVE TWO ARE YOU ON THIS FREQUENCY"
Tahoe 52:	"TAHOE FIVE TWO AFFIRMATIVE WE'RE PASSING TWO FOUR ZERO FOR THREE ONE ZERO"
Swanwick Mil:	"TAHOE FIVE TWO NEGATIVE MAINTAIN YOUR CURRENT ER LEVEL FLIGHT LEVEL TWO FOUR ZERO REQUEST YOUR HEADING AND CONFIRM YOU'RE AN EMERGENCY AIRCRAFT AS WELL"

Tahoe 52:	"TAHOE FIVE TWO IS UNABLE WE ARE EMERGENCY AIRCRAFT CLIMBING TO THREE ONE ZERO AT THIS TIME ER WE ARE HEADING THREE ZERO ZERO DIRECT VALLEY"
Swanwick Mil:	"TAHOE FIVE TWO THAT'S UNDERSTOOD BOTH AIRCRAFT EXPEDITE CLIMB FLIGHT LEVEL THREE ONE ZERO MAKE YOUR HEADING TWO NINE ZERO BOTH AIRCRAFT ARE NOW UNDER RADAR CONTROL"

Both aircraft then climbed to FL310 and continued towards RAF Valley. During their transit Swanwick Military questioned Tahoe 52 to confirm that the aircraft also had a fuel emergency. The controller then confirmed the relative position of both aircraft and that each callsign was now that of a single aircraft and not a formation.

Four minutes after being cleared to climb to FL310, Tahoe 52 informed Swanwick Military that he was beginning his descent for RAF Valley. The reported cloudbase over the airfield was 1,300 ft with a visibility of 30 km. Both aircraft were guided onto precision radar approaches to Runway 32 at RAF Valley and made successful landings. Tahoe 52 had a low fuel warning approximately 40 nm from the airfield and landed with 1,100 lb of fuel remaining. Tahoe 51 landed slightly behind Tahoe 52 with 2,000 lb of fuel onboard.

Weather

Weather information at Lakenheath was provided by USAF meteorological resources. The Terminal Approach Forecast (TAF) for Lakenheath available at the time the flight was planned was as follows:

EGUL 270404 36010KT 9999 VCSH SCT020 BKN030 OVC050 QNH3026INS

TEMPO 0410 36010G15KT 9999 -SHRA BKN015 OVC030 BECMG 0910 35010G15KT 9999 -SHRA FEW020 BKN030 OVC050 QNH3023INS BECMG 1516 34010G20KT 9999 -SHRA FEW010 BKN0

The TAF had been updated by the time the aircraft began their return from Otterburn range to:

EGUL 271004 36010KT 8000 -DZ FEW006 BKN010 OVC025 QNH3023INS TEMPO 1114 3200 -DZ BKN007 OVC015 BECMG 1516 34010G20KT 9999 –RA FEW010 BKN020 OVC050 QNH3020INS BECMG 1920 35010G20KT 9999 –RA BKN010 OVC030

The actual conditions (METAR) for Lakenheath at the time of takeoff were:

EGUL 270955Z 36007KT 8000 DZ BR FEW006 BKN018 OVC027 06/03

The actual conditions (METAR) at Lakenheath when the aircraft began their return flight from Otterburn range were:

EGUL 271055Z 00008KT 5000 -DZ BR SCT008 BKN010 OVC015 05/04

The formation commander also stated that the aircraft experienced a tail wind component of 40 to 50 kt during their return transit to Lakenheath.

The METARs for RAF Cottesmore and RAF Waddington at the time of the diversion were:

RAF Cottesmore:

EGXJ 271050Z 36010KT 9999 -RADZ SCT005 OVC008 05/05 Q1027
EGXJ 271150Z 35010KT 2300 DZ SCT003 OVC006 05/05 Q1026

RAF Waddington:

EGXW 271050Z 34007KT 2500 -RADZ BKN004 OVC014 06/05 Q1027

EGXW 271150Z 34009KT 9000 -DZ SCT004 BKN008 OVC015 06/06 Q1026

Aircraft description and operating procedures

The F15E is a twin-engined fighter ground attack jet aircraft operated by a pilot and a weapons systems operator. The aircraft are operated in the UK by the United States Air Force at various bases, including Lakenheath in Suffolk. The F15C is a lighter, single seat fighter version of the aircraft.

The aircraft involved in this incident were equipped with a datalink which allowed the position of all aircraft operating the system to be shown on a display selectable by either crew member. In addition, they were equipped with radar capable of identifying the position of other aircraft. They were also fitted with an auxiliary radio which allowed communication between the two aircraft on a discrete frequency.

Fuel consumption is dependent on numerous factors but estimated figures for the aircraft involved in this incident indicate a fuel burn of between 7,000-10,000 lb/hr in the cruise and for the range exercise, reducing to 1,500 lb/hr in the idle descent. Standard operating procedures state a minimum required fuel quantity on landing of 1,200 lb and the declaration of an emergency fuel state when a landing at 800 lb or less is predicted. Tables carried by the aircrew gave a planned diversion fuel requirement for RAF Valley from Lakenheath of 6,900 lb and a 'SNAP' diversion[2] requirement of 3,200 lb plus landing fuel (approximately 1,000 lb).

The formation commander had an A category instrument rating which allowed an approach to the published minimums, which for Runway 06 at Lakenheath were 200 ft aal and 800 m RVR. The wingman had a cat B instrument rating which allowed an approach to 300 ft aal and 1 nm (1854 m) RVR.

Radar data

Civilian air traffic control radar recordings were obtained covering the time of the incident. They show that at 1131 hrs the formation began squawking the emergency Mode A code 7700 with a concurrent Mode C altitude of 16,800 ft. Twenty five seconds later both the Mode A and C squawks disappeared, the last Mode C altitude recorded being 18,500 ft. The Mode A emergency squawk 7700 then reappeared 1 minute and 21 seconds later concurrent with a Mode C altitude of 22,400 ft.

The recordings showed a minimum lateral separation between Tahoe 52 and the Embraer 145 of 0.53 nm and a minimum lateral separation between Tahoe 51 and the Embraer 145 of 1.18 nm. No Mode C altitude information is displayed for either of the military aircraft during this period and it has not been possible to verify the minimum vertical separation.

Footnote

[2] The SNAP diversion fuel is that required to fly direct from runway to runway in still air at the optimum altitude, arriving overhead the destination at 1,000 ft with zero fuel remaining. In practice, the fuel required to divert is greater to allow sufficient fuel for an approach and landing with a minimum fuel remaining of 800 lb on touchdown.

Analysis

When the crews carried out their fuel planning the weather conditions for Lakenheath were forecast to deteriorate with temporary light showers and a cloudbase of 1,500 ft predicted for around the time of their return. However when they took off the weather conditions were already worse than forecast with drizzle, mist and a cloudbase as low as 600 ft in parts. The worse than forecast conditions were reflected in the updated forecast promulgated later that morning but it was not available until after the two aircraft had departed.

The formation commander stated he had wished to remain at the range as long as possible in order to make use of the unusual opportunity presented by the presence of ground controllers at the range. Once his wingman had called at 'BINGO' fuel the formation commander had used his experience to re-calculate the minimum fuel required. This was done in the knowledge that fuel would be saved due to the tail wind on their return flight and by carrying out a minimum thrust descent, but importantly also under the misconception that there would be no problem with the weather on their return and that they would not be delayed by other aircraft trying to land. As a result Tahoe 52 had significantly less than the required fuel when the formation began its transit back to Lakenheath.

The request by Tahoe 52 to slow down in order to conserve fuel during their return was rejected by the formation leader because he was concerned that by doing so they would not complete the flight within the ASD. The ASD forms part of the flying hour program, a system allocating time to sorties in order to ensure that all squadrons were provided with sufficient flying time to complete their annual training requirements. Had this ASD been overflown then the system would have required a cut in the duration of another sortie. The formation commander had another flight that afternoon and did not wish to reduce its duration by exceeding the ASD in the morning, nor did he want the additional time to be deducted from a colleague's sorties instead.

The formation commander considered they were also unable to conserve fuel by flying at a higher altitude as this would have put the aircraft into upper airspace and therefore under radar control, with any vectors imposed outweighing the benefit of any fuel saving at this altitude.

It was quite normal for the wingman in a formation to use more fuel than the formation leader due to the necessity to manoeuvre more in order to maintain position. In this incident, whilst the main fuel problem existed with Tahoe 52, the formation commander was also below his required fuel state during the return transit.

By the time the formation was about 50 nm from Lakenheath the formation commander was aware of the worse than expected weather conditions, including the fact that the cloudbase was now as low as 800 ft. Futhermore, he was aware that there were eight other aircraft operating in the area of the airfield. The formation commander however continued to believe that the aircraft would be able to land at Lakenheath despite the conditions and their low fuel state. The pressure started to increase when the formation was given extended radar vectors by ATC in order to provide adequate spacing between aircraft recovering to the airfield. This had not been anticipated by the formation commander and he received conflicting information from ATC as to the extent of the delay. Crucially, ATC had responded at one point that there would be "negative delay" and this contributed to his continuing view that they would have adequate fuel to land at Lakenheath.

It appears that Lakenheath ATC were under pressure due to the deteriorating weather. Their requirement to maintain a 10 nm separation between landing aircraft (excepting those within the same formation) provided protection of approach aids for aircraft carrying out instrument approaches. The formation commander considered the reduced separation of 6 nm between his wingman and the F15C was likely to lead to a go-around. He decided to divert when he heard another aircraft go around at the same time as the SOF advised that the cloudbase was at 300 ft aal and reducing.

When the formation elected to divert, Tahoe 52 had 1,900 lb less than the planned diversion fuel of 6,900 lb and only about 1,000 lb above the SNAP diversion fuel requirement. Tahoe 51 had an additional 200 lb of fuel on board. It is understandable, therefore, that foremost on their minds was the need to divert to RAF Valley without further delay, by the most direct route and at a suitably high altitude in order to conserve the remaining fuel. Communications taking place between the two aircraft at this time are unclear but they appeared to have ceased operating as a formation, both aircraft setting off on different tracks and soon becoming separated by several miles.

The handover to London Military took one minute to arrange during which time the formation commander had instructed Tahoe 52 on the auxiliary radio to climb to FL240 followed by Lakenheath ATC instructing both aircraft to climb to FL230, later corrected to FL150. None of the replies to these transmissions included the cleared level in the read back, a fact that went unchallenged. Despite replying to the transmission correcting their cleared level to FL150, by the time the aircraft were handed over to London Military Tahoe 52 was already passing FL160 in the climb and both aircraft continued until level at FL230, suggesting the clearance was either misunderstood or ignored.

The formation commander then mistakenly selected the wrong frequency when handed over to London Military. He thought this might have happened as the frequency selection keypad had the '8' button positioned immediately above the '0' button. However, his mistake was not corrected by the other three flight crew. The resulting delay in having to free call another frequency and then getting the aircraft identified on radar meant that the controller had insufficient time to provide adequate separation between the two military aircraft and the commercial aircraft on the airway.

London Military's attempt to identify the two F15E aircraft was complicated by the fact that on handover neither of them was displaying any secondary radar information. The decision by Tahoe 52 to stop transponding was possibly linked to the fact that Tahoe 51 had resumed responsibility for making the radio calls. Equally, no information was provided explaining why Tahoe 52 had taken over the radio calls during the approach into Lakenheath, except that at the time this happened he had just become the lead aircraft. Certainly it would appear that Tahoe 52 did not inform the formation commander of his intentions or actions on either occasion. The re-appearance of the Mode A and Mode C squawks on both aircraft coincided with the formation leader's request to ATC to squawk emergency.

Comments received raise concerns about the fact that the secondary radar data disappeared as the aircraft entered controlled airspace and only re-appeared once the aircraft had cleared the airway. From the radio transcripts this does not appear to have been intentional on the part of the pilots. In addition it has been suggested that the disappearance was due to a failure of the ground radar, however because the secondary data from the F15E disappeared on more than one ground radar but other aircraft were unaffected, this does not seem to be the case. The absence of the secondary data, through whatever cause, effectively disabled both the ground radar's short term conflict alert and the Embraer 145's TCAS, representing a serious loss in conflict warning and resolution ability for all the aircraft and ATC.

Because Mode C data from the F15E aircraft was not available when the controller warned of the potential conflict, it has not been possible to determine which of the two F15s was seen by the crew of the commercial aircraft. The controller's comment that the conflicting traffic was to the east seems incorrect, whether the comment referred to Tahoe 51 or Tahoe 52, because for both aircraft the commercial traffic was approaching from the west. Reports filed by the military pilots state that the commercial aircraft was not seen at all by Tahoe 52 and that when seen by Tahoe 51, the commercial aircraft was about 1,000 ft below at a range of about 1 to 2 nm. The Embraer 145 commander's view that the F15 seen was only 200 yards away would suggest that he saw Tahoe 52, the closer of the two aircraft, although his impression that the F15 was descending seems to be incorrect.

When asked whether he was aware of the airway, the formation commander stated that he was but that he believed he would have been to the north of it by the time he had climbed through its level. He also stated that he was busy looking out and so was paying little attention to his airborne radar or navigation display and that the systems operator was busy reprogramming the navigation computer for their diversion. This might explain why neither military pilot claimed to have seen the Embraer 145 on their radars. Information available suggests that the formation commander was working particularly hard to try and rectify a rapidly worsening situation, with little evidence of help from the other crew members in the formation.

Once the F15s had cleared the conflicting traffic, the controller had the task of identifying each aircraft, confirming the full nature of each one's emergency and trying to hand them over to Swanwick Military in order to clear them for further climb. The difficulty in doing so was compounded by trying to ascertain whether the callsign "Tahoe 51" related to a single aircraft or to a formation, and why Tahoe 52 was now ahead by some 10 nm and flying on a different track. This was complicated still further by the audio volume of the landline used in trying to co-ordinate a handover and the pressing need of the aircraft to continue their climb in order to conserve fuel. As a result the formation commander's attempt to select a closer diversion was, in the end overlooked, although the weather at both RAF Cottesmore and Waddington appears to have been unsuitable.

The confusion was not restricted to ATC, who were by then treating both aircraft as single callsigns. When Tahoe 51 was cleared to climb to FL300, Tahoe 52 also began a climb despite being miles away and cleared only to maintain FL230. Finally, ATC were able to provide the necessary clearance to both aircraft to climb to their required level and there seems to have been no further reported problems during their recovery into RAF Valley.

Previous events

In carrying out this investigation it has become apparent that there have been previous incidents involving loss of separation between aircraft due to confusion between ATC and military aircraft operating in formation. In particular the AAIB carried out an investigation (Ref: EW/C2000/11/05) in November 2000 in which an Airprox occurred between a civilian airliner in controlled airspace and an F15E. This investigation made recommendations about radio and secondary radar procedures for military aircraft transiting in formation. As a result, military aircraft within the UK are required to fly within 100 ft vertically and 1 nm horizontally of each other when operating as a formation, using one callsign and one transponder only.

A further incident was highlighted (Airprox Report No 102/02) in which an RAF Jaguar aircraft pulled up from low level in order to conserve fuel when returning to base at minimum fuel level without first being identified by ATC. This too resulted in an Airprox with a civilian airliner.

Conclusion

On departure from Lakenheath there was cloud significantly lower than the 1,500 ft forecast lowest cloud for the time of take-off in the TAF issued to the crews to plan their mission. This unforecast weather deterioration could have been assessed as reinforcing the plan to depart Otterburn with Valley diversion fuel. However, the incorrect assessment of the weather conditions for the aircrafts' return led to their departure from Otterburn range with less than the planned diversion fuel requirements, but sufficient fuel for a 'SNAP' diversion.

The decision to divert due to the unforecast poor weather and extended ATC vectoring encountered on their return was left too late. The formation commander continued in the hope that they would be able to land at Lakenheath despite their obviously low fuel state, delayed approach and deteriorating weather. This in turn resulted in an extremely high workload for the crews, in particular for the formation commander.

Lakenheath ATC's shortfall in not communicating the transponder code change requested by London Military contributed to the subsequent radar identification problems near civil controlled airspace. Moreover, working under pressure, the formation commander instructed the wingman to switch to the assigned frequency for London Military. Then, on not receiving the appropriate acknowledgement from his wingman, he inadvertently instructed him to change to the wrong frequency using an auxiliary radio. This confusion delayed the handover of positive control between Lakenheath and London Military at a crucial stage of the diversion. Most notably, because they were critically short of fuel, the aircraft climbed through their cleared flight level, without transponding, entered controlled airspace and conflicted with the Embraer 145.

Inadequate transmission and acknowledgement of clearances within the formation plus the crews' inability to fly either as a coherent formation or as two independent aircraft during the diversion were major contributory factors to the ensuing general confusion. Also, poor use was made of the highly sophisticated aids available to the crews in monitoring fuel loads, monitoring ground position and using airborne radar. Whilst it is accepted that aircraft such as the F15E necessarily operate at times close to their minimum fuel requirements, this places an even greater emphasis on the need to make early decisions when a deteriorating weather situation makes a diversion more probable. This is especially so when the diverting aircraft are required to negotiate some of the UK's busiest areas of civil controlled airspace.

ACCIDENT

Aircraft Type and Registration:	Fokker 50, OO-VLQ
No & Type of Engines:	2 Pratt and Whitney 125B turboprop engines
Year of Manufacture:	1989
Date & Time (UTC):	25 August 2005 at 2058 hrs
Location:	Cardiff Airport, South Glamorgan
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 3 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Port wingtip and three feet of leading edge damaged
Commander's Licence:	Dutch Air Transports Pilot's Licence
Commander's Age:	39 years
Commander's Flying Experience:	9,000 hours (of which 5,500 were on type) Last 90 days - 180 hours Last 28 days - 50 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot, reports submitted by the handling agent and further enquiries by the AAIB

Synopsis

Having landed on Cardiff Airport's Runway 30 and vacated the runway at E1, the empty aircraft was being taxied onto Stand 3, under the guidance of a marshaller, when its left wing tip collided with the end of West Pier on the Domestic Passenger Terminal. It was dark at the time and the taxiway surface was wet. This was the only stand available due to airport congestion.

History of events

The aircraft could not be parked nose-in on a stand because the handling agent did not possess a tow bar for this type of aircraft to enable a normal push back to be carried out. The marshaller stated that he was asked, by the apron controller, to marshal the aircraft onto Stand 3 facing out, 180º from the normal nose-in alignment. The marshaller added that he would normally have another colleague to assist him in monitoring the aircraft's wing tip however; there were no other members of staff available at the time.

As the marshaller brought the aircraft towards the West Pier, in an easterly direction, he signalled to the aircraft to turn to the right in order to manoeuvre the aircraft onto the stand's yellow line. The aircraft then continued forward before starting the right turn and its right wing tip then hit the end of the West Pier (see Figure 1).

Figure 1
Aircraft position immediately after impact

The apron controller stated that he asked the marshaller to park the aircraft through the stand with the wings over the yellow line, 90º off the norm. He added that he was not aware that a tow bar might be available from another handling agent and that he did not enquire to see if one might be available. A tow bar for this type of aircraft was available from another handling agent at Cardiff Airport.

The aircraft dispatcher was standing at the end of the West Pier to wait for the aircraft to come onto Stand 3 (see Figure 2 for a plan of the stands). As the aircraft was being brought along the edge of adjacent Stand 2, he was not unduly alarmed by the approaching aircraft as he thought the marshaller was going to turn the aircraft quite late in order to line it up with the line on Stand 3, as this was common practise. When the aircraft was about 10 ft away he realised that there was a problem. He shouted "Stop" and crossed his arms to indicate stop to the marshaller but the aircraft's wing tip then hit the pier near to where he was standing. He was struck on the head by a small piece of plastic from the left wing tip navigation light covering, sustaining no injury.

The dispatcher and the marshaller both stated that they felt the speed of the aircraft may have been excessive for an empty aircraft. They also felt that the pilot may have been unaware of the apron layout because the aircraft operator is not a regular user of Cardiff Airport.

The aircraft commander stated that he was taxiing at normal speed. He reported that he thought he was going to park on Stand 3 facing out, as indicated by the marshaller.

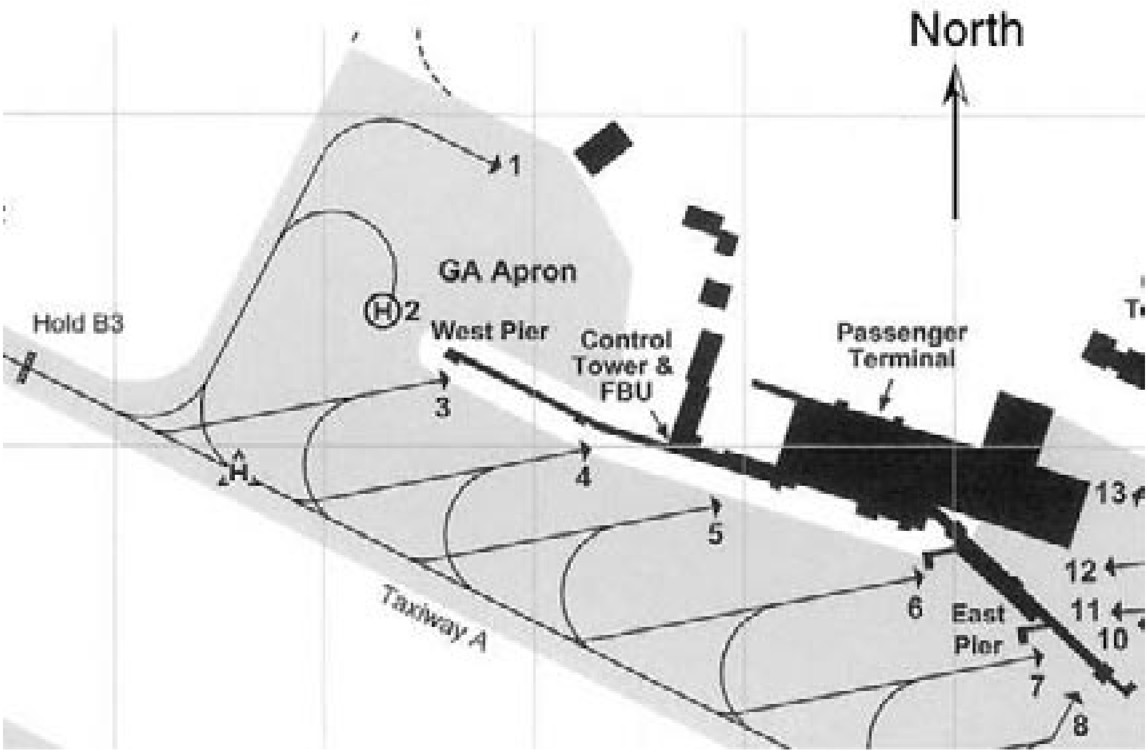


Figure 2

Extract from Cardiff Airport AIP chart

When instructed by the marshaller he immediately initiated a right turn, following the marshaller's instructions precisely. The aircraft's left wing tip then hit the building. He added that due to spotlights on top of the West Pier shining towards him, he found it hard to determine his distance from the building.

