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(ALL TIMES IN THIS BULLETIN ARE UTC)

ACCIDENT

Aircraft Type and Registration:	BAE Systems Jetstream 31, G-CCPW
No & Type of Engines:	2 Garrett Airesearch TPE 331-10UGR-5164 turboprop engines
Year of Manufacture:	1987
Location:	Runway 26, Isle of Man Airport
Date & Time (UTC):	8 March 2012 at 1757 hrs
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 2 Passengers - 12
Injuries:	Crew - None Passengers - None
Nature of Damage:	Right main landing gear yoke pintle fractured, right engine and propeller blades damaged
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	58 years
Commander's Flying Experience:	About 6,000 hrs (of which about 1,500 hrs were on type)
Information Source:	AAIB Field Investigation

Synopsis

The aircraft's right main landing gear failed as it landed on Runway 26 at Isle of Man Airport. The right main landing gear detached, the aircraft slid along the runway on its remaining landing gears, right wingtip and luggage pannier and came to rest on the grass adjacent to the runway. The passengers and crew vacated the aircraft without injury. The mechanism to final failure is not yet fully understood, but was initiated as a result of stress corrosion cracking in the forward yoke pintle at the top of the right main landing gear leg. One Safety Recommendation is made.

History of the flight

The aircraft and crew were operating a passenger service from Leeds Bradford International Airport to Isle of Man Airport. The flight had been routine and the crew were flying a day, visual approach to Runway 26, in good weather, with the surface wind reported as 210° at 14 kt. The commander was the pilot flying (PF) and the co-pilot, who had recently joined the company, was nearing the end of his line training on type.

The approach was flown with full flap and the gear locked and confirmed down by the three green gear indicators. The landing weight was estimated to be 13,448 lb (6,099 kg) and the crew recalled that the V_{ref} was about 105 kt.

Almost immediately the aircraft touched down it leaned to the right and there was an unusual noise. The commander levelled the aircraft with a left roll input. However, as the speed decayed the lean increased and it became apparent that there was a problem with the right gear. The commander continued to apply left aileron and rudder. Both pilots recognised that the aircraft was likely to leave the paved surface and so the co-pilot held the control wheel and rudder to allow the commander to apply nosewheel steering and operate the feather levers[1]. The left engine was shut down and feathered as the aircraft departed the runway. The right engine was also shut down but its propeller did not feather as the mechanism appears to have been damaged when the blades contacted the runway. The aircraft left the paved surface, yawed to the right and slid sideways before it came to a stop 90° to the runway heading.

The Air Traffic Controller Officer located in the visual control room of the tower, to the north of the runway, saw the right propeller strike the runway as the gear collapsed. This was also seen by the airport fire-fighter on duty at the Airport Fire and Rescue Service (AFRS) watch office, located to the south of the runway. Both pressed their respective crash alarms while the aircraft was still moving and the AFRS arrived at the aircraft less than 2 minutes after it had come to a stop.

The commander shut down the aircraft while the co-pilot entered the passenger cabin, ascertained that there were no significant injuries and opened the rear passenger door. The passengers and crew deplaned without injury.

Runway marks and debris

The aircraft left a number of marks on the runway surface starting approximately 90 m from the start of the threshold markings. The first marks were made by the right engine propeller blades cutting into the runway surface. Sections of the right landing gear yoke pintle were found at 150 m and 180 m from the runway threshold near the right landing gear door.

Flight data

The aircraft was equipped with a 25 hour continuous-loop Digital Flight Data Recorder (DFDR) that recorded five parameters: time, pressure altitude, indicated airspeed, normal acceleration and heading. The normal acceleration at touchdown, after adjusting for maximum accelerometer drift of 0.04 g, was established as 1.72 g. This was the highest value recorded during the 20 flights recorded on the DFDR.

Additionally, a Terrain Avoidance Warning System (TAWS) installed in the aircraft recorded 30 separate parameters including Radio Altitude (Rad Alt) and

Footnote

[1] The appropriate feather lever shuts off fuel to its engine as well as feathering the propeller.

pressure altitude at a higher sampling rate than the DFDR. From this altitude information it was established that the rate of descent, just prior to touchdown, was 463 ft / min (7.7 ft/sec). This is within the landing gear limit load defined for a touchdown with a rate of descent of 10 ft/sec at the maximum landing weight of 14,900 lb (6,758 kg).