The resulting damage was a broken wing tip light and a three foot long dent to the leading edge of the left wing.

INCIDENT

Aircraft Type and Registration:	Jetstream 4100, G-MAJA
No & Type of Engines:	2 Garrett Airesearch (Honeywell) TPE331-14HR-802H Turboprop engines
Year of Manufacture:	1994
Date & Time (UTC):	29 June 2005 at 1523 hrs
Location:	Manchester Airport, Manchester
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 3 Passengers - 10
Injuries:	Crew - None Passengers - None
Nature of Damage:	Nil
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	50 years
Commander's Flying Experience:	3,270 hours (of which 1,310 were on type) Last 90 days - 275 hours Last 28 days - 52 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft departed from Hamburg Airport with an overloaded baggage compartment and with the centre of gravity outside the aft limit of the operating company's approved aircraft flight envelope, although it was within the manufacturer's less restrictive envelope. On landing at Manchester Airport in benign weather conditions, an oscillation in yaw developed which the pilot was unable to correct through use of the rudder or nose wheel steering (NWS). After several cycles the oscillations rapidly became divergent and the aircraft veered off the runway, coming to a halt on the grass approximately 80 m from the runway centreline.

History of the flight

On the morning of the incident, the commander and first officer flew the aircraft from Humberside Airport to Hamburg Airport with a cabin attendant on board, but with no passengers or cargo. Whilst taxiing prior to departure the commander noted that the aircraft had a tendency to meander about the taxiway centreline without any associated crew NWS input. The aircraft arrived at 1029 hrs and was scheduled to depart with 10 passengers and their associated luggage at 1200 hrs, for a chartered flight to Manchester. After the aircraft had been catered and refuelled, the passenger baggage arrived at the aircraft. The commander noted that there were several large and heavy bags and enquired as to whether they had been weighed. He was told by the handling agent they had not been weighed and that they were not planning to weigh them. The bags were then loaded into the two baggage compartments; Holds 4 and 6 (see Figure 1). These were both filled to volumetric capacity and the remaining bags (approximately five) were stored in the passenger cabin. The commander appreciated that the centre of gravity would be positioned significantly aft as a result of the full baggage compartments and asked the cabin attendant to seat the passengers in the forward seats. All the loading information was then passed to the first officer who completed the manual loadsheet which the commander then signed. Throughout this period the first officer had remained on the flight deck. The passengers then boarded the aircraft and it was noted by the commander that they possessed a significant amount of hand baggage.

After a normal start, the commander, who was the handling pilot for this sector, taxied the aircraft to Runway 33 for departure; there was no tendency for the aircraft to meander whilst operating on the ground and the NWS operation was normal. During the taxi the ANTI-SKID caption on the central annunciator panel illuminated. The anti-skid switch was recycled two or three times before the light extinguished and the taxying proceeded as normal. The flight then continued without incident until it arrived at Manchester Airport An ILS was flown to Runway 06R in benign weather conditions; a light and variable surface wind, 10 km visibility, a cloudbase of 2,000 ft and a temperature of +16°C. Following the ILS approach the autopilot was disengaged and a reportedly smooth touchdown achieved on the runway centreline. The spoilers, which had been pre-armed, deployed and, after confirmation of power in the 'beta' range, reverse power was selected.

The commander reported that almost immediately the aircraft touched down it began to meander about the runway centreline, and this rapidly became more progressive. He initially attempted to control this instability with rudder but as this had no noticeable effect, he resorted to using NWS through the tiller. Although the tiller handle moved freely, he was unable to control the aircraft's heading and shortly afterwards the aircraft yawed rapidly to the left and departed off the side of the runway. At this point full wheel braking was being applied and the rudder was used in addition to the tiller in an attempt to keep straight.

The aircraft decelerated rapidly on the furrowed grass and came to a stop after approximately 10 seconds. The commander made a public address announcement to the passengers to let them know that the situation was under control and to remain in their seats. He also opened the flight deck door to check on the situation in the cabin and received a 'thumbs up' from the cabin attendant. After the AFRS arrived at the scene the engines were shut down and the commander, having established that there were no hazards outside the aircraft, released the passengers. There was no smoke, fire or apparent damage to the aircraft.

Aircraft layout (Refer to Figure 1)

This particular variant of the Jetstream 4100 has a passenger cabin comprising nine rows of three seats and a tenth row of two seats. The cabin attendant's seat is immediately behind the tenth row, adjacent to the galley and a wardrobe is situated behind the first officer's seat. For loading purposes, the cabin is divided into three bays; Bay A contains seat rows 1-3, Bay B contains Rows 4-6 and Bay C contains rows 7-10. There are two cargo holds; Hold 4 just aft of the wing and Hold 6 towards the rear of the fuselage. The wardrobe, Bay A and Bay B all have a forward effect on centre of gravity whilst Bay C, both holds and the fuel load have an aft effect.

Baggage loading

The commander, having filled both baggage holds to volumetric capacity at Hamburg, estimated their contents weight as the maximum allowed in each hold; that is 330 kg in Hold 6 and 158 kg in Hold 4, and these were the figures that were entered onto the loadsheet.

After the incident at Manchester, the company's handling agents were asked to assist with offloading the hold baggage. On opening the door to Hold 6, the ramp supervisor was surprised by the volume of bags in the hold and decided to weigh the contents. An engineer from the aircraft's operating company unloaded Hold 4 and these bags were added to those in Hold 6 prior to weighing, with the exception of two crew bags. The engineer could not recall exactly how many bags were in Hold 4 but thought that there were probably 4 or 5 large bags, a guitar and 6 smaller bags in addition to the crew baggage. The crew baggage along with the internal cabin bags were taken separately to be reunited with the passengers and crew.

Thirty items of baggage were weighed giving a total weight of 610.9 kg which is 122.9 kg greater than the maximum allowed combined hold weights. The exact distribution of weight between the holds is not known but from the engineer's recollection it appears likely that Hold 4 was close to its weight capacity of 158 kg. Hold 6 is thus likely to have contained approximately 453 kg.

The hold baggage that was taken into the passenger cabin and strapped onto the passenger seats was not shown on the loadsheet as it was considered part of the allowed passenger hand baggage of 6 kg per person. There was one bag of approximately 5 kg placed in the wardrobe behind the first officer's seat.

Passenger loading

Prior to the boarding of the passengers the commander asked the cabin attendant to seat them in the forward seats. As a result of this request, the loadsheet was completed showing nine passengers sat in Bay A and one passenger sat in Bay B. However the cabin attendant did not seat any passengers in Row 1 due to its unpopularity; the seats being close to the forward bulkhead. Excess baggage from the hold had already been strapped into some of the seats in Rows 2 and 3 which meant that Bay A actually contained just two passengers, Bay B contained seven passengers and Bay C contained one passenger. This difference, particularly the number of passengers sat in Bay A, had a significant impact on the actual position of the centre of gravity. The loadsheet compiled by the crew is shown at Figure 1 whilst the loadsheet detailing the actual load positions is shown at Figure 2. It can be seen that the actual load positions placed the aircraft's centre of gravity aft of the operating company's flight envelope and into the 'unsafe' region for both takeoff and landing. The manufacturer's flight envelope is less restrictive and using their envelope the centre of gravity fell within the aft limit for both takeoff and landing.

Flight testing of this series of Jetstream aircraft included assessment of handling characteristics with a centre of gravity up to two inches outside the manufacturer's certified aft limit in the takeoff and landing configurations and four inches outside the aft limit in the en-route configuration. The aerodynamics department's flight test report concluded that:

> *'At no time during any of these tests were any adverse or undesirable handling characteristics encountered. Positive longitudinal stability was demonstrated and the aircraft was easily controlled, requiring no exceptional pilot skills.'*

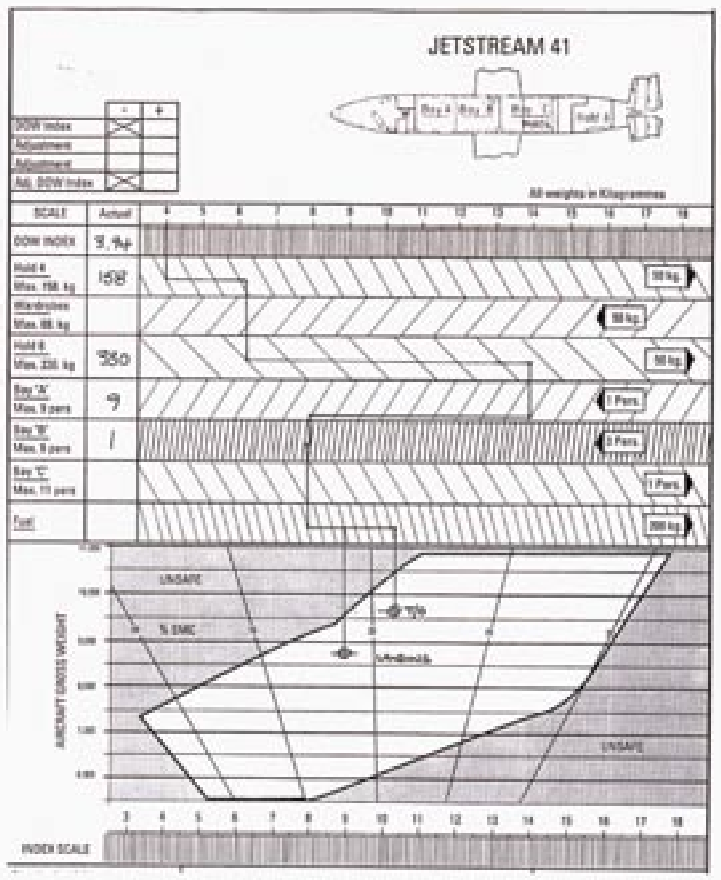


Figure 1 (Left)

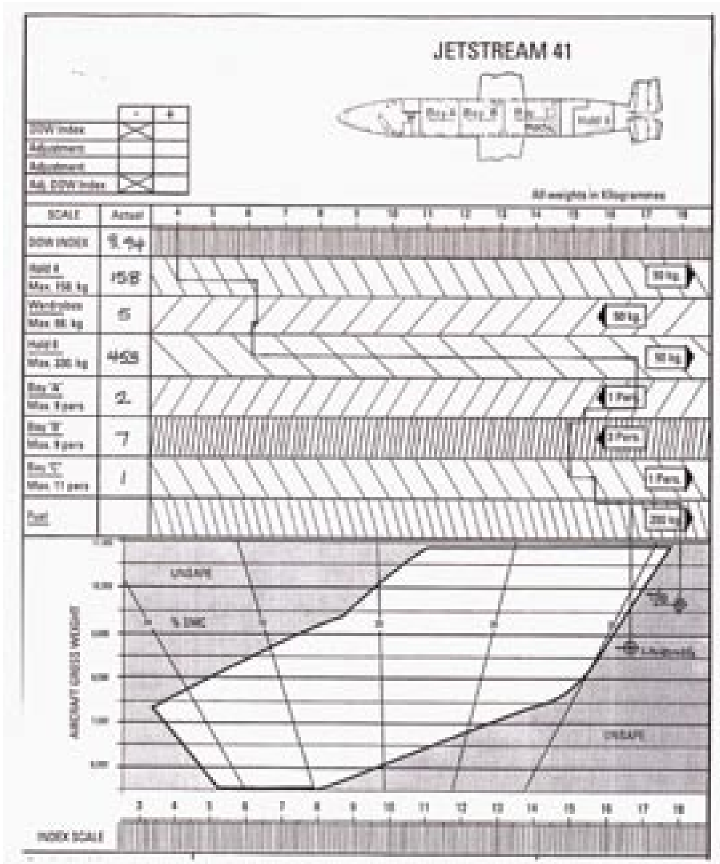


Figure 2 (Right)

Operator's Charter Brief

The aircraft's operator, whose normal business involves scheduled public transport operations, uses a Crew Flight Aide Memoir form to facilitate pre-flight planning for charter flights; flight crews generally being less familiar with this side of the operation. This form consists of a series of tick boxes for various elements of the charter flight such as performance, aircraft defects and passenger numbers. A company operations officer prepares this form in advance of the flight and initialises the relevant boxes when they have each been checked. The commander is then required to brief and tick each relevant box or contact operations for further clarification. The boxes marked *'pax nos'* and *'estimated baggage weight'* had not been ticked by either the operations officer or the commander for this particular charter flight. This is apparently not unusual as passenger numbers and baggage weights are often only finalised at the very last minute.

Flight Recorders

The aircraft was fitted with a Solid State Flight Data Recorder (FDR)[1] capable of recording a range of flight parameters[2] into solid state memory when power was applied to the aircraft. The aircraft was also fitted with a Cockpit Voice Recorder (CVR), however, these recordings from the incident landing were over written with more recent information whilst the aircraft was on the ground after the landing.

A time-history of the relevant parameters during the incident landing is shown at Figure 3. The data presented starts just over 30 seconds before the touchdown, with the aircraft established on the glideslope at 295 ft agl, with the autopilot engaged, flaps at 25º, at 121 kt IAS (ie V_{ref} +14 kt) and with a descent rate of about 670 ft/minute. Vref is the target airspeed at 50 ft on the approach.

At approximately 80 ft agl the autopilot[3] was disconnected. Coincident with the autopilot disconnect, and about 12 seconds before touchdown, the aircraft pitched nose down from -5º to -7º. Following an application of nose up elevator the pitch angle increased by 6º to -1º. Two further pitch oscillations were recorded prior to the flare. These pitch oscillations are indicated by Point A at Figure 3.

Just before touchdown the aircraft had a yaw rate to the left of approximately 0.5º/s. The aircraft then banked to the right with a 2.5º roll attitude recorded at touchdown as the yaw rate reduced to zero. At touchdown, the pitch attitude was +2.5º, the airspeed was 107 kt IAS (ie V_{ref}), and the normal acceleration peaked at 1.25 g. Immediately after touchdown the aircraft pitched nose-down to -4º.

Landing gear squat switches indicated that the nose gear and right main gear were the first to contact the ground with the right main gear almost immediately bouncing back up to disconnect the squat switch. The aircraft then commenced a yaw to the right at a rate of approximately 0.5º/s. The left main gear followed shortly by the right main gear (for the second time) finally made contact with the ground three seconds after the initial contact, as the aircraft pitch increased from about -4º to -1º. The

Footnotes

[1] LORAL Fairchild Model F1000 FDR: which contains memory capable of recording at least 25 hours of data at 64 words per second data rate.

[2] The range of parameters included aircraft control surface deflections but none of the associated control inputs. Also not recorded are nose wheel steering, tiller angle and braking.

Footnote

[3] Discrete parameters (for example autopilot disconnect, landing gear squat switches, reverse thrust selection) are recorded with a one second sample rate that could result in a delay of up to one second between when an event is sensed and when the event is recorded on the FDR.

air/ground landing gear squat switch positions after touchdown are indicated by Point B at Figure 3. Revere thrust from the propeller blades was selected shortly after this without any noticeable change in aircraft pitch or heading.

Three seconds after touchdown, the aircraft yawed more sharply to the right (at just under 3º/s) before reversing the direction of yaw to the left. The aircraft yawed right then left another three times, each directional-oscillation growing in amplitude, before coming to a rest off to the left of the runway on a heading of 358ºM. These oscillations in yaw are indicated by Point C at Figure 3. Increasing rudder deflections to a maximum of +24° were recorded (where positive indicates yaw to the right and ± 24° is full deflection); these rudder deflections commenced about 10 seconds after touchdown and were in phase with, but slightly lagging the oscillations, and in the same sense (ie driving the oscillation).

Examination of the runway

The aircraft had left skid marks from all six tyres as the final left turn commenced, and which continued across the grass until it came to rest. There were no other marks discernible prior to the point at which the right mainwheel tyres, on the right side of the centreline and heading slightly to the right, changed direction in a turn to the left. Almost immediately, the left main and nosewheel tyres also started to produce marks. Several conclusions were drawn from observations and measurements of these marks:

- The aircraft left the paved surface approximately 1,400 m from the runway threshold, coming to a halt on the grass 81 m from the runway centreline and on a heading of about 360°.
- All six tyres were skidding sideways to produce the marks.
- The change of direction from right to left was consistent with a divergent oscillatory behaviour.
- The fact that the nosewheel marks were some 2.4 m closer to the left mainwheels than the right indicates that the aircraft was yawed about 7-8º to the left.
- Braking was being applied as the aircraft left the paved surface and the distinctive 'dashed' appearance of the left mainwheel marks just prior to this showed that the anti-skid system was operating (this was not the case with the right mainwheels, almost certainly because the weight distribution was being transferred from the left wheels to the right under the action of cornering).
- The aircraft was not being steered by the nosewheel but subjected to other forces being applied to change its path across the ground.

Examination of the aircraft

The aircraft was examined by the AAIB and a senior engineer from the operating company the day after the incident; the baggage had been off-loaded. After a visual inspection of the landing gears, during which no abnormalities were noticed, it was towed onto a 'grease plate' which enables the nosewheel steering to be exercised under power with the normal weight of the aircraft on the wheels. Both engines were then started, hydraulic power applied to the system and the steering exercised several times throughout its operating range using the tiller on the captain's side console. The nosewheel steering functioned correctly and the 'feel' of the tiller was normal.

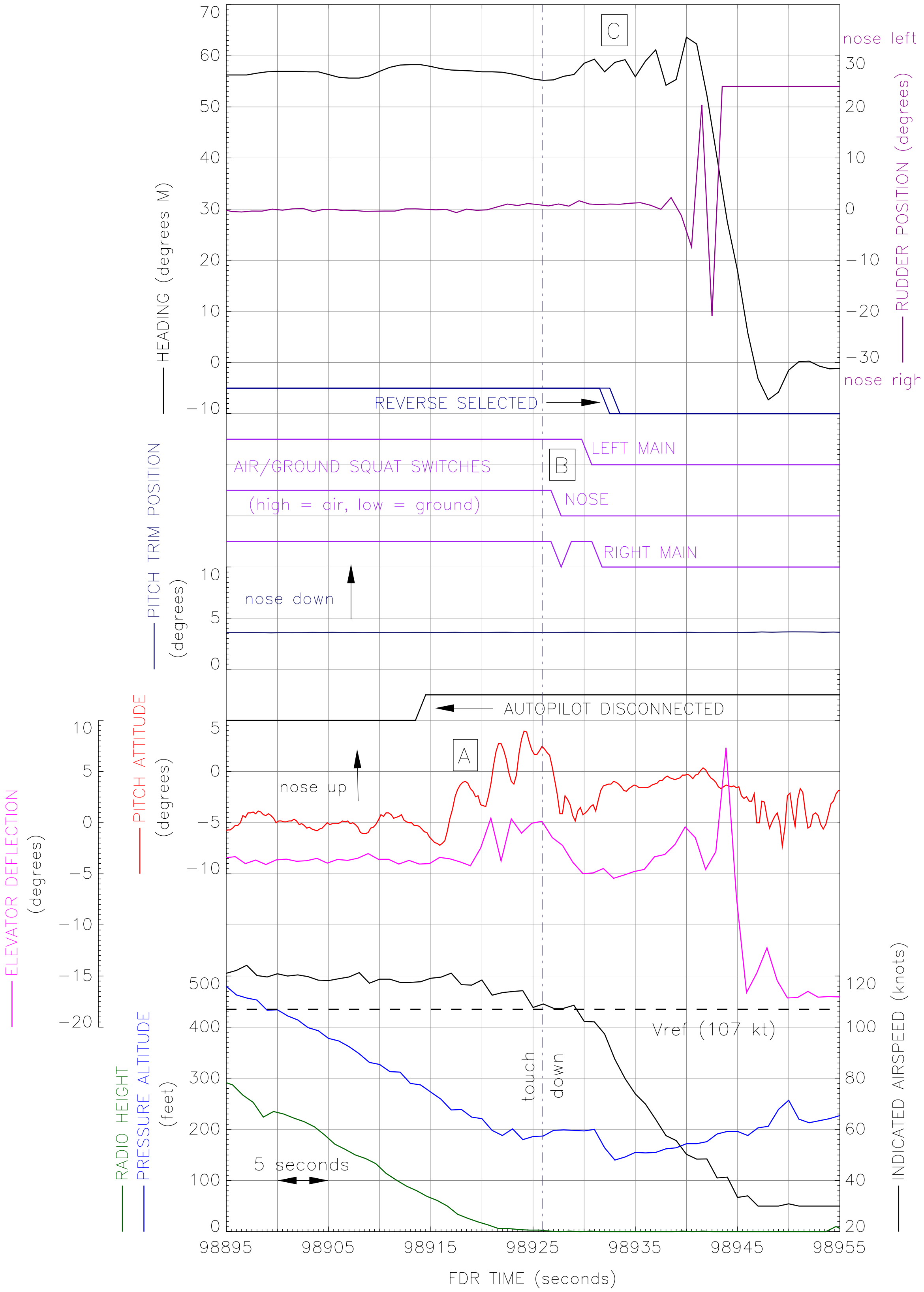


Figure 3

Salient FDR Parameters
(Serious Incident to G-MAJA on 29 June 2005)

The engines and propellers were then exercised through the flight, beta and reverse pitch ranges to check for evidence of differential operation – none was found. Later in the day the aircraft was taxied by a company pilot at high speed along the runway several times to check for normal operation of the steering and brake systems. He reported that the handling was normal and, after some tyre changes, the aircraft was ferried to the operator's maintenance base for further checks. These found no anomalies and the aircraft was returned to service.

A few days later, a captain who had flown G-MAJA on a revenue flight reported an apparent 'over-sensitivity' of the nosewheel steering at high speeds. The aircraft was removed from service and placed on jacks. In this condition, great difficulty was found in moving the nosewheel steering by hand with hydraulic power removed, although operation with power applied was normal (note: there is no maintenance manual procedure requiring manual movement of the steering - the engineer simply felt that G-MAJA's steering resisted his efforts much more than other aircraft in his experience). Upon opening the steering actuator cover plate on the back of the noseleg, a quantity of water spilled out and the grease inside appeared old and hard. After fresh grease was applied and the mechanism exercised, the steering could be turned by hand freely. The aircraft was returned to service and there have been no other reports of abnormalities in the steering system.