The aircraft was also equipped with a 30 minute continuous-loop Cockpit Voice Recorder (CVR), which recorded crew speech and ambient flight deck sounds from an area microphone. From the area microphone it was possible to identify a loud mechanical noise and the propeller blades striking the runway as the aircraft touched down.

The information from the DFDR, TAWS and CVR has been combined and is shown in Figure 1.

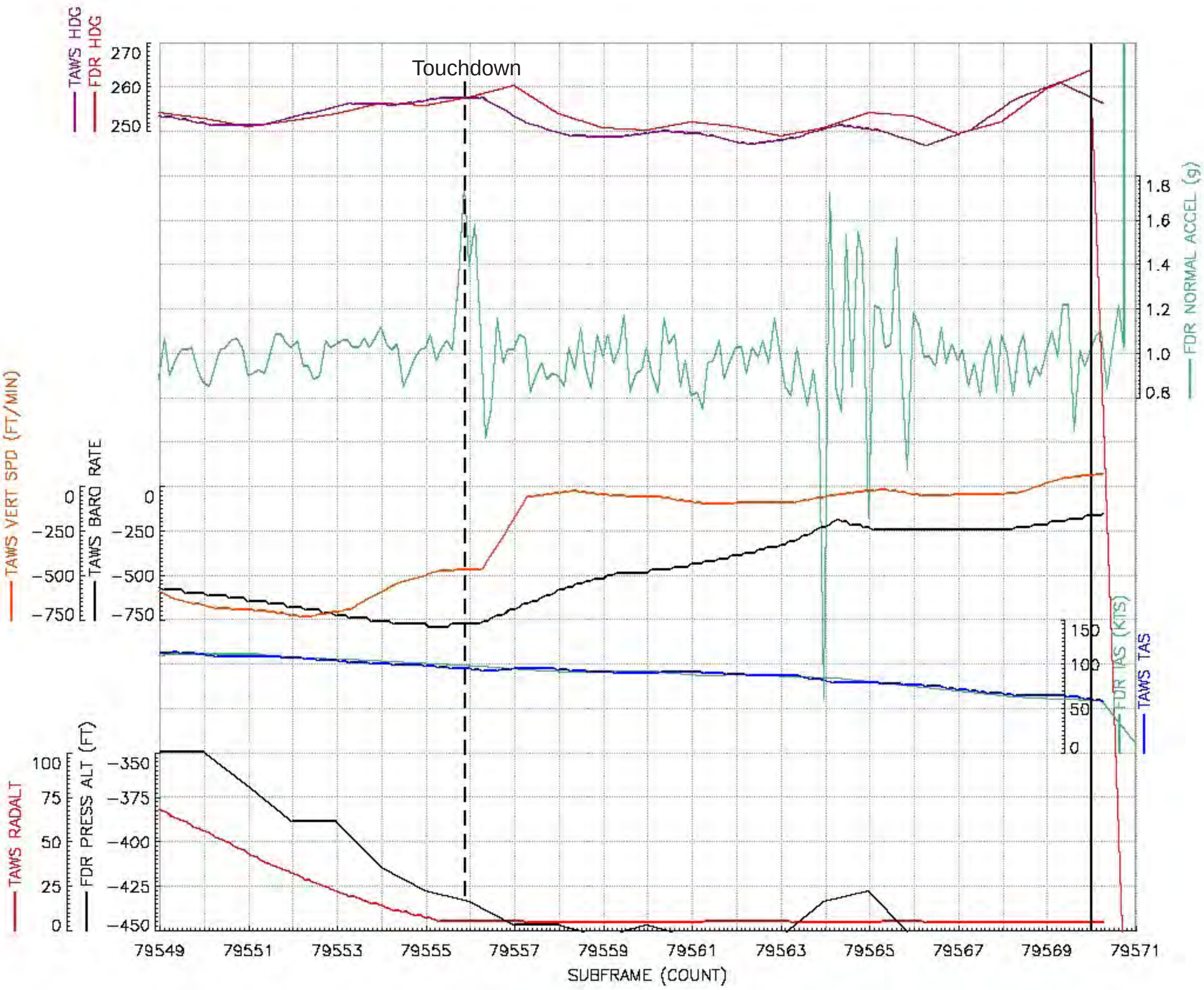


Figure 1

Data recorded during the landing

Aircraft damage

The right landing gear had broken away from its trunnions as a result of a failure of the forward yoke pintle housing (refer to Figure 2). However, the landing gear remained attached to the aircraft by the radius arm (retraction jack) and hydraulic pipelines. The downlock microswitch, which is fitted to the radius arm, remained intact and when electrical power was selected ON all three green landing gear position lights illuminated.

The blades on the right propeller had been badly damaged and the right engine appeared to be distorted in its engine mounts. The right aileron balance horn, wingtip and a section of the pannier had abraded away. There was some distortion to the right wheel well and flaps where the landing gear had broken away; there was no evidence of a leak from the wing fuel tanks. The main cabin door and over-wing emergency exit both opened freely. Apart from the failure of the yoke forward pintle on the right main landing gear, there was no visible evidence that the aircraft had sustained a heavy landing.

Metallurgy

The main landing gear is manufactured from DTD 5094 aluminium alloy, which is known to be susceptible to Stress Corrosion Cracking (SCC). The landing gear is attached to the airframe by trunnions that fit into steel spigots that are bolted to the inside of the yoke pintles. The upper surfaces of the pintles have been machined to introduce a weak link that, in the event of the landing gear being subjected to a force outside of its design limits, will fail and allow the gear to detach from the aircraft without damaging the fuel tanks. During the accident sequence the forward yoke pintle had failed with three large segments breaking away from the landing gear.

Figure 2

Right main landing gear yoke forward pintle

Examination established that the failure initiated at the top outer edge of the forward yoke pintle (see Figure 3) and the crack extended along the top of the pintle for approximately 120 mm before final failure occurred. The first 10 mm of the crack was heavily corroded and lighter deposits of corrosion were found along the remainder of the crack. Scanning Electron Microscopy (SEM) of the first 10 mm of the crack showed evidence of inter-granular failure consistent with SCC. A microsection through the first 35 mm of the crack identified branching crack growth which is a characteristic of SCC. The remainder of the crack showed a combination of both ductile overload and patches of SCC. Corrosion was also found on the steel spigot. Energy-dispersive X-ray spectroscopy (EDX) of the fracture surface of the crack in the yoke pintle identified the presence of cadmium that had leached into the crack from the corroded steel spigot.

Main landing gear leg

This model of landing gear is fitted to Jetstream 31 aircraft only. The landing gear legs are overhauled every 10,000 cycles or six calendar years after the previous overhaul. Both legs had last been overhauled in July 2009 and fitted to G-CCPW in August 2009. At the time of the accident they had been subjected to 1,445 cycles.

SCC was identified in the yoke pintle housing of a main landing gear in 1985 and there is currently an Airworthiness Directive (EASA AD G-003-01-86) and Mandatory Service Bulletin (SB A-JA851226) in force to carry out an eddy current and visual inspection of this area. The eddy current inspection is required every 1,200 cycles or within one calendar year of the last eddy current inspection. The visual inspection is required