Engineering conclusions

The nature of the marks on the runway suggested that the nosewheel steering was not responsible for the aircraft leaving the runway – the presence of clear tracks of the nosewheel tyre indicate that the steering was trying to resist the forces turning the aircraft to the left. Despite this, attention focussed on the serviceability of the steering system since it appeared to have been ineffective at countering the first minor oscillations, according to the pilot. The testing at Manchester did not reveal any functional anomalies and even the later discovery of water in the steering actuator did not appear to impede operation of the system under hydraulic power. Some consideration was given to the possibility that the water could have frozen during the flight but any resistance to tiller movement, if the nosewheel had become seized in the fore-and-aft position, should have been easily sensed by the pilot (he reported tiller 'feel' as normal). The apparent abnormally high forces required to rotate the steering by hand could have been explained by residual hydraulic pressure in the system.

Some consideration was also given to the possibility that the extreme aft centre of gravity at touchdown could have resulted in such light loads on the nose leg that the steering became ineffective due to lack of friction. Information from BAE Systems indicated that, even with the centre of gravity at its most probable position, there would still have been significant, if reduced, loading on the nose landing gear.

The AAIB have investigated another incident in which a Jetstream 31 aircraft left the side of the runway whilst taking off from London Stansted Airport (G-LOVA, AAIB Bulletin 1/2000). The Jetstream 31 and 41 series of aircraft employ a very similar nosewheel steering system. In the case of G-LOVA, the cause of the loss of directional control was considered to be a worn spring plunger in the steering valve which put a small 'steer left' hydraulic flow into the steering actuator, after the pilot had released his hand from the tiller. In this case, however, there no suggestion of any oscillatory motion of the aircraft.

Discussion

The chain of events that led to this incident began with an incomplete charter brief. A provisional baggage weight estimate at this stage may have highlighted a potential loading issue. However, the nature of the charter business invariably means significant last minute changes and commanders would be expected to safely handle whatever loading issues they are presented with. During the turnaround at Hamburg Airport the commander had to decide whether to delay the flight in order to allow the baggage to be weighed. Although in hindsight this would have been the sensible option there was pressure, possibly self-imposed, to depart on schedule in order to meet the passengers expectations, and consequently, the bags were not weighed. Having loaded the baggage, the commander estimated the weights as the maximum allowable for each hold which, considering both holds were full and no actual weights were known, was his only realistic option. The fact that the baggage, particularly in Hold 6, was tightly packed in might have been an indication at this stage that there was an overloading issue. The commander obviously realised the implication of the full baggage holds on the position of the centre of gravity, in that he instructed the cabin attendant to sit the passengers in the forward seats. However the full significance of this instruction was not understood by the cabin attendant as she did not use the front row of seats that are known to be unpopular with the passengers. This misunderstanding may have arisen because the instruction was not clear or significantly emphasised or because the cabin attendant did not understand the implication of what she was being asked to do. Either way, the loadsheet did not accurately reflect the actual passenger seating positions, and this led to an incorrectly calculated centre of gravity and trim position. At the time of this incident there was no company procedure for a final check of loadsheet seating accuracy other than the commander physically checking the seating positions.

During the final approach, the aircraft was being flown through the autopilot which would have automatically trimmed the aircraft. As it is not normal procedure to check the trim indicator position at this stage of flight the flight crew were unlikely to be aware that it was in an unusually nose down position. When the commander took control manually, at 80 ft agl, the aircraft was correctly positioned and stabilised on the approach path, and in the landing configuration. During the landing flare several pitch oscillations were identified from the flight data recordings, although none of the flight crew recall anything problematic with the approach. With a centre of gravity further aft than normal the aircraft would have been more responsive to control input than anticipated; however, flight tests have indicated that with the CG 2 inches outside of the manufacturers limit the stick forces are acceptable and that there are no adverse or undesirable handling characteristics.

The approach speed was close to the maximum allowable of V_{ref} +15 kt and as such resulted in a more pronounced nose down attitude during the approach. A combination of landing at V_{ref} and the oscillatory nature of the flare led to the nose wheel contacting the ground almost coincidentally with the right main wheel followed by a period with just the nose wheel in contact with the ground. During this period the aircraft was yawing to the right, a motion that would have been difficult to correct until all main landing wheels were in ground contact and restoring forces were then available. There was no noticeable rudder activity for 10 seconds after touchdown during which time directional oscillations developed. Thereafter, significant alternating and increasing rudder deflections occurred coincident with rapidly diverging directional oscillations until the aircraft departed the runway.

The commander recalls using NWS and wheel braking during the landing roll but the lack of FDR data for these parameter prevents analysis as to their effectiveness. If he did utilise these controls the reported 'sensitivity' of this aircraft's NWS system at high speeds would make directional control more prone to pilot induced oscillation. However, the final skid marks from the tyres suggest that the aircraft was not being steered by the nosewheel but subjected to other forces being applied to change its path across the ground.

Conclusion

The aircraft departed Hamburg and arrived at Manchester Airport with its centre of gravity in the unsafe region of the operator's flight envelope due to incorrect loading, although the centre of gravity was within the manufacturer's safe envelope which is less restrictive than the operator's. During the cruise, the autopilot was engaged which would have masked any symptoms of an aft centre of gravity. However, the oscillatory behaviour, in both pitch and yaw, experienced during the final approach after the autopilot was disconnected, was symptomatic of an aft centre of gravity position. After touchdown at Manchester a directional oscillation developed, possibly as a result of a period of time spent with just the nosewheel in contact with the ground. Although directional stability on the ground may have been reduced by an aft centre of gravity, it is unclear as to why these oscillations were not controllable. A rapid increase in rudder deflection occurred at a similar time to a rapid increase in heading change and this quickly led to runway departure. In the absence of mechanical failure it is possible that this was a pilot induced oscillation but without NWS data, a definitive conclusion cannot be drawn.

Operator's findings and recommendations

In response to this incident, the aircraft's operator reviewed its supervision of charter flights and made a number of changes which were issued as Flight Crew Instruction 07/2005 on 8 August, and then re-issued, with minor editorial changes, on 1 September. The changes included the following:

The Charter Manager will receive recurrent guidance and appropriate training in Weight and Balance, Range and Payload, and Aircraft Limitations for each of the aircraft types operated by the company. The baggage capacity and capabilities of the aircraft will be demonstrated to potential charter customers via a simple user guide for each aircraft type, and will be reflected in the Terms and Conditions of Carriage.

Operations staff will be formally trained in Weight and Balance, Range and Payload, Aircraft Performance, Limitations, Meteorology, NOTAMS and FTL. The training will be recurrent and sufficient such that staff are aware of the importance of this information to operational safety.

For those flights identified above, Operations will, using the Flight Aide Memoir, ensure that each element of the planning is completed by initialling the relevant signature box, or filling in the details such as expected baggage weight, aircraft registration, Handling Agent, Fuel Payment method etc. Baggage weighing facilities are particularly important. Guidance notes will be issued to Operations staff so that the requirements for each element of the planning procedure are clear. The completed boxes certify that the particular requirement has been fulfilled by the Operations staff, and subsequently by the commander.

On receipt of the Charter Brief and Aide Memoir from Operations, the aircraft commander is to ensure that the crew are adequately briefed using the aide memoir, and certify as having done so using the certificate at the bottom of Part One of the Aide Memoir. This is to be faxed to Operations before the charter commences. If any element of the planning needs clarification, the aircraft commander is to contact operations or relevant management staff.

Operations staff are to ensure that a faxed copy of Part One of the Aide Memoir is received in Operations and that it has been signed by the commander, prior to the departure of the first flight of that charter.

Crews are reminded of the importance of the safe loading of the aircraft, and the seating of passengers commensurate with Weight and Balance. Prior to closing the main door, the Cabin Attendant is to use a Passenger Seating Proformae to mark the actual seating positions of the passengers. This is to be handed to the Captain, who will confirm that the seating positions are as per the loadsheet. The proformae is to be placed in the 'Ship's Papers' envelope.

All Cabin Attendants are to undergo appropriate training in Weight and Balance to emphasise the importance of correct passenger seating.

Captains are reminded that, despite the process described above, ground staff cannot be expected to have the level of expertise requisite of flight crew. Ultimate responsibility for safe conduct of all flights rests with the aircraft commander and Flight Safety is not to be prejudiced under any circumstances.

ACCIDENT

Aircraft Type and Registration:	Cessna 152, G-BGIB
No & Type of Engines:	1 Lycoming O-235-L2C piston engine
Year of Manufacture:	1979
Date & Time (UTC):	9 October 2005 at 1335 hrs
Location:	Field north of Arlington Reservoir, East Sussex
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nose landing gear, left wing tip, propeller and underside of the engine cowling
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	38 years
Commander's Flying Experience:	813 hours (of which 514 were on type) Last 90 days - 169 hours Last 28 days - 54 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot, further telephone enquiries by AAIB

The flight was planned as a practice 'forced landing without power' exercise for the student. The student carried out a pre-flight inspection, observed by the instructor, following which the instructor confirmed the fuel and oil quantities by visual inspection. The student started the engine in accordance with normal procedure; however a few seconds later the engine stopped. The student re-started the engine which ran briefly before stopping again. The instructor intervened, primed the engine and restarted the engine which ran satisfactorily. The after-start checks were completed and the student taxied the aircraft to the holding point. The power checks were completed satisfactorily, followed by a normal takeoff and climb.

The aircraft was climbed to 2,000 ft and the en-route or 'FREDA' checks were carried out. The aircraft continued the climb to 3,000 ft and the en-route checks were repeated. The instructor then demonstrated the actions and touch drills to be completed in the event of an engine failure during the cruise. The aircraft was descended to 2,000 ft and the instructor handed control of the aircraft back to the student. The aircraft was climbed back to 3,000 ft and the en-route checks repeated. The student then repeated the actions and checks, full carburettor heat was applied before the power reduction, and the engine 'warmed' during the glide descent, by applying full power every 500 ft, in the demonstration and subsequent practice by the student. Following a second practice glide descent from 3,000 ft to 2,000 ft the student was instructed to level at 2,000 ft and following a few minutes of straight and level flight complete another en-route check.

As planned, the next exercise was to include selection of a suitable landing area; once again all checks and touch drills were completed and the carburettor heat was selected to 'HOT' where it remained as the engine power was reduced to idle at 2,000 ft. During the descent the power was increased on two occasions to warm the engine and the carburettor heat remained 'HOT'. At 800 ft the instructor asked the student to initiate a full power climb. The student advanced the throttle but the engine did not respond. The instructor took control and exercised the throttle, again without response from the engine and he then shut down the engine, repeating the student's touch drills in preparation for a forced landing.

The selected field sloped down in the direction of the landing and, following a ground roll of approximately 200 m, the instructor considered that the aircraft was not going to stop before a densely wooded area ahead. He therefore applied heavy braking which resulted in the collapse of the nose landing gear and the aircraft tipped onto its nose. Both occupants exited the aircraft via the doors.

The instructor reported that all checks had been satisfactorily carried out by the student and the engine had been performing 'within limits' with no rough running. Examination at the accident site by the club's Chief Flying Instructor and an engineer from the Maintenance Organisation revealed that the flexible hose supplying hot air to the carburettor air box had a split extending approximately two-thirds of the way round its circumference. The instructor also observed discoloration around the split.

Maintenance information

The engine is fitted with a carburettor air box on the underside which normally allows outside air from a filter intake on the front of the cowling into the carburettor. When carburettor heat is selected to 'HOT' warm air is drawn instead through an air hose from a muff around the exhaust system. The hose fitted was a double-ply 'Sceet' hose rather than the specified single-ply 'Scat' hose which is more commonly used. The installation, in 'as seen at the accident site' condition, was not available for examination by AAIB; however part of the hose was returned to AAIB.

The maintenance organisation reported from their examination on site that the flexible hose was fully connected to the metal tube stub on the carburettor air box and held in place by a metal clamp. They considered a split had developed due to chaffing around the metal clamp.

Weather conditions

The following meteorological observations were made in the Eastbourne area for the 9 October.

Herstmonceux: 1300Z:
Temperature 16.3º
Dew point 7.1º
Humidity 54%

Shoreham: 1300Z:
Temperature 15.2º
Dew point 9.9º
Humidity 71%

Carburettor icing

CAA General Aviation Safety Sense leaflet 14A describes piston engine icing. Piston engine induction system icing, commonly referred to as carburettor icing, is 'caused by the sudden temperature drop due to fuel vaporisation and pressure reduction at the carburettor venturi. The temperature drop of 20–30ºC results in atmospheric moisture turning into ice which gradually blocks the venturi. This upsets the fuel/air ratio causing a progressive, smooth loss of power and slowly 'strangles' the engine. Conventional float type carburettors are more prone to icing than pressure jet types.'

The chart in leaflet 14A shows the wide range of ambient conditions where the formation of carburettor icing is most likely. Particular note should be taken of the much greater risk of serious icing with descent power. The recorded weather conditions at ground level are consistent with a serious risk of at descent power and bordering on the risk of serious icing at cruise power. The conditions were likely to have become increasingly conducive to carburettor icing at higher altitudes.

Discussion

The weather conditions were conducive to carburettor icing. The instructor and student followed the recommended procedures for engine handling in these conditions. Engines at reduced power settings are more prone to icing because engine induction temperatures are lower and also, the partially closed butterfly can more easily be restricted by the ice build-up. The presence of a split in the hose supplying hot air could have allowed colder air from around the engine bay into the carburettor, making carburettor ice build-up more likely, despite the selection of hot air.

ACCIDENT

Aircraft Type and Registration:	Diamond HK 36 TC, G-OSFA
No & Type of Engines:	1 Rotax 912-A3 piston engine
Year of Manufacture:	1999
Date & Time (UTC):	15 November 2005 at 1340 hrs
Location:	Enstone Airfield, Oxfordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 Passengers - N/A
Nature of Damage:	Nose landing gear failed and fibreglass cracked
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	67 years
Commander's Flying Experience:	631 hours (of which 10 were on type) Last 90 days - 2 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

Following a local flight the aircraft rejoined the circuit from the west at about 800 ft agl. The pilot noticed some strong turbulence on the base leg and after turning onto the final approach was aware that the crosswind was stronger than forecast. The turbulence that was encountered on the base leg continued during the final approach. During the late stage of the final approach the aircraft encountered a particularly rough area of turbulence with an associated downdraft. The pilot decided to apply full power and execute a 'go-around', but the rapid descent continued and the aircraft struck the runway, breaking off the nose landing gear.

In the past the pilot had carried out some mountain flying in Scotland, Wales and Italy and he likened the turbulence that he encountered to the curl-over effect that he experienced during his mountain flying.

ACCIDENT

Aircraft Type and Registration:	Europa XL, N8027U
No & Type of Engines:	1 Rotax 912 piston engine
Year of Manufacture:	2004
Date & Time (UTC):	25 March 2005 at 1430 hrs
Location:	Kemble Airfield, Gloucestershire
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
Commander's Age:	55 years
Commander's Flying Experience:	636 hours (of which 28 were on type) Last 90 days - 4 hours Last 28 days - 1 hour
Information Source:	AAIB Field Investigation

Synopsis

The kit built aircraft was taking off in good weather conditions with the owner and his daughter, both pilots, on board. During the climb-out it entered a spin, from which it did not recover. Both pilots were fatally injured in the accident. A post crash fire destroyed much of the aircraft rendering identification of features of the aircraft and hence the process of investigation more difficult. It was concluded, however, that the aircraft probably lacked any form of effective stall warning and may well have retained undesirable stall/spin characteristics. Development flying to improve such characteristics, normally carried out on British registered examples of the type, appears not to have taken place on this aircraft. No positive evidence of mechanical or structural failure or of pilot incapacitation was found.

History of the flight

The pilot and his daughter had travelled to Nympsfield on the morning of 25 March 2005 in order for the daughter to have a trial glider lesson. The gliding instructor subsequently commented that the daughter demonstrated a high level of competence during the 40 minute flight and quickly became comfortable with glider operation, landing the glider under the instructor's supervision. The instructor stated that father and daughter appeared happy and that the daughter was very keen to carry out a further launch after lunch. However, as they were leaving, they told the instructor that the launch queue was too long and that they had decided instead to go to Kemble to fly in their own powered aircraft. The instructor recalled that they left at or shortly after 1230 hrs.

They were next seen at a hangar on the south side of Kemble Airfield, preparing their aircraft for flight. The owner of another aircraft that was kept in the same hangar helped them to pull their aircraft out of the hangar and did not recall anything unusual about the occupants, the aircraft or its preparation. He recalls seeing the father occupying the left seat as the aircraft taxied for departure, and presumed that he was therefore the pilot.

At 1430 hrs N8027U contacted AFIS, which was manned by a Flight Information Service Officer (FISO) and his assistant, to book out for a VFR flight to Shobdon. The FISO saw the aircraft taxi to Hold C1, at the intersection of the perimeter track and Runway 26, and hold here for a few minutes, suggesting to him that power checks were accomplished. At 1436 hrs the aircraft reported ready for departure and was told to line up on Runway 26 and takeoff at the pilot's discretion. The aircraft began its take-off roll at approximately 1437 hrs and was seen to climb normally to a height of 80 to 100 ft as it passed the air traffic control tower. At this point, judging that the departure was successful, the FISO turned his attention to a microlight aircraft which was holding opposite Hold C1 prior to departure from Runway 26. This aircraft was also advised to line up and depart at the pilot's discretion.

There was then a transmission, heard by the FISO, the pilot of the microlight and other pilots on the Kemble frequency, which sounded like a scream. This caused the FISO to look up, and he saw what he thought initially was a model aircraft descending almost vertically at the south-western edge of the airfield. The pilot of the microlight also saw this, and also thought initially that it was a model aircraft. The aircraft was observed to continue its descent, with a slow, probably right hand, rotation, which the FISO called a "spiral dive". He pressed the crash button to alert the AFRS and called his assistant, who saw the aircraft moments before impact at 1438 hrs. The AFRS was on site within one minute and extinguished numerous fires which had ignited around the wreckage. The occupants had been fatally injured in the impact.

Personnel information

Pilot

The pilot spent a considerable amount of time in the United States, where previously he had a financial interest in a flying club, although there is no record of him having held an instructor rating. He possessed a Private Pilot's Licence (PPL) which had been issued by the United Kingdom CAA on 3 January 1997. He also held an FAA pilot certificate, which had been issued on the basis of his UK PPL, on 22 March 1997. The pilot required an FAA pilot certificate in order to fly as the commander of N8027U, a US registered civil aircraft, but could only exercise the privileges of that licence whilst his UK PPL remained effective. Although the pilot had carried out the required FAA biennial flight review on 15 April 2003, the available records showed that he had not conducted a CAA single engine piston class rating renewal since 16 November 2001. As this renewal was required at intervals of not more than 24 months, this indicates that his UK PPL, and hence his FAA pilot certificate, were invalid at the time of the accident flight. He had, however, carried out a flight of one hour duration with an instructor on 25 May 2004, which included a practice forced landing and simulated engine failure after takeoff. This flight would have satisfied the requirement to revalidate his licence for a further 24 months had his licence been so endorsed. It should be noted that training for neither the UK PPL nor the FAA pilot certificate requires entry into and recovery from a spin to be either demonstrated or practiced.

At the time of the accident, the pilot's flying log book indicated that he had completed a total of 636 hours flying. This represents an average of almost 80 hours flying each year, which is a considerable amount for an individual whose primary occupation was not flying. His first recorded flight in N8027U was on 5 February 2004, departing its base in Winter Haven, Florida and returning after one hour. During the course of the next four months he recorded a total of 16.5 hours flying in N8027U, before its was shipped to the UK. Thereafter, he recorded 11.5 hours in this aircraft between 10 September 2004 and 13 March 2005; this flying encompassed only four flights, three of which lasted for three hours or more.

Passenger

The passenger, who was the pilot's daughter, held a UK PPL issued on 11 July 2001 and an FAA PPL issued on the basis of her UK PPL on 17 July 2001. At the time of the accident her flying log book indicated that she had completed a total of 131 hours flying in a variety of US and UK registered single engine light aircraft, including two hours in N8027U.

Witness information

Unfortunately, no witnesses were identified who saw the transition between the apparently normal climb and the subsequent vertical descent. Statements were, however, taken from several eye witnesses who saw the aircraft both on takeoff and just prior to impact. Some of these witnesses referred to its final manoeuvre as a "spiral dive".

Meteorological information

The surface wind recorded at Kemble at the time of the accident was from 190º at 5 kt and the visibility was approximately 25 km; the runway surface was dry. An aftercast produced by the Met Office for the time of the accident indicated that visibility in the area would have been greater than 20 km, with a few cumulous clouds at 3,000 ft and scattered strato-cumulus clouds at 4,500 ft. Conditions of temperature and humidity were not recorded at Kemble; the figures of 12ºC and 8ºC respectively were recorded at Lyneham whilst 13ºC and 6ºC respectively were recorded at Brize Norton. Kemble lies approximately 10 nm north of Lynham and 20 nm west of Brize Norton and is approximately mid-way between the two elevations.

Witnesses on the airfield and other pilots described the general conditions as excellent for flying.

Medical and pathological information

The pilot held a valid UK CAA Class 2 medical certificate, which satisfied the medical requirements of his FAA PPL. He had a visual impairment in his left eye, following an accident as a child, but limitations recorded in his UK PPL in relation to this fact did not preclude him from conducting the planned flight. The medical certificate was endorsed with the limitation that he should wear corrective lenses and carry a spare set of spectacles.

The post mortem examination of both occupants carried out by a consultant aviation pathologist revealed no evidence of natural disease or the presence of any substance which may have caused or contributed to the accident. Toxicology on the pilot revealed a very low level of salicylic acid, which is the active constituent of aspirin and other pain killers, but this was present at a sub-therapeutic level and played no part in the accident.

The injuries to the occupants, although fatal, indicated a relatively low velocity at impact. Nevertheless, the impact severity, combined with the small size of the aircraft and the consequent proximity of the occupants to the surrounding structure was such that the provision of additional or alternative safety equipment would not have altered the fatal outcome. Injuries to the father's hands suggested that he was handling the controls at the time of the accident.

Aircraft information

The aircraft type was developed in the UK for production as a kit, capable of being de-rigged for ease of transport, whilst having performance characteristics enabling it to use short, semi-prepared strips, yet possessing a high cruise speed and a low fuel burn. To achieve the desired performance, an advanced wing design profile was adopted. The aircraft type used a glass-reinforced plastic (GRP) structure in which the fuselage consisted of a number of pre-molded modules to be joined, using adhesive bonding, following detailed fitting out. The wings, tail-plane and control surfaces required a wet lay-up of glass fibre and resin to be carried out over a pre-profiled foam core. In the case of the wings, both the spars and the blocks of profiled foam were factory prepared.

The original aircraft was developed as a retractable mono-wheel type in which a large diameter main wheel and a pair of light outriggers were arranged to retract manually in unison with the flaps. A fixed tail wheel was also fitted. At a later date the fuselage profile of newly supplied kits was altered, the built-up wings using wet lay-up were replaced by factory pre-molded items and the cowlings supplied from the factory were substantially modified. Numerous other modifications became available as factory furnished options. These included a fixed tricycle undercarriage with electrically operated flaps in place of the linked mechanical system used in the mono-wheel aircraft.

UK home-built aircraft are generally constructed under regulations which enable the CAA to delegate supervision to the PFA who fulfill the design, construction and quality functions. Such aircraft normally operate after issue of a Permit to Fly.

Large numbers of Europa Kits have been exported, notably to the USA, where the regulation of home-built aircraft is carried out somewhat differently. Such aircraft are normally issued with a Certificate of Airworthiness in the Experimental category, by the FAA, before flight.

During development, the kit manufacturers and the PFA established that the stall characteristics of individual aircraft having those earlier wings incorporating wet lay-up were a consequence of both the design profile and the consistency of build. Accordingly, test flying of each finished example was required by the PFA to include extensive evaluation of stall behaviour, and modification action when necessary, to prevent excessive wing-drop during a power-off 1g stall. This modification was achieved by fitting short triangular section strips (stall strips) to the inboard sections of the wing leading-edges, as required after initial test flights, thus promoting stall initiation symmetrically at the roots and rendering the stall behaviour benign in addition to providing some warning of the impending stall. The PFA have reported that most Europas they have tested, having the earlier wet lay-up wing structures, have required installation of stall strips to obtain acceptable stall characteristics.

Europas may be powered by a variety of engine types; however, the Rotax 912 is one of the types specifically recommended by the kit manufacturer. Similarly, a number of propeller types are also recommended. Although instructions for assembly of the airframe fuel system were provided by the kit manufacturers, these left considerable scope for individual variation in components and layout of the system. A study of six different completed Europas showed detailed differences between each example.

The accident aircraft

N8027U was constructed using a kit supplied to the USA in the late 1990s where it was partly built by the original owner before being sold to the pilot involved in the accident. It was apparently completed for him in 2004 by a company specializing in providing assistance to home builders and having considerable experience of Europa aircraft. It was fitted with a Rotax 912 engine obtained locally by the pilot and as the original kit did not incorporate the items forward of the firewall, certain differences in this area from the layout recommended by the Kit manufacturer may have occurred. The aircraft appeared to have a number of features known to be standard on later machines built from kit parts supplied in significant numbers only well after the date on which the original kit, or part kit was supplied. In particular the aircraft was fitted with a fixed tricycle undercarriage.

The propeller fitted was a three-bladed unit of a type not specifically recommended by the kit manufacturer and was of a design capable of being installed as an in-flight controllable pitch unit, also having the capability to be used in a constant-speed mode. These functions were electrically/electronically controlled. Documentation indicates that this in-flight pitch change capability had been disconnected.

The Rotax 912 series of engines incorporate a reduction gear between the crankshaft and the propeller. This enables the engine and propeller to be optimized to each rotate at speeds close to those most suitable to their efficient function. The gearing has the effect, however, that should an in-flight loss of engine power occur at other than high airspeeds, the propeller will not be capable of driving the engine, so rotation will not continue under the effects of airflow in the manner familiar to users of slower revolving, un-geared engines.

The aircraft was issued with a Special Airworthiness Certificate in the Experimental category on 2 March 2004, by the FAA. This certificate was issued before the first flight, which occurred in Florida. Operating limitations dated the same day formed part of this certificate. These included the limitation that the aircraft was permitted to undertake 40 hours of flight test within 45 miles of Winter Haven, Florida, USA. The aircraft appears to have been shipped to the UK following a period of flying from its base at Winter Haven.

Other information

Information obtained during test flying of the first example of the aircraft type to be built, which was supplied to AAIB following the accident, indicated that once appropriate development flying had been carried out and any necessary modifications applied, the stall behaviour of the prototype involved considerable aerodynamic warning followed by a benign stall. When a spin was deliberately induced, the attitude was approximately 40º nose-down and rotation was rapid.

A log book detailing flights carried out by the aircraft survived the post-crash fire and remained legible. It apparently detailed all the flying undertaken, including in-flight engine cooling tests, but did not refer to any evaluation of the low-speed or stall characteristics of the machine.

A digital photograph taken some months before the accident of the aircraft in a hangar at Kemble was obtained. The leading edge of the starboard wing was visible but no stall strips could be discerned. The accident aircraft appeared not to be fitted with any artificial stall-warning device.

The original layout of the fuel system normally included attachment of the fuel cock to the fuselage lower skin between the two occupant seats. The pilot could reach the fuel selector handle, attached directly to the fuel cock spindle, by way of an aperture in the console between the occupants. This aperture was normally closed by a hinged or velcro-ed door panel. During examination of other completed examples of the type it was noted that some aircraft had an extension tube pinned to the upper end of the fuel cock spindle. This enabled the operating handle to be attached to the upper end of the tube, thus positioned more accessibly in a recess on top of the console, rather than lower down within the console, close to the fuselage bottom skin.

Two full containers of motor fuel were recovered from the owner's car after the accident together with a receipt for the appropriate quantity of fuel dated on the day of the accident and clearly purchased from an outlet between the owner's home and Nympsfield.

Site examination

The accident site was 1.2 nm approximately WSW of the holding point C1, which was abeam the point at which the takeoff was reported to commence. The aircraft was destroyed by a combination of impact and fire. The initial impact had occurred at a steep nose-down angle but at a relatively low speed and descent rate. An assessment of the aircraft component damage and ground markings confirmed that they were not consistent with the effects of a spiral dive but were as would be expected to result from ground impact occurring during a spin.

The complete forward section, from the propeller to a station aft of the instrument panel, was separated from the remainder of the structure. The latter was lying in a nose down attitude and had been extensively burnt such that most of the aft fuselage and tail unit had ceased to exist as a structure and the wings had rotated in their heat-softened mountings in the fuselage attachments. Much of the burnt structure remained as glassfibre laminates without the uniting resin matrix materials. Hence all structural shape and stiffness was lost from these areas.

No evidence of wing-tip ground strikes could be detected at the site. Two small staggered impact depressions, sited between the initial impact point and the final position of the wing/aft fuselage structure were subsequently identified as those produced by the main-wheels which were later determined to have not been equipped with their wheel spats during the final flight.

The glass-fibre laminates of both tailplanes, the fin and rudder and one of the two trim/anti balance tabs were identified in the extensively burnt wreckage. Both complete wings were present.

Examination of the propeller revealed no evidence of rotational damage on two of the blades. The third blade was found orientated at the vertically downward position, extensively damaged by fire and with the central steel tube bent backwards. Fragments of the composite blade sheath, including the tip section, were recovered from the site. They revealed no conclusive evidence of rotational damage nor of their direction of loading and separation from the remainder of the blade. No rotational 'slash' marks were observed in the ground impact area. Examination of the surviving two blades indicated that they were in a fine but positive pitch position.

Examination of the inboard sections of the wing leading edges showed that neither had contacted the ground during the impact sequence, both were fire damaged to the extent that the gel coat had decomposed and some of the resin was beginning to be lost. There was no evidence of the presence of the stall strips and no shadowing effects to suggest that they had been present during the early part of the fire.

Subsequent detailed examination

Detailed examination revealed no evidence of any pre-impact defects in the surviving parts of the flying control system. Extensive fire damage did, however, inhibit effective examination of certain components. The plastic material of the rack assembly of the flap drive motor had melted preventing assessment of the flap position at impact. The electric trim motor was identified and was found to be in the fully nose down position. The remains of the engine cowlings and the locations of the radiator and oil cooler therein were noted as being of the general design found on the later types of kits.

The engine was removed and subjected to a strip examination at the premises of the UK importers of the units. It was found that the propeller shaft had been displaced aft in the casing of the reduction gear by the impact and the carburetors had similarly been extensively damaged. No internal damage or defect was found and no evidence of tooth damage was found in the displaced reduction gearing. The carburetors were free from contamination. The ignition harnesses were extensively fire damaged although the ignition stator remained intact. The sparking plugs remained in good condition.

It was noted that the installed fuel piping included a vapour return line and restrictor required to eliminate vapour locking of the fuel system; this had been introduced as a modification to overcome a significant problem encountered on early aircraft.

The flattened exhaust system muffler unit was cut open and subjected to an internal examination. It was noted that this was a late model, of a type normally free from the problem of a separated baffle blocking the exhaust outlet, a difficulty encountered on some early examples of the type. Internal examination of the unit confirmed that the baffles remained correctly positioned.

Examination of the surviving fuel piping and fuel cock assembly indicated that the latter was mounted on the lower skin of the fuselage in broadly the way described in the builder's manual for the early examples of the type. Examination of fragments of the wreckage further confirmed that the aircraft was equipped with a narrow console between the occupants, as used in many later build aircraft, an arrangement which leaves insufficient room to enable the handle to be reached if the cock is mounted directly on the bottom skin and the handle fixed to the top of the spindle. Examination of the fuel cock in the wreckage indicated that it had a tube pinned to the upper end of the spindle but this was fractured approximately flush with the end face of the latter and neither the remainder of the tube nor the operating handle was recovered. It was presumed, however, that the valve was operated by a lever mounted remotely on a tubular extension and positioned in a circular recess in the top surface of the console. Boroscope examination of the interior of the cock revealed that the rotating inner cylinder had its internal passages positioned so as to allow flow from the tank supply to the engine supply pipe, but not fully aligned and hence capable of providing more restriction of the flow rate to the engine than would occur with full alignment.

Tests and research

The UK agents for the Rotax engine were requested to establish the length of time a Rotax 912 would operate at takeoff/climb power, with the fuel supply isolated, before the unit lost power. Utilising a similarly powered EV 97 Eurostar microlight aircraft, they were able to operate it statically at maximum power, select the fuel OFF and time the period until the engine began to loose power. The interval was found to be approximately 22 seconds.

Shortly after the completion of the component examination from this aircraft, an accident occurred to a different type of aircraft having a similar engine. This second accident involved a similar type of ground impact to that which occurred to N8027U. Examination of the two bladed propeller of the second aircraft showed that one blade had failed as a result of backward bending whilst the other blade was undamaged. No slash marks were evident in the ground. This was originally judged to be consistent with the accident occurring with the engine not operating. (It should be noted that any complete loss of engine power on this type of geared unit at other than very high airspeeds results in the engine and propeller ceasing to rotate.)

The circumstances of the second accident, however, were such that a complete loss of engine power was judged to be unlikely. The engine was therefore subjected to an unusual sequence of examination. Before any attempt to rotate it was embarked upon, the reduction gear was dismantled. Positive evidence was then found, via microscopic examination, of marks on the aft (forward facing) internal surface of the reduction gear casing which matched the faint circular machine marks present on the adjacent propeller shaft gear. In addition fine slivers of casing material in a form analogous with swarf could be seen by microscopic examination of the spaces between teeth of the gear wheel.

Analysis

Although both occupants possessed licenses appropriate to the operation of the accident aircraft, the father was probably acting as pilot during the accident. His hand injuries further suggest that he was handling the controls at impact. The available documentary evidence suggests that he was in current flying experience on the aircraft and, although his license was not valid at the time of the accident, his log book indicated that he had conducted sufficient flying, including a flight with an instructor, for it to have been valid had it been so endorsed.

The fact that the two containers of motor fuel in the pilot's car were full after the accident, and the engine performs best in the long term using such motor fuel, indicates that the pilot intended filling the tank at some time during the day but did not do so before takeoff. It thus suggests that the aircraft was not re-fuelled before the flight and that a substantial quantity of fuel, sufficient for the planned trip to Shobdon and back was already in the single fuel tank.

The aircraft was seen descending in a manner described by observers as a spiral dive. The relatively limited impact damage to the aircraft, the lightness of ground impact marks and the compact distribution of the wreckage, together with the limited impact effects on the occupants, were not consistent with the descent speeds encountered in spiral dives nor of the previously observed degree of destruction to aircraft known to have been lost as a result of such events. The relatively tall undercarriage legs (compared with the wing-span and dihedral angle) enabled the aircraft to strike the ground with a significant bank angle (as well as a steeply nose-down attitude) without experiencing an initial wing-tip strike. Hence small to moderate bank angles at impact would not have been evident from this source. The staggered positions of the depressions produced by the main-wheels, however, enabled it to be confirmed that the aircraft was banked at initial impact. From these indications it was clear that the impact parameters were consistent with the aircraft having been descending in a spin.

Analysis of the test data relating to spinning of the early retractable mono-wheel equipped prototype version of the aircraft confirmed that the type spins in an attitude of approximately 40° nose-down; it is reasonable to deduce that a fixed tricycle version would behave in a fairly similar manner to the prototype. The nature of the impact damage to the accident aircraft was consistent with a 40° nose down attitude.

Thus, taking material evidence, known aircraft behaviour and eye witness recollections into account, there is little doubt that the aircraft was in a spin just before and at the time of the impact.

The absence of any evidence of stall strips on the inboard wing leading edges, the absence of any sign of such strips in the photograph taken some months before the accident and the absence of any reference to stall evaluation in the otherwise comprehensive log book record of flights, lead to the conclusion that no such evaluation was done, and that the aircraft, with no stall strips, may well have retained undesirable wing-drop characteristics at the stall, together with a lack of aerodynamic warning of the impending stall.

The trim position of fully nose down is surprising (although no information has been found regarding whether any adjustments to the trim range were found necessary and if so whether they were carried out between the first flight and the accident). The trial carried out on a mono-wheel version with the 90 HP engine showed that the trim needed to be moved well forward during the established climb once the landing gear was retracted. It is not possible to reliably establish the likely trim position required on N8027U since no test data relating to the pitch trim characteristics of that particular aircraft were available.

The damage to the three-bladed propeller was restricted to that inflicted to the blade found to have been in the approximately vertically down position at the time of the impact. Neither of the other two blades had sustained any damage. The composite sheath of the damaged blade was largely broken away in a manner which did not make it clear in which direction the failure forces were orientated; however, its tubular steel central shaft was defected aft, with no deflection in the plane of rotation. It was thus initially concluded that the propeller was not turning at the time of the impact.

Strip examination of the engine and internal examination of the exhaust muffler revealed no evidence of any defect which could have resulted in loss of power. There was no reason to believe that any deficiency in the intake system could have resulted in a power loss. Although the ignition wiring was not in a condition to be tested, the system's 'dual' nature, coupled with the largely undamaged state of the only common parts, make it most unlikely that both ignition systems ceased to work.

The test carried out to determine the operating time of the engine at maximum power, following an OFF selection of the fuel cock confirmed that under such circumstances the engine would stop in a time interval which is far shorter than the time the aircraft required to travel from the point where the take-off roll began to the region of the accident site. Accidental selection of the fuel-cock control to the OFF position just before takeoff can thus be ruled out.

Study of the fuel cock design confirmed that significant restriction of flow rate would not occur even with the unit positioned well away from the fully ON position, either as a result of a simple mis-selection, inaccurate relative angular assembly of the lever, shaft and cock during build, or a combination of both. Hence the setting of the fuel cock as found (ie in a partially restricted flow position) would not have affected the engine at climb power, even if the cock had been set during the flight to the position in which it was found after impact.

Interpolating between the temperature and humidity recordings made at locations adjacent to Kemble would put the local conditions just within the region of 'serious carburetor icing at cruise conditions'. This definition applies to 'traditional' aero-engine float type carburetors operating without carburetor heat selected. Those used in the Rotax engine have not been subjected to the same degree of testing for onset of such ice, the layout of the intake system on N8027U and hence the temperature of the air entering the carburetor is not known and the engine type has not been shown to be particularly prone to carburetor icing. In addition, with full throttle presumably set for take-off and climb, the propensity for ice formation to lead to engine stoppage is minimized. It is therefore considered very unlikely that engine problems brought about by carburetor icing occurred.

In the light of all of these findings, no mode of failure or cause of power loss for the engine could be determined.

Evidence drawn from a later accident of a similar type of engine involved in a similar impact (albeit in a different aircraft type) confirmed that the initial impressions of power condition on this engine type could be misleading; at low power settings the engine can cease to revolve during the impact as a result of the propeller shaft being displaced aft and a gear on the shaft coming into firm contact with the rear of the reduction gear casing. This leaves subtle evidence which can only be detected if a specific part of the aft section of the gearbox is microscopically examined before the propeller is rotated.

Normal piston engine examination involves initially rotating the propeller. This sequence was followed in the case of N8027U. As a result of this process the microscopic evidence of rotating contact of the reduction gear pinion and the casing was presumed to have been overlaid on more subtle evidence of rotation at impact. It was therefore not possible to confirm whether or not the engine was developing power and the condition of the propeller was not considered to be a reliable guide.

Loss of power in the climb, whist the aircraft is correctly trimmed, normally results in a lowering of the nose on most aircraft in this category, if not resisted, and does not usually result in sudden loss of airspeed. It is thus not obvious how this aircraft can easily have progressed from a normal climb to the region of the stall and then a spin, following a loss of engine power, without an inappropriate pilot input.

In contrast, the behaviour of an aircraft when climbed too steeply is not entirely predictable. The asymmetry of airflow, as a consequence of the propeller wash, can encourage a sudden wing-drop as the stall condition is reached on some single engined piston types. The absence of stall strips (or the possible possession of a pronounced wing drop characteristic during a level 1 g stall) on this aircraft is likely to have accentuated the suddenness of any wing drop at the power-on stall, and the absence of strips will have lead to minimal stall warning. It appears, however, that the known evidence is more consistent with the aircraft suffering a power-on stall/spin condition rather than entering a spin following a power loss.

A pilot having trained in accordance with either the CAA or the FAA syllabus is not required to undertake spinning. There is no evidence that the pilot of this aircraft underwent any spin recovery training after the issue of his license. It is therefore probable that this was the first occasion either he or his daughter had experienced this flight condition. The disorientating effect of such an event would undoubtedly have reduced the pilot's chances of carrying out the correct spin recovery actions even if he had been familiar with them.

Conclusions

The aircraft was complete at the time of impact and there was no evidence of any mechanical or structural failure.

The aircraft probably entered a spin during the initial climb out. The precise reason for entry into the spin is not known. There was no conclusive evidence of loss of engine power. The possibility that the aircraft was climbed at too steep an angle and therefore lost flying speed whilst under power cannot be ruled out as a cause for initiation of the spin. During the spin the attitude was approximately 40º nose-down and rotation would have been rapid. The aircraft had insufficient height at the entry to the spin to offer a good chance of recovery.

The absence of any evidence of development work to identify and if necessary improve the stall characteristics of this particular aircraft probably rendered it more prone to an accidental spin than would be the case with other Europa aircraft. The aircraft does not appear to have possessed natural or artificial stall warning.

The pilot, who had minor administrative irregularities with his license, but was nonetheless in good flying practice, is unlikely to have possessed the skill or experience to initiate recover action from such a condition in the time available. The ease of spin recovery of the aircraft as built, and without refinement of the stall behaviour, remains unknown.

ACCIDENT

Aircraft Type and Registration:	Grob G115E, G-BYVZ
No & Type of Engines:	1 Lycoming AEIO-360-B1F piston engine
Year of Manufacture:	2000
Date & Time (UTC):	3 November 2005 at 1400 hrs
Location:	RAF Church Fenton, North Yorkshire
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Propeller and nose wheel assembly damaged
Commander's Licence:	RAF pilot's licence
Commander's Age:	24 years
Commander's Flying Experience:	289 hours (of which 116 were on type) Last 90 days - 41 hours Last 28 days - 21 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and company engineering investigation report

Synopsis

The nose landing gear had been incorrectly assembled during a 150 hour maintenance activity with the result that on the aircraft's ninth landing following return to service, the nose leg collapsed and the aircraft skidded to a halt on the runway.

History of the flight

On the day of the accident the pilot had flown a number of air experience flights, all in the subject aircraft, each lasting approximately 25 minutes. At the end of the fourth sortie the pilot made a normal powered approach, in blustery conditions, to Runway 16 and following an uneventful touchdown on the main wheels he lowered the nose wheel onto the runway and commenced normal braking action. However, as the aircraft decelerated the nose wheel slowly collapsed and the aircraft skidded to a halt. The emergency services responded and the pilot and passenger vacated the aircraft through the normal exit.

Description of nose landing leg assembly

The nose landing leg is secured to the aircraft by a steel housing and consists of a tubular strut, sliding tube, gas spring strut and a flange which is mounted on to the nose wheel fork assembly. The top of the sliding tube is retained within the tubular strut and the bottom of the sliding tube is secured by a bolt to the flange. The top of the gas spring strut is secured to the steering actuator lever by a nut and washer arrangement and the bottom of the gas spring strut is screwed into the bottom fitting, which is secured to the flange by a bolt. The same bolt is used to secure the sliding tube and gas spring strut to the flange. See Figure 1.

Engineering investigation

An investigation by the company's maintenance organisation revealed that the bolt which secured the nose landing gear sliding tube and gas spring strut bottom fitting to the flange had been incorrectly fitted such that the bolt only secured the bottom fitting to the flange. Consequently, when the aircraft landed, the weight on the nose wheel was sufficient to cause the failure of the bottom of the gas spring strut which resulted in the collapse of the nose wheel. See Figure 2.