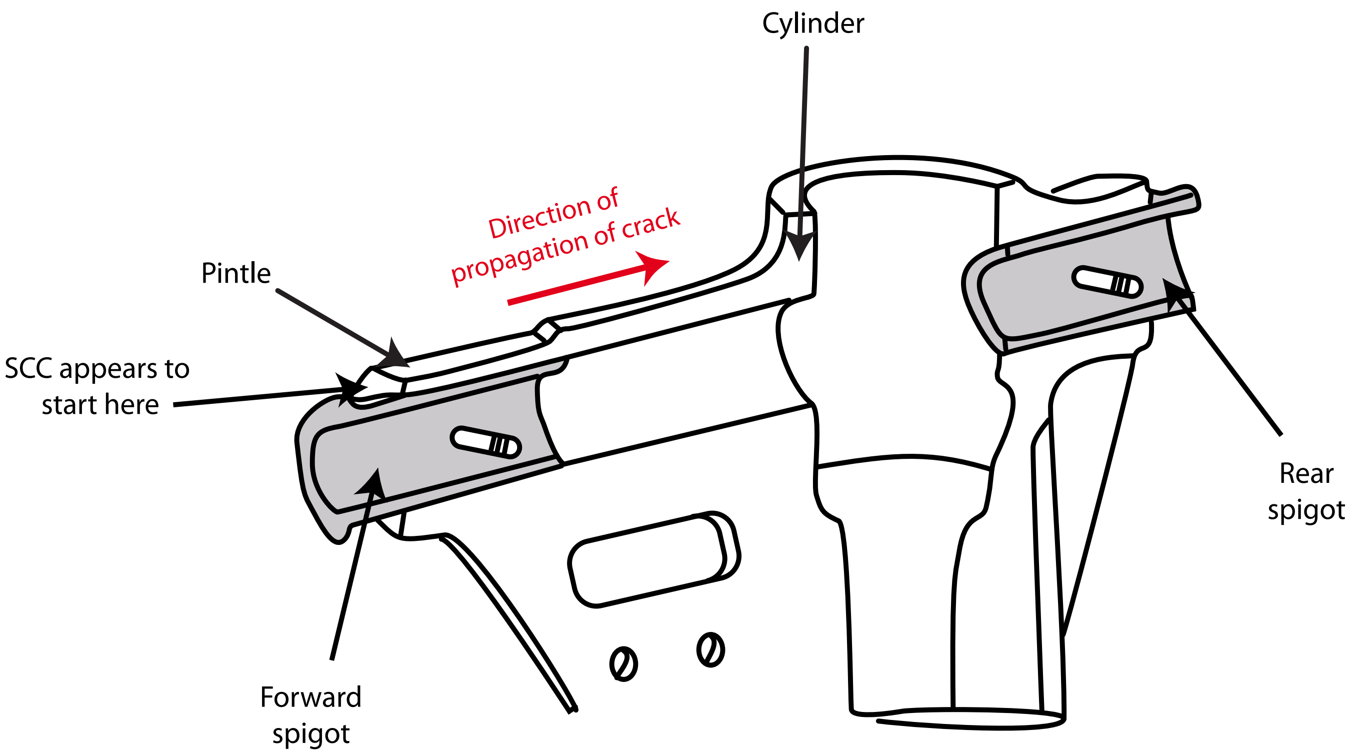


Figure 3

Main landing gear diagram

every 300 cycles or within three calendar months of the last visual inspection. The SB also requires the inspections to be carried out following a heavy or abnormal landing.

The last eddy current inspection on both landing gear legs was carried out on 13 May 2011, 743 cycles prior to the accident, and a visual inspection was carried out on 26 February 2012, 29 cycles prior to the accident. There was no record of any damage having been found during these inspections. The aircraft operator also advised the investigation that they had no reports of the aircraft having sustained a heavy landing.

Other reports of stress corrosion cracking in the yoke pintle

In addition to the failure on G-CCPW, the investigation is aware of only one other occurrence of SCC in the yoke pintle, which occurred in 1985 and resulted in the mandatory SB to inspect this area. Both the aircraft manufacturer and the landing gear design authority have advised the investigation that they have received no reports of cracking found as a result of carrying out the mandated inspections detailed in SB A-JA851226.

Discussion

The propeller marks on the runway, the location of the detached right main landing gear door and segments of the right main landing gear yoke pintle, together with audio analysis of the CVR indicates that the right main landing gear failed at touchdown.

The landing gear was designed to BCAR Section D with a limit load that equates to a maximum landing weight of 14,900 lb (6,758 kg) at a descent rate of10 ft / sec. On the accident flight the landing weight was estimated to be 13,448 lb (6,099 kg) and from the data on the TAWS it was established that the descent rate was 7.7 ft /sec. Therefore the forces exerted on the landing gear leg were within the design specifications and thus the leg should not have failed.

The metallurgy determined that a crack, emanating from the top edge of the forward yoke pintle, grew to approximately 120 mm before the remainder of the pintle failed in ductile overload. The first 10 mm of the crack occurred as a result of SCC and the heavy corrosion deposits indicated that this damage had been present for some time. The failure mechanism of the remainder of the crack is less clear. The patches of ductile overload and SCC, and the presence of cadmium in the crack, suggest that the crack grew over a period of time. Whilst the investigation has not yet determined how long the crack took to grow to failure, the amount of corrosion in the crack and on the steel spigots suggests that it was present during the last visual inspection carried out 11 days earlier and may have been present during the last eddy current inspection undertaken ten months earlier.