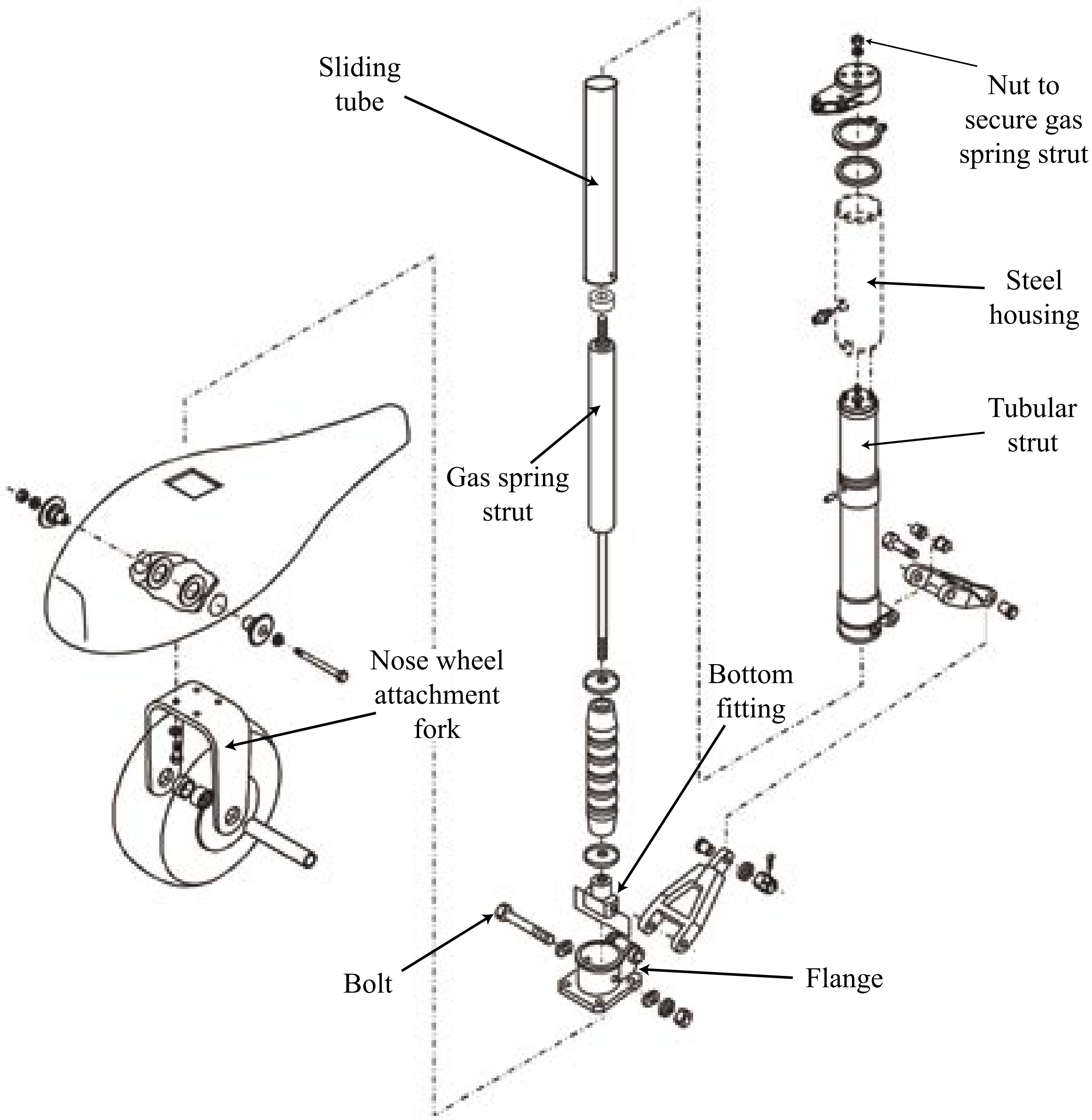


Figure 1

Nose landing leg assembley

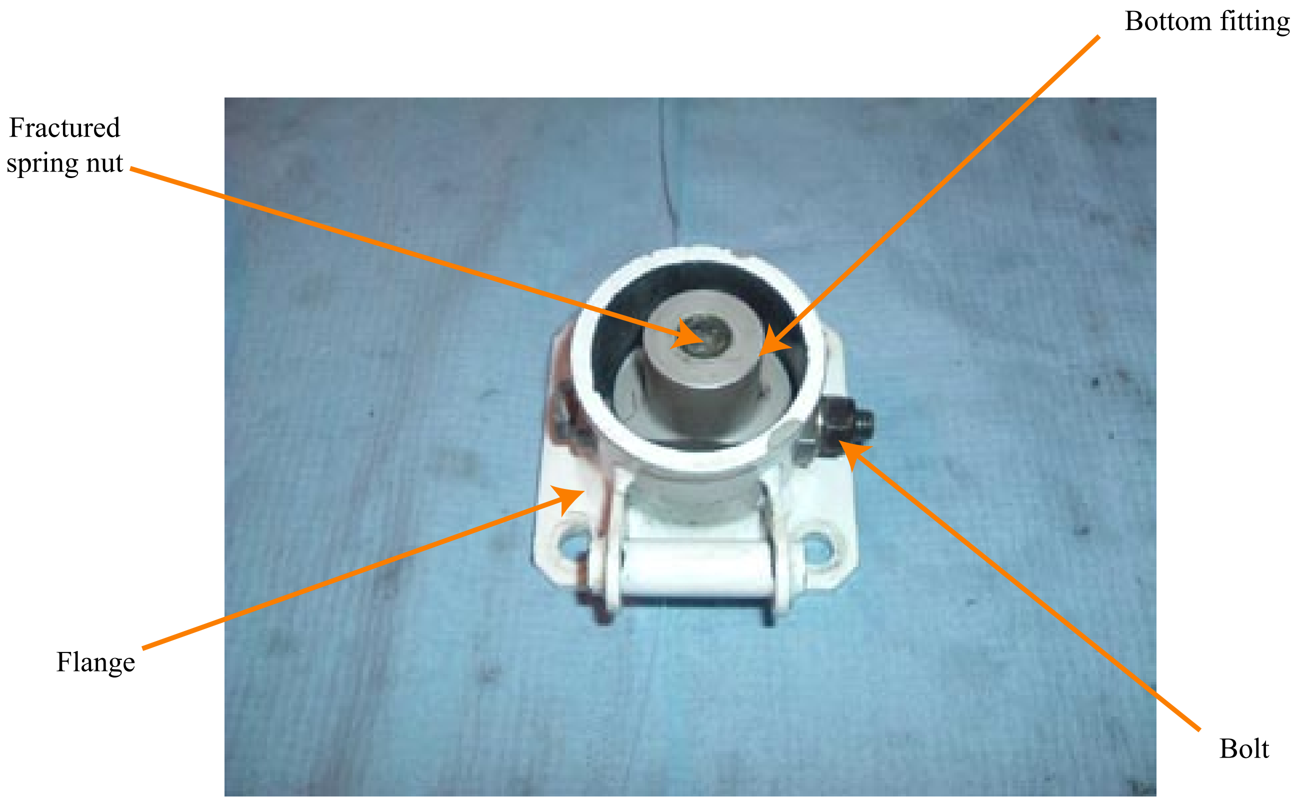


Figure 2

Failure of gas spring strut

The nose landing gear was last refitted to the aircraft during the 150 hour maintenance activity and failure of the gas spring strut occurred 3.5 flying hours and 9 landings later.

Remedial action

A similar incident occurred in June 2002 which resulted in the maintenance organisation instigating a fleet check to determine if the bolts on any other aircraft had been incorrectly fitted. Believing this to be an isolated occurrence, the maintenance organisation introduced a cautionary note into the maintenance manual emphasising the need to ensure that the bolt passes through both the sliding tube and gas spring bottom fitting.

The maintenance organisation estimates that there are approximately 60 occurrences a year when the subject bolt in the nose landing leg is disturbed. Nevertheless, despite the relatively low frequency of the bolt being incorrectly fitted, the maintenance organisation has reclassified the assembly of the nose leg as a critical task and has introduced a Vital/Duplicate inspection to confirm that the nose wheel undercarriage flange assembly is correctly assembled prior to fitment of the nose wheel fork.

ACCIDENT

Aircraft Type and Registration:	Maule MX-7-180, G-BSKG
No & Type of Engines:	1 Lycoming O-360-C1F piston engine
Year of Manufacture:	1990
Date & Time (UTC):	20 November 2005 at 1550 hrs
Location:	Top Farm, Cambridge, Cambridgeshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Wing, tailplane and rudder damaged, fuselage twisted
Commander's Licence:	Private Pilot's Licence
Commander's Age:	56 years
Commander's Flying Experience:	554 hours (of which 51 were on type) Last 90 days - 28 hours Last 28 days - 15 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

After an uneventful local flight the pilot rejoined the circuit at Top Farm, where he and the aircraft are based, approximately 15 minutes before sunset. The windsock indicated a gentle south-westerly wind and, having overheard the Cranfield Airfield (20 miles to the west) surface wind being given as 240º/5 kt, he decided to make an approach to the grass Runway 24. A curved final approach from the south was made to avoid a noise sensitive area on the runway centreline. Having established the aircraft on the runway centreline, the pilot was looking directly into the setting sun which significantly reduced his forward vision. He concentrated on what he believed to be the runway threshold and attempted to establish the aircraft on the correct approach path at the correct speed. The landing appeared normal although the runway surface seemed different from usual. As the aircraft slowed a parked light aircraft appeared out of the glare from the sun and the pilot was unable to prevent his left wing from colliding with the rear of the parked aircraft's right wing. His aircraft came to a stop and he was able to vacate through the normal exit without injury. Both aircraft had severe damage to their wings and were considered damaged beyond economic repair.

The pilot had landed the aircraft to the left of Runway 24 in an area containing young plants, resembling grass. During the landing roll he had crossed the unmarked airfield boundary into the airfield's parking area and run into the parked aircraft. The pilot stated that the reduced forward visibility arising from the setting sun led to his misplaced landing and lack of awareness of the parked aircraft. With the relatively light wind, he now considers that an approach to the reciprocal runway would have been a more sensible option. He also believes that he over concentrated on controlling his speed and height and avoiding a noise sensitive area during the final approach and in hindsight should have taken an early decision to go-around.

ACCIDENT

Aircraft Type and Registration:	Maule MX-7-180, G-RAZZ	
No & Type of Engines:	1 Lycoming O-360-C1F piston engine	
Year of Manufacture:	1988	
Date & Time (UTC):	21 June 2005 at 1740 hrs	
Location:	Plaistow Microlight Field, Hertfordshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 2
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Aircraft damaged beyond economic repair, and damage to crop	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	39 years	
Commander's Flying Experience:	1,052 hours (of which 42 were on type) Last 90 days - 92 hours Last 28 days - 43 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

The pilot reported that G-RAZZ was lined up for takeoff on Runway 33, which is a grass runway, 357 m long. The surface was dry, the Outside Air Temperature (OAT) was 25ºC and by reference to a windsock, the pilot estimated the headwind as being 10 kt. Based on his experience of similar conditions, the pilot estimated that the takeoff was within the performance capabilities of the aircraft.

During the takeoff the aircraft failed to reach sufficient height to clear a hedge at the departure end of the runway. The landing gear clipped the top of the hedge, causing the aircraft to come to rest upright, in a standing crop on the far side of a road beyond the hedge. The pilot and passengers were uninjured and were able to vacate the aircraft without difficulty.

The pilot attributed the accident to an incorrect estimate of the wind strength, and the runway slope.

ACCIDENT

Aircraft Type and Registration:	Pierre Robin HR100/200B, G-CBFN
No & Type of Engines:	1 Lycoming IO-360-A1D6 piston engine
Year of Manufacture:	1971
Date & Time (UTC):	29 May 2005 at 1651 hrs
Location:	Blackbushe Airport, Hampshire
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - 2 Passengers - N/A
Nature of Damage:	Damage to right wing leading edge, nose landing gear and nose structure
Commander's Licence:	Private Pilot's Licence
Commander's Age:	45 years
Commander's Flying Experience:	163 hours (of which 34 were on type) Last 90 days - 4 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot, further enquiries by the AAIB and metallurgical examination

The aircraft had completed a flight to Perranporth where the landing was uneventful, as was the subsequent taxiing and airborne portion of the return flight. The pilot reported that following a normal approach to Runway 25 at Blackbushe, with a speed of between 85 and 90 kt, flaps 1 selected, and calm wind, the aircraft touched down normally. However, when the pilot applied the brakes he felt no retardation and asked the passenger to assist him in applying brake pressure, which again had no effect. Around 200 m before the end of the runway he made an RT transmission stating 'brake failure'. By this time he judged it was too late to perform a go-around and the aircraft overran the end of the runway coming to rest on a small bank in amongst some gorse bushes. Both the pilot and passenger exited the aircraft unaided.

The Air Traffic Controller reported the aircraft seemed fast on final approach and touched down on Runway 25, which has a published landing distance available (LDA) of 1,058 m, 200 m beyond the threshold. No debris was found on the runway at Blackbushe.

Brake description and maintenance requirements

This type of aircraft is fitted with hydraulically operated disk type brakes on both main wheels. Brake pressure is applied via a floating cylinder assembly to compress the brake pads against the rotating disks (Figure 1). The manufacturer's approved brake pads consist of a backing plate to which friction material (Flertex 379) is bonded using Redux 64 adhesive. In 2001, a modification was introduced following instances where the friction material had become disbonded from the backing plates. The modification required the additional use of rivets to ensure attachment of the friction material to the backing plate (ref Robin Aviation drawing number 41-22-16).

The aircraft was maintained to the CAA Light Aircraft Maintenance Schedule (LAMS) ref CAA/LAMS/A/1999. The general inspection standards applied to individual inspection tasks must meet the recommended standards and practices of the organisation responsible for the type design and are normally published in maintenance manuals. The general inspection standard in LAMS requires the inspection of the landing gear including brake system, brake linings, drums/discs, wheels and tyres to be completed every 50 flying hours or 6 months whichever is the sooner. There is also a requirement for a pre-flight inspection of the 'brake installation for external evidence of leaks, and for damage and security'.

This aircraft was fitted with 'spats' covering the wheels and brakes, which made any pre-flight inspection of the condition of the brakes difficult.

Brake examination

The brakes were examined by the AAIB following the aircraft's recovery to a repair agency and subjected to further metallurgical examination at QinetiQ. Examination showed extensive damage to both sets of brake pads; the inboard (piston side - see Figures 2 & 3) backing plate of each brake exhibited evidence of metal smearing and material build-up towards one edge. There was some evidence of small amounts of friction material remaining on the backing plates along the edges at the inner radius of contact on the brake disc (Figures 2 and 3), and there was also evidence of deformation of the backing plates themselves.

Figure 1

Landing gear showing brake piston, disc and pads

The backing plates on the outboard side similarly showed extensive wear marks but did not show the material build-up. There was however evidence of corrosion around the outer edges of the backing plates. There was no evidence of any friction material being present.

Sections were taken through the edge of each backing plate and examined in a Scanning Electron Microscope (SEM), they showed that

> *'a thin surface layer approximately 40 µm thick was present, which energy dispersive x-ray (EDX) analysis showed to consist of iron and oxygen. It was also observed that the surface layer showed evidence of spalling.'*

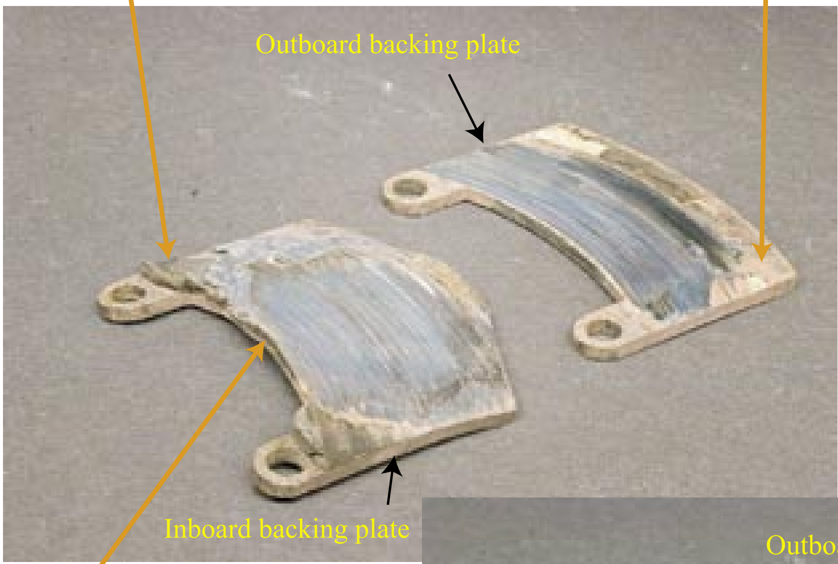


Figure 2

Brake pads (left)

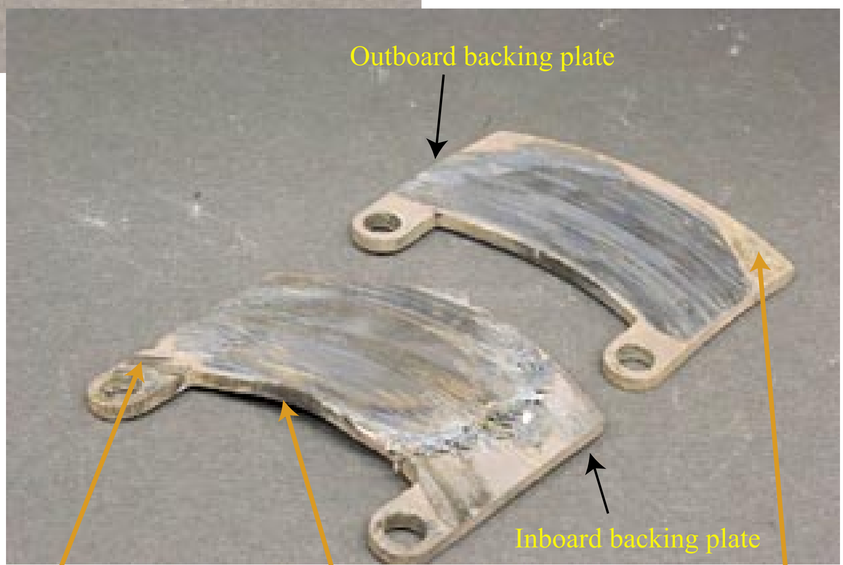


Figure 3

Brake pads (right)

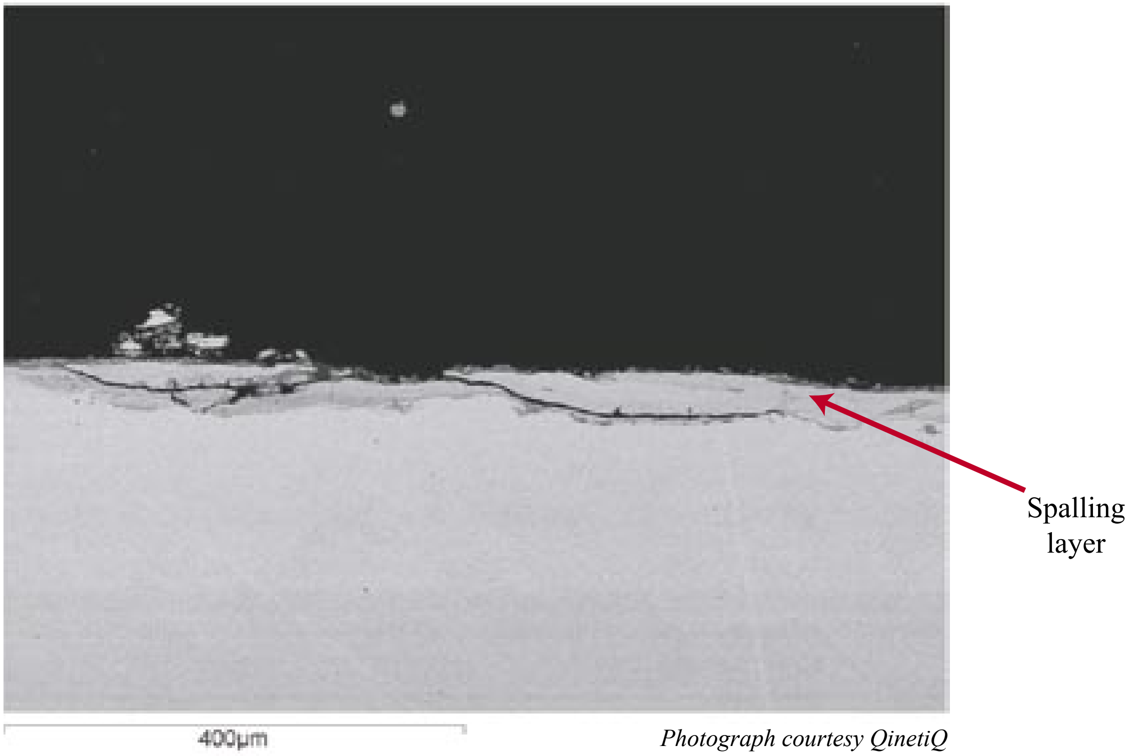
Photographs courtesy QinetiQ

Spalling describes the flaking of a surface where cracks run parallel to the surface, in this case due to the oxide layer (see Figure 4). They found

> *'where the material build-up was more pronounced, the analysis showed similar evidence of iron and oxygen present indicating that the material-build up consisted of the pad backing material.'*

A section through the remaining area of friction material

> *'showed evidence of cracking within the friction material and surface oxidation on the surface of the backing plate.'*



Photograph courtesy QinetiQ

Figure 4

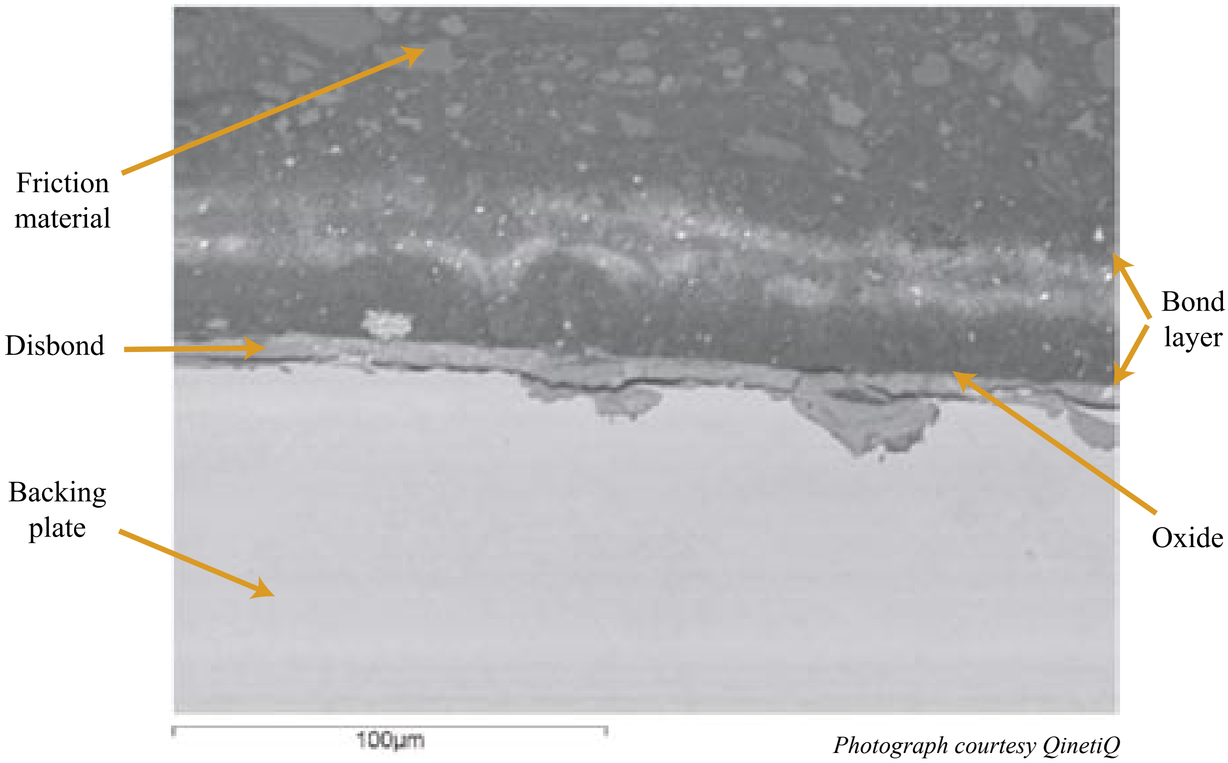
Cross Section through a smooth area of the right inner backing plate

There was a bond layer

> *'approximately 40 μm thick with the friction material appearing to be well bonded to it. A layer of surface oxide was present between the backing plate and bond layer approximately 7 μm thick, which appeared to have separated from the backing plate. This indicates that the friction material was not bonded to the backing plate in this area.' (see Figure 5)*

The report on the metallurgical examination of the brake pads concluded

> *'that very little of the friction material was present. The majority of the pads showed evidence of material removal and oxidation most likely from contact with the brake discs. The majority of the oxidation that was observed appeared to be blue in colour, which suggests thermal oxidation, as opposed to atmospheric corrosion. The oxidation is likely to have resulted from overheating of the pads during braking as the backing material was contacting the discs, overheating could also account for the distortion that was observed in two of the pads. Where small sections of friction material remained, examination showed that it was bonded to an oxide layer that was present on the surface of the backing plate. In some areas the oxide layer had separated from the backing plate, resulting in the friction material no longer being bonded.*
>
> *The cause of the brake pad failure can not be positively identified due to the lack of evidence remaining. The small sections of friction pad that did remain showed evidence of the friction*



Photograph courtesy QinetiQ

Figure 5

Cross Section through the bond line of the right inner backing plate

material being bonded to the oxidised surface of the backing plate, which suggests that the pad was not adequately cleaned before bonding. Evidence of surface corrosion was observed on pads, which could also be indicative of the surface condition prior to bonding.

The sections of friction material that did remain showed evidence of wear on the surface, which suggested that the pads had worn down at these points, as opposed to the friction material disbonding and spalling. As the majority of the backing plate material showed evidence of wear, it is not known if the friction material in these areas had worn or disbonded. However, the available evidence suggests that the friction material was bonded to an oxide layer on the backing plates, which could cause a weak bond. Sections of the friction material may have disbonded causing the remaining areas to wear a lot faster than normal due to the increased work load during braking.'

Brake history

The aircraft had a Certificate of Airworthiness in the Transport (Passenger) category and was operated by a group of pilots. In June 2004 the brake pads and right brake disc were replaced at the annual check having been found to be 'worn to limits' with metal to metal contact between the pad backing plates and the discs. Subsequently, the group reported an 'immediately noticeable drop in braking performance'; and the aircraft later suffered an overrun from the end of a runway into a flat field. There was no damage to the aircraft on this occasion. However, the pilot reported that the brakes had given 'poor braking effect'. The brakes would hold against a static load, but seemed poor when applied during the landing roll. Following the overrun incident the aircraft the brakes were checked and reported as satisfactory.

In September 2004, at the next 50 hour check, the brakes were reported as 'not being 100%'. The brakes were examined and the maintenance agency reported 'brakes rectified'.

The most recent maintenance on the brakes was during a 50 hour check carried out in March 2005; prior to this the brakes had again been reported as 'not being 100%'. The maintenance agency examined the brakes and their Worksheet states 'replace, re-line and refit' the pads, following which the aircraft was test flown and the brake system was reported to be satisfactory. The maintenance organisation indicated that approved manufacturer's pads were not readily available, not being held in stock by their aircraft parts supplier, and had sent the pads to the supplier to be re-lined. The relining had been performed by an automotive supplier; the process involved the use of '416' industrial material which was bonded to the existing backing plate using 'Bostik 177' and heat treated to 300ºC. The pads were not riveted.

At the time of the accident the aircraft had flown approximately 30 hours since the maintenance input.

Brake relining

Relining of brakes is not uncommon, particularly on aircraft where approved parts are not available. The CAA does not publish any advice on the relining of brakes. General guidance and advice on wheels and brakes is published in CAP 562 CA AIP leaflet 5-8. This supplements the manufacturer's information published in their maintenance manual. The replacement of brake pads and the parts to be used would need to be those specified in the manufacturer's manuals. Relining would be classified as a repair and, if permitted, would need to be carried out in accordance with approved repair data, normally specified in the maintenance manual. It is recognised that, owing to the inflexibility of the brake lining material, a poor bond is likely to be achieved if an attempt is made to reline a distorted backing plate. It could not be established whether the backing plates in this instance, were distorted before relining or during this event.

No approval for relining the brake pads had been given by the manufacturer of this aircraft type, nor, given their experience of pad disbonding in other incidents would they have given approval for relining using only adhesive to attach the friction material to the backing plates.

Discussion

The landing distance available on Runway 25 at Blackbushe is quite adequate for this type of aircraft, which typically requires a landing roll of less than 400 m. The runway also has 3.1º PAPIs available for approach path assistance on request. Consequently the major reason for the aircraft overrunning is considered to be misjudgement of the approach to land. Approaches misjudged to varying degrees are not particularly unusual in General Aviation, however, and it would be reasonable for pilots to have an expectation of normal aircraft braking performance.

There was a history of braking problems on this aircraft which had already resulted in one overrun incident. The brakes were checked at the 50 hour interval specified in LAMS but it was difficult for the group to routinely monitor brake wear as the aircraft was fitted with spats. The pilot on this incident reported no braking problems on the previous flight, or while taxiing prior to the accident flight. The nature of the damage to the brake pads is consistent with hydraulic pressure operating to apply pressure to the pads; the evidence indicates that a large amount of heat energy was generated by the friction between the pads and the discs. However, there was little retardation of the aircraft.

It was not possible to determine whether the incident resulted from disbonding of significant amounts of friction material, or simply from an absence of material due to excessive wear. However, the metallurgical examination did produce evidence that the friction material had been bonded to an oxide layer on the backing plates, which could have caused a weak bond. There was no evidence of debris on the runway at Blackbushe.

The brake pads fitted to G-CBFN were not manufacturer's approved parts. The manufacturer had introduced the new standard of bonded and riveted pad in 2001 due to an in service problem of brake friction material disbonding from the backing plates. However, this change had not been communicated to owners and maintenance agencies, some of whom were not aware of the new standard.

Safety Recommendation 2005-145

It is recommended that Apex Aircraft, the Manufacturer and Type Certificate holder for Robin aircraft types, issues appropriate information to owners and maintenance organisations regarding the revised standard of brake pads with bonded and riveted friction material and clarify the acceptability of fitting brake pads which have been relined.

ACCIDENT

Aircraft Type and Registration:	Piper PA-22-160 Tri-Pacer, G-BTLM
No & Type of Engines:	1 Lycoming O-320-B2A piston engine
Year of Manufacture:	1958
Date & Time (UTC):	1 November 2005 at 1410 hrs
Location:	Tattenhill Airfield, Staffordshire
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to the right wing, elevator and stern post
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	48 years
Commander's Flying Experience:	12,837 hours (of which 1 was on type) Last 90 days - 90 hours Last 28 days - 50 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot was flying G-BTLM with its owner, with a view to purchasing the aircraft. The intention had been to use the grass runway at the airfield because of the greater controllability of tail wheeled aircraft on that surface, but that was not available. The surface wind was from 240º at 10-15 kt and the asphalt Runway 26 was used instead.

After some general handling to the west of Tattenhill, the aircraft returned to the airfield for two touch and go landings before a final landing. The pilot reported that the wind had become rather gusty and he believed that trees to the left of the runway were causing some turbulence. The touch and go landings were completed without incident and the final approach was reportedly good, in spite of the gusty wind. However, G-BTLM touched down firmly on the main wheels and bounced. On the next touch down the aircraft veered to the right and the pilot attempted to maintain directional control with rudder and light left wheel braking. With the engine at idle power, the aircraft continued on to the grass to the right of the runway at an angle of 45º, then ground looped to the left, tipping on to its right wing tip in the process. It finally came to a halt on a heading of about 130º. During the ground loop the right wing, the elevator and stern post had been damaged. Neither of the crew was injured and they exited the aircraft normally.

The pilot stated candidly that the accident was the result of an inability to maintain directional control on touchdown. Contributory factors were his unfamiliarity with the aircraft, the gusty conditions and operating from an asphalt runway. He concluded that, because of the aircraft's low takeoff speed, if he had applied full power and gone around as soon as the aircraft had started to veer, the accident could have been prevented.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28R-180 Cherokee Arrow, G-OKAG
No & Type of Engines:	1 Lycoming IO-360-B1E piston engine
Year of Manufacture:	1967
Date & Time (UTC):	23 September 2005 at 1850 hrs
Location:	Chirk, North Wales
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Both wings, propeller and fuel tank
Commander's Licence:	Private Pilot's Licence
Commander's Age:	41 years
Commander's Flying Experience:	350 hours (of which 80 were on type) Last 90 days - 15 hours Last 28 days - 7 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

History of the flight

The pilot was carrying out a flight from Stapleford Aerodrome near London to Llandegla Airfield near Ruthin in Wales. The weather forecast for the route was: surface wind from 240º at 8 kt becoming northerly, CAVOK but with occasional showers with visibility reducing to 7,000 m and cloudbase 3,000 ft reducing to 1,000 ft in the showers.

The transit was flown between 2,000 ft and 3,000 ft and was uneventful until nearing the intended destination. When approximately 10 nm from Llandegla, the weather there deteriorated and the pilot elected to divert to the private airfield at Chirk. His flight guide showed the airfield had two runways but, with the prevailing wind conditions, Runway 19 would be the more suitable for landing. That runway was 500 m in length and 20 m wide with a grass surface and an uphill slope. Earlier in the day the pilot had contacted both Llandegla and Chirk Airfields by telephone to confirm their availability and any special instructions.

On arrival at Chirk, the pilot made an overhead join followed by an orbit of the field to familiarise himself with the layout. He had not operated from Chirk before and established that the surface wind indicated by the windsock was 230º/10 kt. Having completed a circuit and configured the aircraft with full flap, the pilot made an approach with a go-around before committing to a landing. The second approach was made with full flap and an approach airspeed of 75 mph. The approach and flare were normal with the aircraft touching down within the first 60 m of the runway. When the wheel brakes were applied, the aircraft skidded along the grass surface but the pilot was able to maintain directional control. He pumped the brake pedals and combined with the upslope, the aircraft slowed down but with insufficient runway remaining, the pilot realised the aircraft would slowly overrun the runway. He steered towards what appeared the least solid obstruction which was a wire fence to the right of a 'Portacabin'. Just prior to striking the obstacles, the pilot began isolating the electrical services but the propeller and left wing struck the Portacabin; then, as the aircraft slewed to the left, the right wing contacted a fence post. The pilot and his passenger were uninjured. The pilot carried out the emergency shut down drills before he and his passenger vacated the aircraft through the normal exit.

Following the accident, the pilot noticed that the wind direction indicated by an industrial chimney adjacent to the airfield showed a surface wind direction of about 270º. He was informed that due to the local geography, variations in wind direction at height are common at Chirk. Later, when visiting the site after the accident, he noticed the windsock showed a westerly direction whilst the chimney smoke was being blown by a northerly wind.

Analysis

Before leaving Stapleford the pilot had contacted both his destination and alternate airfields and established all the relevant information he required. As the weather at his destination deteriorated, he made the prudent decision to divert to his alternate airfield. The Runway 19 length of 500 m was on long, wet grass with an ill-defined uphill slope. Moreover, the variable direction of the wind at Chirk meant that he may have landed without any significant headwind component.

The landing distance required for the aircraft weight and ambient conditions was 340 m based on a normal landing profile from a height of 50 ft. The CAA Safety Sense leaflet number 7C entitled '*Aeroplane Performance*' advises that landing on long, wet, grass (up to 20 cm long) on firm soil may require a 35% increase in the landing distance required on tarmac or concrete. Very short, wet, grass on firm soil may require up to a 60% increase in landing distance required. From these additional factors, depending on the length of the grass, the actual landing distance required could have been between 459 m (340 x 1.35) and 544 m (340 x 1.6).

Conclusions

Whilst the pilot had attempted to ensure that he was fully apprised of all the relevant information for his destination and alternate airfields, the runway length for the runway surface conditions was marginal and he was unable to stop the aircraft before the end of the runway.

ACCIDENT

Aircraft Type and Registration:	PZL-Koliber 160A, G-BZAJ
No & Type of Engines:	1 Lycoming O-320-D2A piston engine
Year of Manufacture:	1999
Date & Time (UTC):	26 October 2005 at 1230 hrs
Location:	Near Clayton, Sussex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Extensive
Commander's Licence:	Private Pilot's Licence
Commander's Age:	67 years
Commander's Flying Experience:	934 hours (of which 196 were on type) Last 90 days - 23 hours Last 28 days - 8 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and enquiries by the AAIB

Synopsis

On a planned flight from North Weald to Bembridge, the pilot encountered deteriorating weather and became lost and disorientated. While attempting to turn back towards better weather, the aircraft struck the ground. The pilot acknowledged that he had not fully evaluated the weather forecast and his decision to turn back was too late.

History of the flight

The pilot intended to fly from North Weald Aerodrome to Bembridge (Isle of Wight) Aerodrome, a route with which he was familiar. On his arrival at North Weald the local weather was good and he checked the METARs for Stansted, Gatwick and Southampton. These all indicated a visibility greater than 10 km and no scattered cloud below 1,400 ft agl. With no apparent weather limitations, the pilot planned his route to pass east of London crossing Mayfield and Goodwood VORs and then to Bembridge.

He took off at 1139 hrs and climbed to 1,900 ft amsl for his initial cruise. Initially, the weather was excellent but, as he passed to the east of Gatwick, he experienced some light turbulence and scattered cloud and he descended to 1,700 ft amsl. At about 1210 hrs, he listened to the Southampton weather frequency (VOLMET), which was broadcasting a visibility of 10 km and cloud scattered at 2,000 ft agl. Then, after passing Mayfield VOR, the pilot became aware of a lowering cloud base and he reduced his altitude to 1,200 ft amsl. Shortly after, the visibility also began to reduce and the pilot was unable to locate one of his planned geographical reference points. He was aware that he was now lost and becoming disorientated and so he decided to turn back towards Mayfield. However, as he was turning left, he suddenly saw ground directly ahead of the aircraft and pulled back hard on the control column. As the nose of the aircraft came up, the pilot felt the aircraft hit the ground. He was knocked unconscious during the impact and, when he regained consciousness, the aircraft was at rest with the gear detached and the canopy slightly open. The pilot was in pain and aware of minor cuts to his face and arms but he was mobile. After switching off the fuel and electrics, he walked across a field and down a lane, where he met police personnel coming to investigate the reports of a crashed aircraft. At the time, the area was covered in thick fog.

The elevation of the crash site was approximately 600 ft amsl.

Weather information

The Met Office provided an aftercast for the area. The synoptic situation at 1200 hrs showed a moistening south-westerly flow covering Sussex as a warm front moved in from the south-west across southern England during the morning. In the area of the crash, there were outbreaks of slight rain or drizzle at times with a surface visibility of 6 to 9 km in haze or rain. There were also patches of stratus with the lowest cloud base between 300 and 700 ft amsl.

The weather forecast shown on the UK Low Level Forecast (Form 215) for 26 October 2005 was substantially correct. This indicated a low cloud base over the coastal area. Additionally, the TAF for Southampton was also accurate with the forecast issued at 0910 hrs and valid between 1000 and 1900 hrs as follows: Surface wind 190º/ 12 kt; visibility greater than 10 km and cloud broken at 1,400 ft agl; temporarily between 1000 and 1500 hrs, visibility of 7,000 m and cloud broken at 700 ft agl; 30% probability of a temporary condition between 1100 and 1400 hrs of visibility of 4,000 m in rain or drizzle and cloud broken at 400 ft agl.

Conclusion

The pilot produced a very honest account of the accident and assessed the cause as a late decision to turn back after encountering deteriorating weather. On reflection, he also acknowledged that a closer evaluation of the weather forecast would have left him better prepared for the possibility of deteriorating weather along his route.

Safety Sense Leaflet 1 *General Aviation* in LASORS 2005 contains advice on general airmanship and includes information that one of the main fatal accident causes during the last 20 years has been continued flight into bad weather. The publication contains good practical advice as does Safety Sense Leaflet 5 *VFR Navigation.*

ACCIDENT

Aircraft Type and Registration:	Reims Cessna F152, G-BIUM
No & Type of Engines:	1 Lycoming O-235-L2C piston engine
Year of Manufacture:	1980
Date & Time (UTC):	19 October 2005 at 1300 hrs
Location:	Netherthorpe Aerodrome, Worksop, Nottinghamshire
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to nose wheel, both wing tips and propeller and engine mounts
Commander's Licence:	Student
Commander's Age:	41 years
Commander's Flying Experience:	14 hours (all on type) Last 90 days - 14 hours Last 28 days - 7 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The student pilot was on his first solo flight in good weather with a light surface wind of about six knots. Having completed a good circuit and approach, the student flared the aircraft in expectation of landing. However, just as the aircraft was about to touch down, it "ballooned" back into the air, most probably because the student applied too much aft movement of the control wheel. As he had been instructed, the pilot then applied power to cushion the subsequent landing but the aircraft stalled from a height of about five feet causing the left wing to drop. The left wing tip struck the ground, after which the aircraft rolled to the right, striking its right wing tip before coming to rest, having also damaged its nose landing gear. The student was uninjured and vacated the aircraft via his cockpit door.

ACCIDENT

Aircraft Type and Registration:	Scheibe SF25B, G-AXEO
No & Type of Engines:	1 MS 1500/2V piston engine
Year of Manufacture:	1969
Date & Time (UTC):	9 July 2005 at 1122 hrs
Location:	Milfield Airfield, Northumberland
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Extensive damage to both wings, fuselage and propeller
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	62 years
Commander's Flying Experience:	135 hours (of which 5 were on type) Last 90 days - 5 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

History of flight

The pilot planned to fly the aircraft once it returned from a cross-country flight of approximately one hour. The pilot on that flight reported that the aircraft was running "very nicely". He also advised against refuelling since the surface temperature was +25°C, and the increased mass would have an adverse effect on performance during the subsequent takeoff. There was approximately 15 ltr of fuel remaining which was more than sufficient for the one hour flight that the pilot had planned: the aircraft was not refuelled.

After starting the engine the pilot taxied to a point short of the take-off position where he completed his power checks and pre-take off checks. Runway 36 was in use and its grass surface was dry. The pilot reported that he observed 2,400 rpm during the power checks prior to takeoff, this being the minimum criteria for power output for takeoff on this aircraft type. He also noted that there was no significant drop in engine rpm on application of carburettor heat. The Chief Flying Instructor of the gliding club reported that this was not unusual on this aircraft type due to the poor performance of the carburettor heating on this engine.

The pilot then continued to the take-off point once a glider that was in the circuit had landed. A wait of some five minutes then passed whilst the glider was retrieved. During this period the engine speed was maintained at

1,100 rpm, which is the usual power setting to apply whilst stationary on the ground. Once the glider had been retrieved the pilot commenced the takeoff.

The aircraft was seen by witnesses to become airborne approximately two thirds of the way along the runway and climb initially to a height of 20 to 30 ft agl. At this point the pilot reported that there was a progressive reduction in engine power. By this time, being at about 80 ft, he realised that he was too high to land in what remained of the airfield ahead. The engine then stopped completely and the aircraft started to descend.

The aircraft's propeller struck the top of a fence which marks the boundary of the airfield with the adjacent field. The left wing made contact with a small tree in this boundary fencing, causing the aircraft to yaw to the left as it struck the ground on the other side of the fence. The aircraft then came to rest on a concrete area in the adjacent field; part of a disused airfield. The pilot vacated the aircraft unassisted and without injury.

Meteorological information

The Meteorological Office provided an aftercast for the area at the time of the accident. It indicated a ridge of high pressure extending across the British Isles from the south west with an area of slack pressure gradient lying over the Scottish Borders.

The visibility was generally 20 km, with no low cloud, with perhaps a few cumulus clouds at 3,000. The surface wind was assessed as variable (mainly east to south easterly) 2 to 5 kt, with a temperature of +24ºC, a dew point of +13ºC and a relative humidity of 51%.

The pilot reported a visibility in excess of 25 km with no significant cloud. The surface wind was variable (mainly north, north easterly) less than 5 kt, temperature +25ºC, dew point +13ºC.

Aircraft and engine examination

The damage to the aircraft was extensive; the left wing spar was broken, the right wing was cracked, the rear fuselage twisted and the propeller was damaged. The aircraft was assessed as damaged beyond economic repair.

The engine was inspected by the resident maintenance organisation. The engine showed no signs of any internal damage and subsequently started without difficulty.

Carburettor icing

The temperature and dew point derived from the aftercast were plotted on the Carb Icing Chart in Safety Sense 14, found in LASORS and AIC 145/1997. They fall into an area where serious icing can occur at descent power and where moderate icing can occur at cruise power.

An extract of LASORS Safety Sense 14, *Piston Engine Icing* is shown below:

> *Carb icing is not restricted to cold weather, and will occur on warm days if the humidity is high, especially at low power settings. Flight tests have produced serious icing at descent power with the ambient (not surface) temperature over 25°C, even with relative humidity as low as 30%. At cruise power, icing occurred at 20°C when the humidity was 60% or more. (Cold, clear winter days are less of a hazard than humid summer days because cold air holds less moisture than warm air.) In the United Kingdom and Europe where high humidity is common, pilots must be constantly on the alert for the possibility of carb icing and take corrective action before an irretrievable situation arises.*

The Chief Flying Instructor believed that the poor performance of the carburettor heat system may have led to carburettor icing. He believed that the length of the hot air ducting to the carburettor would allow the heat to dissipate from the ducting material. In addition, the routing of the normal air supply to the carburettor is from the front of the engine through the cylinder cooling apertures at the front of the close-fitting engine cowlings. This air would therefore be warmed as it passed over the cylinder cooling fins and this effect would be amplified when the aircraft was on the ground at low engine rpm and with no ram-air effect. Thus, the temperature differential between the normal air supply to the carburettor and the heated air would be reduced.

A search of the CAA's Mandatory Occurrence Report database of carburettor icing incidents to SF25b aircraft fitted with these engines revealed no previous occurrences.

Manufacturer's comments

In discussion with the manufacturer a number of possibilities were considered that might have caused the engine to stop. However, given the high outside air temperature, the warm engine from the previous flight and the protracted time awaiting the takeoff, they believed that a vapour lock in the fuel system might have been the cause.

Conclusion

Neither carburettor icing nor a vapour lock in the fuel system would leave any subsequent evidence.

Prior to the takeoff the aircraft was stationary on a dry grass surface for approximately five minutes with the engine set to 1,100 rpm. The ambient temperature was +25ºC, the dew point was +13ºC and the relative humidity was 51%. The engine was already warm from its previous flight and the normal air supply to the carburettor would have provided very warm air as a consequence of its low flow rate through the engine compartment in the absence of any ram effect. It is therefore considered unlikely that carburettor icing would have occurred in these conditions. Conversely, these conditions were ideal for the formation of a vapour lock in the fuel line.

INCIDENT

Aircraft Type and Registration:	Streak Shadow, G-BUVX
No & Type of Engines:	1 Rotax 582 piston engine
Year of Manufacture:	1994
Date & Time (UTC):	11 December 2005 at 1300 hrs
Location:	Brook Farm, near Garstang, Lancashire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Minor damage to the landing gear
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	180 hours (of which 53 were on type) Last 90 days - 3 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot, plus follow up telephone inquiries to pilot

After taking off from a 300 m long farm strip for a flight in the local area, G-BUVX reached a height of approximately 50 to 80 ft in the climb out when the engine lost all power. Trees situated beyond the upwind end of the strip precluded a landing directly ahead, the pilot lowered the nose and initiated a turn to the left. After dismissing the option of landing in a field of sheep to the left of the strip, he turned back into wind and carried out a landing into a rough field of 'set-aside' land, situated just beyond a barbed wire fence and ditch which formed to boundary of the upwind end of the strip, to the left of the trees.

The pilot was subsequently able to establish that the engine had failed as a result of fuel starvation, resulting from the blockage of a fuel pipe by excess sealant used to seal the fuel gauge sender unit mounting flange against the tank wall.

ACCIDENT

Aircraft Type and Registration:	Thorp T-18, G-BSVN
No & Type of Engines:	1 Lycoming O-290-G4 piston engine
Year of Manufacture:	1967
Date & Time (UTC):	9 October 2005 at 1430 hrs
Location:	Near Ashcroft Airfield, Winsford, Cheshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Undercarriage frame and bulkhead distorted, propeller damaged
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	79 years
Commander's Flying Experience:	1,026 hours (of which 256 were on type) Last 90 days - 0 hours Last 28 days - 0 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

During a test flight from Ashcroft Airfield for the purpose of renewing the aircraft's Permit to Fly, the pilot noticed that spots of oil were appearing on the windscreen and attempted to return to the airfield to investigate the problem. On final approach to grass Runway 27, the aircraft stalled and touched down in a farm field approximately 50 m short of the runway threshold. The pilot's assessment of the cause was that, pre-occupied by the need to land immediately, he had allowed the airspeed to decay during the final approach and the aircraft stalled before he was able to initiate an effective recovery. When he inspected the aircraft immediately after the accident, the pilot found that the return oil pipe had become detached from a recently fitted air/oil separator. He determined that this was probably the cause of oil contamination on the windscreen.

History of the flight

On levelling at 2,500 ft in preparation for a series of manoeuvres, the pilot noticed spots of oil gathering on the windscreen. He decided to return to the airfield immediately to investigate the problem. He reported that on final approach to the grass Runway 27, his attention became pre-occupied with the increasing amount of oil on the windscreen and the need to land immediately. At approximately 50 ft agl the left wing dropped suddenly. The pilot recalled that he glanced at the ASI, which indicated an airspeed of approximately 60 kt, causing him to apply power and possibly a right aileron input. The aircraft continued to descend and it touched down heavily in a field approximately 50 m short of the runway threshold. The heavy landing inflicted damage to the main landing gear 'A' frame and the fuselage bulkhead to which it was attached. The pilot was uninjured and vacated the aircraft unaided.

The aircraft was recovered immediately to Ashcroft Airfield where the owner assessed the damage.

Meteorological conditions

An unofficial weather report provided by the airfield indicated a wind of 10 kt from 230º with good visibility, air temperature 17ºC and dew point 11ºC. The QNH measured locally was 1013 hPa.

Aircraft information

The Thorp T-18 is a high performance, homebuilt, two-seat monoplane with tail wheel landing gear. The stalling characteristics of individual aircraft vary, but are generally characterised by an abrupt stall with little warning, during which a wing may drop. Some have 'V'-section stall strips fitted to the inboard wing leading edges in order to promote a more predictable stall, but the subject aircraft was not so equipped. Information obtained from several owner organisations indicated that a stalling speed of between 50 and 56 kt is representative for the type.

The owner maintained the aircraft himself and operated it under the supervision of the PFA. The most recent certificate of validity of the aircraft's Permit to Fly expired in July 2005. The aircraft was inspected by a PFA accredited engineer on 26 September 2005 and issued with a Permit Flight Release Certificate allowing it to undertake the test flight.

During maintenance in preparation for the permit renewal, a replacement air/oil separator had been fitted and secured using jubilee clips. The owner stated that when he inspected the aircraft immediately after the accident, he noticed that the return oil pipe from the exit side of the air/oil separator was detached. Although it was not possible to establish whether this had occurred at or prior to impact, the owner stated that he had not encountered similar difficulties with this aircraft before the accident flight.

Conclusion

The aircraft had been maintained, operated and certificated in accordance with standards published by the PFA. It is likely that the return oil pipe detached from the exit side of the recently fitted air/oil separator before or during the accident flight, allowing oil to contaminate the windscreen. During the approach to the airfield, the pilot became pre-occupied with the need to land the aircraft and allowed its airspeed to decay to such an extent that the left wing stalled. The application of power and the right aileron input probably exacerbated the left wing drop and the aircraft hit the ground before effective recovery action could be initiated.

ACCIDENT

Aircraft Type and Registration:	Yak-52, G-CBMI
No & Type of Engines:	1 Ivchenko Vedeneyev M-14P piston engine
Year of Manufacture:	1985
Date & Time (UTC):	28 June 2005 at 1300 hrs
Location:	Onecote Strip, Staffordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Port and starboard wings damaged. Minor damage to propeller and engine possibly shock loaded
Commander's Licence:	Private Pilot's Licence
Commander's Age:	50 years
Commander's Flying Experience:	450 hours (of which 17 were on type) Last 90 days - 60 hours Last 28 days - 22 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

On a return flight from East Midlands, the pilot overflew the strip at Onecote to check the windsock before making his approach to land on the grass Runway 34. This runway is 600 m by 30 m, but also has a 50 m extension at the far end. It is located on the spine of a high ridge, and is subject to strong up and downdraughts. There is also a fence close to the left edge of the runway.

The pilot reports that he landed slightly long and fast, and maintained braking in order to stop in the remaining distance available, however he was unable to prevent the aircraft drifting to the left until it struck a gatepost with the left wing, some distance short of the end of the runway. The aircraft then swung left into the fence. The pilot was uninjured and was able to vacate the aircraft normally.

The pilot attributed the cause of the accident to his misjudgement compounded by variations in the wind direction whilst landing.

ACCIDENT

Aircraft Type and Registration:	Bell 206B Jet Ranger III, G-CVIP
No & Type of Engines:	1 Allison 250-C20B turbine engine
Year of Manufacture:	1981
Date & Time (UTC):	16 July 2005 at 1320 hrs
Location:	Flecknoe, Warwickshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 3
Injuries:	Crew - None Passengers - None
Nature of Damage:	Tail pylon severed immediately aft of the horizontal stabiliser
Commander's Licence:	Private Pilot's Licence
Commander's Age:	34 years
Commander's Flying Experience:	113 hours (of which 30 were on type) Last 90 days - 1.4 hours Last 28 days - 0.7 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

History of the flight

The pilot had hired the helicopter to carry out a local area flight from Sywell Aerodrome with three friends culminating with a landing at a private site at Flecknoe near Daventry. Prior to that flight he carried out a 28 day check flight with an instructor pilot which covered both normal and abnormal procedures including autorotations. The weather for the area of the flight was CAVOK with the surface wind at Sywell from 030° at 6 kt.

Having completed the pre-start checks, the pilot noted the fuel onboard was 67 USG and started the engine. He depressed the starter button and, as the engine N_1 increased to 15%, he opened the throttle. The engine accelerated normally and the power turbine inlet temperature remained within limits. As N_1 reached 50%, the engine began to run down. The pilot maintained the starter engagement until the N_1 reduced to approximately 20% at which point he shut down the engine. The pilot had never experienced this before and having pulled the starter circuit breaker, sought the assistance of a more experienced commercial pilot. That pilot sat in the aircraft and observed the second start which was normal without a repeat of the earlier problem.

The pilot completed the pre-takeoff checks and made a normal departure, climbing to 1,500 ft and flew around the local area for approximately 20 minutes. A course was set for the private site at Flecknoe and during the transit the low voltage light "blinked" twice. The pilot depressed the light to test it and after blinking three times, it extinguished. The pilot considered it safe to continue whilst monitoring the light which, to his knowledge, did not illuminate again during the flight.

Upon reaching Flecknoe, the fuel was noted at 50 USG; engine temperatures and pressures were all normal. The QFE and surface wind check at Sywell were noted and Sywell AFIS was advised that the aircraft would be landing at Flecknoe and leaving the frequency. Before landing, the pilot flew over the landing site to confirm that it was clear of wires and other obstructions. He approached into wind and reduced speed to about 70 KIAS whilst lowering the collective control lever to establish a rate of descent. A check of the engine instruments showed all was normal and the approach was continued. At a height of approximately 100 ft he became aware of an intermittent audio warning tone followed by a continuous audio warning tone. He noted that the ROT LOW RPM warning light on the CWP (Central Warning Panel) was illuminated and so he immediately entered autorotation, concentrating on carrying out an engine-off landing. At about 20 ft the pilot flared the helicopter and raised the collective control lever "aggressively" to check the rate of descent. There was a loud bang and a violent shuddering through the airframe that coincided with the large control inputs. The pilot lowered the collective and allowed the aircraft to run along the grass surface. A cloud of smoke appeared to the pilot's left and he evacuated the passengers and shut down the helicopter.

When clear of the aircraft, the pilot checked that all his passengers were accounted for and there were no signs of fire with the aircraft. The tail pylon had been completely severed immediately aft of the horizontal stabiliser by the main rotor blades. The pilot notified the helicopter operator of the situation and shortly afterwards, one of the operator's staff attended the scene in another helicopter.

The passengers confirmed that they had heard the loud intermittent audio warning noise prior to the pilot entering autorotation. Witnesses watching the helicopter's approach informed the pilot that during the descent, the helicopter was seen to de-stabilise and the rotors coned upwards. This probably happened when the pilot entered autorotation.

Engine and rotor warning systems

The 'Engine Out' warning system is activated when N_1 drops below 55%. It comprises an intermittent audio signal and an illuminated ENG OUT caption on the CWP.

The 'Rotor Low RPM' audio warning is activated when the collective pitch lever is off the down stop and rotor RPM is less than 90%. It comprises a steady audio signal and an illuminated ROT LOW RPM caption on the CWP.

Engineering action

The engine was removed and sent by the operator to an approved overhaul facility for inspection and bench testing. Engine acceleration and deceleration checks were accomplished satisfactorily. These were accomplished for the second time and recorded parameters were within the specified limits. No hesitation was noted during starts and power transients. No magnetic chip light indications were observed. Oil consumption was recorded as nil. In all tests, the engine did not smoke during any phase of operation. The exhaust collector was dry and no smoke was observed after shut down. The test data indicated that the engine met the manufacturer's minimum specification requirements. No technical reason for a loss of power was identified.

Analysis

After the training flight, the pilot attempted to start the helicopter for his local area flight. In the absence of any technical reason, a possible cause of the inability of the engine to accelerate beyond 50% N_1 was the throttle not being opened sufficiently to permit adequate fuel flow. A second start was accomplished normally. During the flight, the low voltage warning light illuminated, indicating that the voltage in the battery had fallen momentarily below a pre-determined level.

On the final approach at about 100 ft the intermittent sound of the ENG OUT warning was heard. This was followed by the continuous tone of the low rotor RPM audio warning and confirmed by the illuminated ROT LOW RPM caption on the CWP. The pilot did not recall seeing the ENG OUT caption illuminated on the CWP. The pilot's prompt action of lowering the collective lever would have minimised further decay in rotor RPM but would have initiated a high rate of descent at a low height. The "aggressive" flare and reduction of the descent rate with the collective lever ensured that the helicopter did not perform a heavy or fast run-on landing, thereby avoiding the associated hazards to those on board. The large control movements did, however, cause the main rotor blades to sever the tail pylon.

The engine was still running once the helicopter was on the ground and had to be shut down by the pilot. The engineering investigation revealed no reason for a loss of power during the approach, but clearly, the pilot had the warnings and symptoms of some sort of power loss, and so he performed an emergency landing.

ACCIDENT

Aircraft Type and Registration:	Robinson R22 Beta, G-IONE
No & Type of Engines:	1 Lycoming O-360-J2A piston engine
Year of Manufacture:	2005
Date & Time (UTC):	12 November 2005 at 1620 hrs
Location:	Private landing site at East Kilbride, Scotland
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damaged beyond economic repair
Commander's Licence:	Private Pilot's Licence
Commander's Age:	43 years
Commander's Flying Experience:	96 hours (all on type) Last 90 days - 8 hours Last 28 days - 8 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The aircraft was prepared for takeoff, whilst positioned directly into the surface wind of 300º at 10 kt, on a private tarmacadam landing site. After receiving a clearance from Glasgow Approach to depart for a local flight, the pilot lifted the aircraft into the hover. As he stabilised the helicopter in the hover the pilot felt uncomfortable in what he perceived to be a crosswind component from the left. He decided to lower the helicopter back onto the ground but in doing so allowed some roll to develop and landed on the right hand skid. The roll continued and the aircraft came to rest on its right hand side. The pilot, who was uninjured, was able to vacate the aircraft through the normal exit.

Adjacent to the landing site, and directly upwind at the time of the accident, are some large storage sheds that may have generated an unexpected crosswind component.

ACCIDENT

Aircraft Type and Registration:	Robinson R44 Raven II, G-CDEY
No & Type of Engines:	1 Lycoming IO-540-AE1A5 piston engine
Year of Manufacture:	2004
Date & Time (UTC):	10 March 2005 at 1700 hrs
Location:	Langley Castle Hotel, Haydon Bridge, Northumberland
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 2
Injuries:	Crew - None Passengers - None
Nature of Damage:	Helicopter destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	59 years
Commander's Flying Experience:	Approx 130 hours (of which about 50 were on type) Last 90 days - approx 11 hours Last 28 days - approx 8 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

History of flight

The pilot took off from Manchester's Barton Airfield with two colleagues as passengers late in the morning on the day of the accident. They flew to Carlisle racecourse where they spent the rest of the afternoon. They intended to fly that evening to a hotel situated about 35 nm away for a meeting with some business partners who were already at the hotel. At about 1400 hrs one of the group at the hotel telephoned the pilot to give him a description of the hotel landing site and to inform him that the correct landing point would be marked with a white sheet.

The group took off from the racecourse at about 1710 hrs and flew for about 20 minutes to get to the hotel. On arriving the pilot overflew the landing site before starting his approach. The landing site next to the hotel consisted of a grass area approximately 60 m by 50 m, which sloped downhill, away from the hotel. It was surrounded on three sides by tall trees.

The pilot completed his approach and brought the helicopter into a low hover, turning to face up the slope to land. The helicopter then touched down and the pilot stated that at that moment he lost control, the helicopter pitching forward and striking one of its main rotor blades on the ground. The helicopter then turned through 180º, striking the end of its tail into the ground. The helicopter came to rest upright with the engine still running but a fire quickly developed; the flames growing rapidly around the cabin. Fortunately, all three people on board were able to vacate the aircraft unassisted and apart from some singed hair, they were otherwise unhurt.

The weather was described by the pilot as good, with a 10 kt surface wind, ample visibility and a cloud base of 3,000 ft. Sunset that day was at 1804 hrs.

Some time after the accident the pilot returned to the landing site in another R44 helicopter with a flying instructor and this time carried out a successful landing. The instructor reported that the slope on the landing site varied with much of it sloping 10º or more, but with some small areas being nearly level. He also commented that when below the level of the trees surrounding the landing site, sight of the horizon was effectively lost.

Analysis

The pilot had little flying experience and had only owned this particular aircraft for about two weeks prior to the accident. He had received training to land on sloping ground during his initial training on the Robinson R22 and again during his conversion training for the R44, although he states that this was well before the accident.

From the description provided by the pilot of the event, when landing on the slope he had mistakenly believed, whilst lowering the collective, that the full weight of the helicopter was on its skids with the collective in mid-travel, prompting him to lower the collective rapidly to its minimum pitch position. The helicopter did not have its full weight on the skids at this time causing it to settle quickly in a marked tail-down attitude as the collective was fully lowered. The motion took the pilot by surprise and he instinctively reacted by pushing the cyclic rapidly forward, but without raising the collective. This caused the helicopter to pitch forward and strike its main rotors on the ground ahead resulting in the remaining impact sequence described. In view of the subsequent fire it was extremely fortunate that the helicopter remained upright and that the occupants were able to escape unimpeded.

Discussions with the instructor, who subsequently flew with the pilot back to the hotel, indicate that the landing site presented numerous problems. The tall trees limited the choice of direction of approach and surrounding the aircraft as they did, would have reduced the available light considerably on the final approach when attempting to land near dusk. The slope of the landing site seems to have varied, but there was certainly a large area over which the slope was probably either at or above the landing capabilities for many light helicopters such as the R44. This, combined with a loss of visual horizon when descending below tree top level, presented a challenging landing site for any pilot.

The pilot accepted these points and also mentioned the added pressures of flying an aircraft with passengers to such a venue, especially when they are business partners, Whilst he was confident he could land at the site, he felt it would not have provided a favourable reflection on his flying abilities had he failed to do so.

The manager of the hotel stated that approximately 10 helicopters a year land at the unofficial landing site and have done so for many years without any apparent problems. He did concede, however, that he had little if any knowledge of helicopter operations. Without such knowledge he was not in a position to provide pilots with any sort of guidance about the site other than to point out its location and the obvious hazards such as the surrounding trees. He was not aware that the degree of slope would present a problem and no pilot had ever complained about it to him. In his absence, and in the absence of any form of written brief, none of his staff were in a position to provide any comprehensive information to pilots seeking permission to land at the hotel.

In investigating this accident it has not been possible to obtain the sloping ground limits for the R44 helicopter either for landing or for shutting down but the flying school, where the pilot was taught, recommends a limit of 10º for landing on a slope. The foundations for this 'empirical' and unofficial advice are not clear and similar but slightly different advice might be given by other training schools.

Neither the US Federal Aviation Regulations (FAR-27) nor the European Joint Airworthiness Regulations (JAR 27) require helicopter manufacturers to determine or publish guidance on sloping ground limits. Enquiries with the helicopter manufacturer have revealed that they do not publish any sloping ground limits because such limits are affected by numerous variable factors, including wind conditions, ground conditions, pilot skill and experience. Whilst this view is accepted in part, there are physical limitations such as maximum rotor tilt angles which are not variable and so could be published.

Conclusion

The private pilot had little flying experience and was attempting to land at a difficult landing site for which he had little information. It is possible that had he known the degree of the sloping ground and been able to compare this against published sloping ground limits for his own helicopter, he may not have attempted the landing. In the event, whilst attempting to land, he applied an inappropriate landing technique followed by an inappropriate recovery technique when the helicopter appeared to be tipping backwards. This led to the main rotors striking the ground, destroying the helicopter.

ACCIDENT

Aircraft Type and Registration:	Aeroprakt A22 Foxbat, G-CDDW
No & Type of Engines:	1 Rotax 912 ULS piston engine
Year of Manufacture:	2004
Date & Time (UTC):	17 November 2005 at 1600 hrs
Location:	Private airfield near Draperstown (30 miles NW of Belfast), Northern Ireland
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Bent nose leg and minor damage to firewall and cockpit floor
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	44 years
Commander's Flying Experience:	50 hours (all on type) Last 90 days - 5 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

Due to fog at his home airfield the pilot elected to land at an alternative strip. The ground at the alternative strip was soft and the available landing distance was reduced due to livestock at one end; hence the pilot applied the brakes firmly, resulting in the nose wheel digging into the soft ground causing damage to the aircraft.

History of flight

The pilot's home strip is located 20 miles west of the south west corner of Loch Neagh in Northern Ireland and he planned to depart from there at around 0900 hrs. He was forced to delay his departure until after some fog had cleared and he took off at around 1230 hrs, later reporting good visibility and no fog in the Belfast area en route to Newtownards, which is to the east of Belfast. He departed Newtownards at 1430 hrs for his return leg and, as he flew towards his home strip, he noticed fog which obscured the ground and reported that he could see only the top 10 ft or so of the large chimney at Cookstown protruding above the fog. This chimney is part of a cement factory and is approximately 300 ft high.

The pilot, conscious of his level of experience and VFR only rating, elected to turn through 180º in the knowledge that he had not encountered fog en route.

He was aware of a private airfield near Draperstown that was likely to be free from fog and, having subsequently visually checked the absence of fog for his approach, he decided to land there.

There were sheep grazing at the far end of the strip at Draperstown, which effectively reduced the available field length by about a third. After touch down, when the pilot applied the brakes, the nose wheel dug into an area of soft ground causing the nose gear leg to bend and some minor damage to the firewall and cockpit floor. Neither the pilot nor the passenger sustained any injuries.

Meteorological conditions

The pilot later learned that the fog had only cleared for about an hour at his home strip, which allowed him to depart, but precluded his landing later that day.

The Met Office were contacted and provided an aftercast for the area. This stated:

> 'Meteorological surface visibility: 15 – 20 kilometres but 100 metres in local fog patches. (Air to ground visibility not known)', 'Cloud: Nil below 10000FT' and 'Weather: Generally nil but with a risk of localised fog patches having persisted in sheltered valleys'.

ACCIDENT

Aircraft Type and Registration:	Pegasus Flash, G-MNGF
No & Type of Engines:	1 Rotax 447 piston engine
Year of Manufacture:	1985
Date & Time (UTC):	9 November 2005 at 1000 hrs
Location:	Great Oakley, Essex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 Passengers - N/A
Nature of Damage:	Extensive damage to fuselage, landing gear and wing
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	52 years
Commander's Flying Experience:	49 hours (all on type) Last 90 days - 12 hours Last 28 days - 0 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft suffered an engine failure after takeoff when at a height of 200 ft. Due to lack of a suitable landing field straight ahead the pilot attempted a downwind landing on a taxiway which resulted in the aircraft somersaulting following a landing on soft ground adjacent to the taxiway. It sustained substantial damaged; the pilot received minor injuries and exited the aircraft unassisted. The most probable cause of the engine failure was an internal defect within the magneto generator, resulting in a loss of power to the engine ignition system.

History of the flight

After removing the aircraft from its hangar and fitting the wing, the pilot carried out a pre-flight check and noted that there was approximately 30 lt of fuel in the fuel tank. He then started the engine and allowed it to warm up for several minutes; the engine was then stopped whilst the pilot prepared himself for the flight. When he was ready the pilot restarted the engine, boarded the aircraft and taxied to Runway 27 for takeoff. He selected maximum power and the aircraft took off normally. When at a height of approximately 200 ft, climbing at 600 fpm at 55 mph, the engine cut out without warning. The pilot established the aircraft in a stable gliding descent and looked for a suitable landing site. The field immediately in front of the aircraft had been ploughed and was assessed as unsuitable by the pilot, who then attempted to land the aircraft on the crosswind runway, Runway 22.

However, after turning onto the runway heading the aircraft was too high to land without overshooting so the pilot then attempted to turn the aircraft onto a heading of 090º for a downwind landing on a taxiway. As aircraft was now becoming low and its lack of height prevented the completion of the turn, the pilot was forced to land in a muddy field adjacent to the taxiway. During the landing, the nose wheel dug into the soft ground resulting in the aircraft somersaulting about its nose, which caused significant damage to the fuselage, landing gear, propeller and wing. The aircraft came to rest upright leaning at 45º to the right. The pilot received minor injuries and exited the aircraft unassisted.

Description of aircraft

The Pegasus Flash is a weight shift microlight aircraft certified under CAA Type Approval Data Sheet BM10 issue 4. The aircraft consists of a fuselage pod fitted with a tricycle landing gear and a Rotax 447 engine, mounted at the rear, and a detachable wing, including the control frame assembly which attaches atop the fuselage pylon.

The engine installed in G-MNGF had operated for 507 hours and was fitted with a 'points' ignition system. This system consists of a magneto generating coil comprised of an low tension (LT) ignition coil, a 110 watt lighting coil and a 30 watt charging coil. Power from the ignition coil passes through an ignition switch to two high tension (HT) ignition coils, each of which provides power to a single spark plug. Thus, it is intended that total power loss should not occur in the event of a failure in one HT ignition circuit.

Engine maintenance history

The pilot reported that the engine had suffered a momentary cut out after takeoff on the previous flight, following which the engine recovered and continued to operate normally. After this event the carburettor was stripped and cleaned, the points were cleaned and reset, the air filter was checked and re-oiled, and the fuel pump and filter were visually inspected. The engine was then run for three minutes at varying power levels with no reported problems.

There have been several reported incidents of erratic or rough running Rotax 447 engines as a result of the tachometer being connected to the ignition coil instead of the low output magneto coils. The pilot was, however, aware of this problem and confirmed that the tachometer was correctly wired and, as the engine had given no indication of impending failure, this was not considered to be a factor in this incident.

Additional information

The magneto generator fitted to a 'points' ignition Rotax 447 provides electric power for the aircraft through the three magneto coils. Previous events of total loss of power in the ignition circuit on relatively high time engines are know to have occurred, resulting from the breakdown of the insulation in the ignition coil. In some cases, this has been attributable to one of the low power magneto coils overheating and burning the 'Shellac' insulation of the ignition coil windings.

Analysis

Metrological conditions at the time of the incident were such that the formation of carburettor icing was possible; the pilot was however aware of this possibility and was familiar with the symptoms of carburettor icing and its prevention. As the engine had cut out with no warning, such as rough running, carburettor icing was considered an unlikely cause of the engine failure. Also as the engine suffered a sudden and complete loss of power, it is considered highly unlikely that the HT section of both ignition systems failed simultaneously. In view of the sudden and complete power loss from the engine, and the previous momentary cut out, it is also considered that a failure of the ignition switch is unlikely to have been the cause of the loss of engine power. Therefore given the life of the engine, the most probable cause of the failure was likely to have been a breakdown of the insulation in the magneto ignition coil resulting in a total loss of power to the HT ignition circuits.

ACCIDENT

Aircraft Type and Registration:	Quad City Challenger II, G-MZHO
No & Type of Engines:	1 Rotax 503 piston engine
Year of Manufacture:	1997
Date & Time (UTC):	9 November 2005 at 1546 hrs
Location:	Barling Magna, near Southend-on-Sea, Essex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 Passengers - 1
Nature of Damage:	Substantial
Commander's Licence:	Private Pilot's Licence
Commander's Age:	73 years
Commander's Flying Experience:	537 hours (of which 445 were on type) Last 90 days - 17 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

History of the flight

The pilot and his wife took off from their private airstrip at 1400 hrs for a local flight lasting approximately one hour and 40 minutes, in what the pilot described as excellent flying conditions. He estimated that visibility was in excess of 25 km and that the surface wind was from 285º at approximately 5 kt. Local sunset was at 1615 hrs. The pilot reported that he had an unrestricted view of the airstrip as he approached for landing in a westerly direction but, as he reduced speed for landing, the low sun obscured his view completely.

At approximately 100 ft agl and only 100 m from the landing threshold, he was unable to see anything outside the cockpit or to distinguish the cockpit instruments and became disorientated. Very shortly afterwards, at approximately 40 ft agl, the left wing of his aircraft struck the topmost branches of a tree. The impact, though slight, caused the aircraft to stall and fall to the ground, where it came to rest inverted in a ditch. The pilot and passenger were suspended in their harnesses but, using her mobile telephone, the passenger was able to alert a neighbour who assisted them shortly afterwards. The passenger had sustained bruising to her head, body and legs. The pilot, however, had sustained a more serious head injury and, upon the arrival of the emergency services, was taken to hospital by air ambulance.

Discussion

The pilot commented that the strength of construction of the aircraft had protected the occupants from more serious injury. The engine, for example, remained attached to its mountings and the cabin area was substantially intact. The pilot stated, however, that he had not tightened his lap restraint sufficiently to prevent his head from striking a structural member in the cabin roof when the aircraft came to rest inverted. Furthermore, the occupants were not in the habit of wearing helmets whilst flying and were not doing so at the time of the accident. The pilot conceded that he might consider doing so in future. In a telephone conversation with the AAIB, he mentioned that on previous occasions he had taken the precaution of diverting to alternative airfields which did not require a landing into the setting sun.

ACCIDENT

Aircraft Type and Registration:	Thruster T600N 450, G-CDBZ
No & Type of Engines:	1 Jabiru Aircraft PTY 2200A piston engine
Year of Manufacture:	2004
Date & Time (UTC):	20 November 2005 at 1300 hrs
Location:	Little Atherfield Farm, Isle of Wight (private strip)
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - 1 (Minor)
Nature of Damage:	Broken propeller, damaged nose pod and upright
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	47 years
Commander's Flying Experience:	285 hours (of which 284 were on type) Last 90 days - 55 hours Last 28 days - 8 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

Following a landing on a wet grass runway, the aircraft overran the airfield boundary before coming to stop in a ditch.

History of the flight

The pilot reported that he had flown from Sandown to a private grass strip at Atherfield on the Isle of Wight. He flew his approach at a speed of 55 kt and the aircraft touched down approximately half way down the runway, which the pilot estimated to be 500 to 600 m long. However, the pilot was unable to stop the aircraft on the runway with the result that it continued beyond the airstrip perimeter, passing through some brambles before coming to stop in a ditch. Both occupants evacuated through the cabin doors. Whilst the pilot was uninjured, the passenger hurt his neck and, therefore, as a precautionary measure was taken by ambulance to the local hospital. The aircraft sustained a broken propeller and damage to the nose pod and upright spar. The pilot stated that at the time of the accident there was no wind and the grass runway was wet.

Remarks

The aircraft manual states that in still or smooth conditions an approach speed of 45 kt should be flown, which on a level, short dry grass surface at ISA conditions should enable the aircraft to come to a full stop within 279 m. The manual also states that on wet grass the landing distance should be increased by 20%, which would have given a landing distance of around 335 m.

The pilot stated that he had landed at this strip on many occasions and was aware of the landing distance quoted in the aircraft manual, but a few months earlier he had measured his landing distance at this airstrip as being 112 m from his touch down point. The pilot believes that this information gave him a false perception as to the stopping distance of his aircraft and that on this occasion the braking effect on wet grass was insufficient to enable him to stop within the airfield boundary.

ACCIDENT

Aircraft Type and Registration:	Whitaker MW6 Merlin (Modified), G-MYZA
No & Type of Engines:	1 Rotax 582 piston engine
Year of Manufacture:	1995
Date & Time (UTC):	13 July 2005 at 1930 hrs
Location:	Airstrip near Newent, Gloucestershire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Extensive
Commander's Licence:	Private Pilot's Licence
Commander's Age:	73 years
Commander's Flying Experience:	550 hours (of which 250 were on type) Last 90 days - 4 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent AAIB enquiries

History of the flight

The pilot had taken off from his own airstrip on the evening of the accident and had flown to a club meeting at another airstrip approximately 20 minutes flying time away. After about an hour on the ground he flew back to a friend's landing strip, close to his own, and remained there for about half an hour.

The pilot then took off for the brief flight back to his own airstrip and reported that on reaching a height of about 200 ft agl the engine 'stopped dead'. There were fields containing crops ahead and the pilot chose to turn through about 90º to the right in order to try and make a forced landing on a grass area adjacent to the strip. This also brought him into wind, which he reported as being 5 kt. In attempting to land, the pilot cleared a hedge and passed upwind of a group of trees. He reports that when passing the trees at a height of about 30 ft the aircraft suddenly stalled, impacting the ground nose down at low speed. The aircraft was badly damaged but the pilot suffered only minor injuries and was able to vacate the wreckage unassisted.

In his report to the AAIB the pilot did not make clear whether he conducted a full power check prior to each takeoff. A meteorological aftercast indicated the likely temperature at the time of the first take off was about 27ºC and at the time of the accident it was about 24ºC.

Aircraft description

The aircraft type is a three axis microlight with a rigid wing mounted above a faired tricycle unit. G-MYZA was fitted with a two-cylinder, two-stroke liquid-cooled engine fitted driving a three bladed propeller through a gearbox. The aircraft had a main fuel tank in the wing centre section and fuel was gravity fed from the wing tank to a header tank located under the engine. The aircraft was issued with a Permit to Fly by the CAA based on the inspections and recommendations of the PFA.

Aircraft refuelling

The aircraft was operated on MOGAS[1] which the pilot purchased at a local petrol station. The aircraft had been stored in a hangar with the fuel tank only partially full the night prior to the accident and was refuelled in the morning using a different batch of fuel to that already in the tank. The pilot stated that he was not in the habit of testing his fuel for water and had not done so on this occasion. In justification, he pointed out that operating this way he had flown his aircraft for many hours without problem.

Analysis

The aircraft's engine was badly damaged by the impact and it has not been possible to determine beyond doubt whether it was a failure of the engine itself or a problem with the fuel system which caused it to stop.

The pilot reported that colleagues had informed him that the exhaust fumes smelled of paraffin and he believed the failure was caused by contaminated fuel purchased from the garage. He sent a sample of this fuel for analytical tests but at the time of writing his report, the results of these tests were inconclusive.

The pilot's statement that he did not test his fuel for water also raises the possibility that the failure was caused by the presence of water in the fuel system. The fact that the aircraft was left parked with the fuel tank partially filled may have allowed the formation of condensation in the tank overnight. However, the presence of any significant quantities of contaminant can probably be eliminated because the aircraft had operated without a problem using the same fuel for two flights prior to the accident.

Motor gasolines have a higher vapour pressure than aviation gasoline (AVGAS) and so engines operating on MOGAS are particularly susceptible to vapour lock. This condition is caused by the fuel vapourising when subjected to ambient low pressure or high temperature. If the vapour forms in a fuel line it effectively cuts off the fuel supply to the engine causing it to stop. For this reason the use of MOGAS is restricted to flights below an altitude of 6,000 ft and a maximum tank fuel temperature of 20ºC. Conditions on the warm summer evening of the accident flight (24º to 27ºC ambient air temperature) suggest that the temperature of the fuel in the tank probably exceeded 20ºC whilst the aircraft was on the ground. If the aircraft had been parked in direct sunlight, this could have raised the fuel temperature in the wing tank well above ambient air temperature. Moreover, residual heat from the engine could also have raised the temperature of the fuel in the header tank and its associated fuel transfer pipes to the engine.

In view of the special precautions required when operating aircraft using MOGAS, both the CAA and the PFA publish specific information highlighting the restrictions that apply. The CAA publish Airworthiness Notice Number 98B entitled "*Use Of Filling Station Forecourt Unleaded Motor Gasoline In Microlight Aeroplanes*" and Airworthiness Notice Number 98C entitled "*Use Of*

Footnote

[1] Motor Vehicle Gasoline

Filling Station Forecourt Unleaded Motor Gasoline In Certain Light Aircraft". The Authority also publishes Safety Sense Leaflet 4b "*Use of MOGAS*". Before permitting aircraft to operate on MOGAS, the PFA requires engine/aircraft combinations to be approved and any necessary engine adjustments to be made. The PFA also requires a placard to be fitted next to the filling point on the fuel tank detailing the standard of fuel that may be used and another in the cockpit detailing operational limitations that must be observed. As part of this process, the PFA issue a MOGAS operating pack to the aircraft owner which contains detailed information on the storage, testing and use of MOGAS, a copy of the relevant CAA Airworthiness Notice and the placards required to be fitted.

All these documents, including the cockpit placard, emphasise the importance of checking fuel for contaminants (primarily water), carrying out a full pre-takeoff power check and operating with a fuel tank temperature not exceeding 20ºC.

Having suffered the engine failure, the pilot chose to attempt a landing on an area close to the airstrip. He explained he was concerned that if he landed in the field straight ahead that the presence of the crops would bring the aircraft to a rapid halt, or turn it over, causing him potentially serious injury. He had decided, therefore, to try and land on the grass area next to the airstrip, but in doing so he was required to make a large turn at low level. He believes the trees had shielded the aircraft from the wind just prior to touchdown, causing him to lose airspeed and stall.

Conclusion

The most likely cause of the engine failure was a vapour lock in the fuel supply, which was probably caused by a combination of high ambient temperature, the aircraft engine heating the fuel between flights and possibly the heating effect of sunlight on the wing fuel tank whilst the aircraft was parked. In attempting the subsequent forced landing, the aircraft stalled at low level resulting in it impacting the ground.

Relevant information exists on the use of MOGAS and is readily available. Irrespective of whether or not a problem has previously been encountered, the advice offered should be followed.

BULLETIN ADDENDUM

AAIB File:	**EW/G2004/12/07**
Aircraft Type and Registration:	DHC-1 Chipmunk 22, G-AOSU
Date & Time (UTC):	19 December 2004 at 1245 hrs
Location:	Easterton Airfield, near Elgin, Scotland
Information Source:	Aircraft Accident Report Form

AAIB Bulletin No: 4/2005, page 38 refers

Summary

The aircraft was returning to the airfield, which was covered in a light layer of snow, and the pilot was keen to land on the first third of grass Runway 27 because the upwind end was wet and soft. He closed the throttle and selected full flap before turning onto final approach, in preparation for a glide landing. However, because the aircraft was very high the pilot then executed a tight S turn. As the aircraft rolled out of the second turn he suddenly realised that he was now too low but he decided to continue. He was aware that he was flying into the low winter sun, which was sitting just above the horizon, and remembers nothing else. Witnesses saw the aircraft drop its left wing and descend from about 100 ft aal into the field immediately short of the airfield. The pilot concluded that he had stalled the aircraft in the final turn. He also considered that the angle and direction of the sun might have been a factor in distracting him from maintaining his scan of the air speed indicator (ASI). There was no fire but the pilot suffered a cut to his head and back injuries.

Addendum

Six months after the accident the pilot was referred to a consultant neurosurgeon following a three month history of symptoms, which had not been present at the time of the crash. One month later the pilot was successfully operated on to remove a brain tumour and subsequently made an excellent recovery. In his report, the neurosurgeon stated that there was a possibility that the pilot's 'intracranial lesion' had contributed to the circumstances leading to the accident. Although the tumour had existed at the time of the accident, the pilot had appeared to be fit and well.

BULLETIN CORRECTION and ADDENDUM

AAIB File:	**EW/G2005/08/26**
Aircraft Type and Registration:	Ikarus C42 FB UK, G-IAJS
Date & Time (UTC):	30 August 2005 at 1920 hrs
Location:	Kinderton Farm, Middlewich, Cheshire
Information Source:	Aircraft Accident Report Form submitted by the pilot

AAIB Bulletin No: 1/2006, page 136 refers

Corrigendum:

In this report under the heading *'Further information'* it was stated:

> 'The pilot/owner later reported that he had purchased a carburettor heating system for the Rotax 912 engine but had decided not to fit this to the aircraft.'.

This text has subsequently been updated as follows:

> *The pilot/owner later reported that he had purchased a carburettor heating system for the Rotax 912 engine; however he had elected not to fit this to the aircraft for the flight test programme.*

Addendum: PFA Response

In the light of this and other incidents the PFA have added the following text to first flight letters.

> *'It is now legally mandatory for all PFA aircraft to have third party and (except for single seaters) passenger liability insurance cover whenever they are flown. You must therefore arrange this cover before the aircraft may commence its flight test program. You must check with your broker that the cover you have in place meets or exceeds the minimum legal requirements.*
>
> *Please be aware that over the years several serious accidents have occurred with homebuilt aircraft during the flight test phase when owners have got airborne inadvertently whilst taxiing their machines, lost control and crashed - in one case leading to a fatality. In some cases the owners were not authorised to fly the aircraft, and in one case had not even done up his straps. Light aircraft, and especially microlights, can easily leave the ground unexpectedly if the throttle should stick, or if there should be a gust of wind when taxiing at speed. They should therefore only be taxied if they are fully airworthy, signed up and legal for flight, and the pilot in control is the one who has been authorised to carry out the flight testing.'*

AIRCRAFT ACCIDENT REPORT NO 1/2006

This report was published on 11 January 2006 and is available on the AAIB Website www.aaib.gov.uk

REPORT ON THE ACCIDENT TO FAIREY BRITTEN NORMAN BN2A Mk III-2 TRISLANDER, G-BEVT at GUERNSEY AIRPORT, CHANNEL ISLANDS on 23 JULY 2004

Registered Owner and Operator:	Aurigny Air Services
Aircraft Type:	Fairey Britten Norman BN2A Mk III-2 'Trislander'
Nationality:	British
Registration:	G-BEVT
Place of Accident:	Guernsey Airport
Date and Time:	23 July 2004 at 0637 hrs All times in this report are UTC

Synopsis

Shortly after takeoff from Guernsey Airport, a loud crack or bang was heard in the aircraft's cabin. The aircraft commander was told by a colleague in the cabin that one or more passengers had been injured and that a cabin window was broken. He decided to return to Guernsey Airport having been airborne for approximately four minutes. After the passengers disembarked the pilot noticed that a de-icer boot had separated from the left hand propeller and was now on the seat inside the cabin, adjacent to the broken window.

The investigation identified the following causal factors:

(i) The accident was caused by the separation of a de-icer boot from the left propeller during takeoff.

(ii) The de-icer boot separated due to peel stresses generated by forces on the propeller. The peel stresses arose because of physical or contamination damage to the adhesive bond which occurred because the required filler material was not used at the root of the de-icer boot.

Two Safety Recommendations were made during the course of the investigation.

Findings

1 During takeoff, while the engines were at high power, a de-icer boot from a blade of the left hand propeller separated and struck an adjacent cabin window, penetrating the window and injuring two passengers.

2 The left hand propeller was fitted with a BF Goodrich de-icing system including the de-icer boots on the propellers, in accordance with BF Goodrich technical report No 59-728.

3 The aircraft was type certificated in accordance with British Civil Airworthiness Requirements (BCAR) Section 'K'. This airworthiness code contained no requirement to protect passengers from piston engine or propeller parts.

4 Installation of the de-icer boots was certified on the appropriate JAA Form One as having being completed in accordance with the appropriate Hartzell Manual 133C. However, the filler material required by that Manual had not been applied.

5 Work was carried out on the propeller to replace a defective harness guard and restrainer strap. It is possible that some damage had occurred to the adhesive bond of the de-icer boot at this time but because the blade number was not recorded, it was not possible to confirm that this was the blade which subsequently shed the de-icer boot.

6 The laboratory report concluded that there was probably a small region of the lead strap of the de-icer boot, outboard of the restrainer strap, which was unbonded.

7 The small unbonded area of the lead strap created a natural chamber for moisture and other contaminants to enter and be trapped, further degrading the adhesive bond.

8 Growth of the disbonded area caused increasing peel stresses which led to final failure of the remainder of the adhesive bond, and separation of the de-icer boot.

9 There was a period when the filler material and suitable alternatives were commercially unavailable in the UK. These materials became available again in mid 2003. However the short shelf life of the materials may have created difficulties in the meantime for maintenance and repair organisations outside the USA.

10 The UK CAA identified approximately 100 propellers which had been overhauled without using the required filler.

11 The manufacturer and the UK CAA have proposed a rectification process for affected propellers.

12 Industry wide, the incidence of de-icer boots becoming completely detached is low, even though disbonding is sometimes detected during inspections.

13 Efforts to control human factors in maintenance need to be continued and enhanced within a pan- European context.

14 There is potential in the use of a thermal imaging to identify hot spots in poorly bonded regions of electrical de-icer boots.

Safety Recommendations

The following safety recommendations have been made:

Safety Recommendation 2005-078

The UK Civil Aviation Authority and the European Aviation Safety Agency should work closely together to develop further the valuable progress already made in human factors in aircraft maintenance, focusing on the underlying reasons for both errors and violations, with a view to reducing the potential for system-induced errors and violations, and therefore the risk of maintenance related accidents.

Safety Recommendation 2005-079

Hartzell Propeller Incorporated should investigate the feasibility and potential benefits of using thermal imaging techniques to inspect de-icer boots for disbonded areas.

FORMAL AIRPORT ACCIDENT REPORTS ISSUED BY THE AIR ACCIDENTS INVESTIGATION BRANCH

2004

1/2004 BAe 146, G-JEAK
during descent into Birmingham
Airport on 5 November 2000.

Published February 2004.

2/2004 Sikorsky S-61, G-BBHM
at Poole, Dorset
on 15 July 2002.

Published April 2004.

3/2004 AS332L Super Puma, G-BKZE
on-board the West Navion Drilling Ship,
80 nm to the west of the Shetland Isles
on 12 November 2001.

Published June 2004.

4/2004 Fokker F27 Mk 500 Friendship,
G-CEXF at Jersey Airport,
Channel Islands on 5 June 2001.

Published July 2004.

5/2004 Bombardier CL600-2B16 Series 604,
N90AG at Birmingham International
Airport on 4 January 2002.

Published August 2004.

2005

1/2005 Sikorsky S-76A+, G-BJVX
near the Leman 49/26 Foxtrot Platform
in the North Sea on 16 July 2002.

Published February 2005.

2/2005 Pegasus Quik, G-STYX
at Eastchurch, Isle of Sheppey, Kent
on 21 August 2004.

Published November 2005.

3/2005 Boeing 757-236, G-CPER
on 7 September 2003.

Published December 2005.

2006

1/2006 Fairey Britten Norman BN2A Mk III-2
Trislander, G-BEVT
at Guernsey Airport, Channel Islands
on 23 July 2004.

Published January 2006.

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