EASA AD G-003-01-86 mandates non-destructive testing and visual inspections to identify cracking in the yoke pintle housing on landing gears fitted to Jetstream 31 aircraft. As these inspection requirements did not detect the crack in the yoke pintle before it failed, the following Safety Recommendation is made to the European Aviation Safety Agency:

Safety Recommendation 2012-008

It is recommended that the European Aviation Safety Agency review the effectiveness of Airworthiness Directive G-003-01-86 in identifying cracks in the yoke pintle housing on landing gears fitted to Jetstream 31 aircraft.

Published 23 March 2012

SERIOUS INCIDENT

Aircraft Type and Registration:	Airbus A319-111, G-EZFI
No & Type of Engines:	2 CFM56-5B5/3 turbofan engines
Year of Manufacture:	2009
Date & Time (UTC):	6 January 2011 at 1955 hrs
Location:	Belfast International Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 6 Passengers - 46
Injuries:	Crew - None Passengers - 1 (Minor)
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	39 years
Commander's Flying Experience:	8,408 hours (of which 2,892 were on type) Last 90 days - 172 hours Last 28 days - 41 hours
Information Source:	AAIB Field Investigation

Synopsis

The airport's runway and taxiways had been treated with de-icing chemicals. After landing, the aircraft vacated Runway 25 on to Taxiway D, with reverse thrust still deployed. Smoke began to enter the cabin and the cabin manager advised the flight crew. As the smoke became thicker, the cabin manager recommended to the flight crew that an evacuation was necessary. The commander stopped the aircraft and the flight crew began their evacuation procedure. At the same time, the cabin manager initiated an evacuation in the cabin. When the commander heard the forward cabin doors being opened, he immediately shut down the engines. During the evacuation one passenger received minor injuries.

The de-icing chemicals were most probably the source of the smoke, the density of which was probably exacerbated by the prolonged use of reverse thrust.

The aircraft and airport operators each conducted their own investigations and made internal recommendations on the lessons learned from this incident.

History of the flight

The aircraft and crew operated from their base at Liverpool Airport to Madrid Barajas Airport and back, before departing for Belfast Aldergrove Airport. The crew consisted of the commander and co-pilot, the cabin manager and one cabin crew member seated in the forward galley, and two further members of the cabin crew seated in the rear galley. The commander was pilot flying (PF) and there were 46 passengers on board.

During the brief cruise portion of the flight, the co-pilot, who was pilot non-flying (PNF), obtained the latest ATIS information for Belfast. It stated that the wind was calm, visibility was 2,900 metres in mist with no significant cloud, dew point and temperature were both -3ºC, and the QNH was 1002 mb. Runway 25 was in use and the runway state was reported as wet in all three sections. The runway and taxiways at Belfast had been treated with potassium acetate and urea during the day, to prevent ice forming; this information was not communicated to inbound aircraft.

The cabin was secured for landing and the cabin lights were dimmed; most of the available illumination in the cabin was from reading lights which some passengers had switched on. The landing was normal; the commander had pre-selected autobrake LO and used idle reverse thrust after touchdown, as he had briefed. During the landing roll, the aerodrome controller instructed the aircraft to continue to the end of the runway and vacate onto Taxiway D (see Figure 1) because the shorter route to the apron via Runway 35 was temporarily blocked. The controller then asked the flight crew to keep the aircraft's speed up prior to vacating.

Idle reverse thrust remained selected and, as the aircraft vacated the runway, the co-pilot carried out the after-landing scan, which included selecting air conditioning pack 2 to OFF and starting the APU. The aircraft was the first to use Taxiway D for some time and deposits of de/anti-icing products were lying on the taxiway.

Shortly after this, a smoke-like substance started filling the cabin from the overhead vents. Passengers and crew, interviewed after the event, described the smoke appearing along the entire length of the cabin, and that it was either brown or black in colour. It was impossible to ascertain precisely the volume or density of the smoke but crew and passengers reported that visibility was affected. They described the smell as being reminiscent of a bonfire or electrical burning.

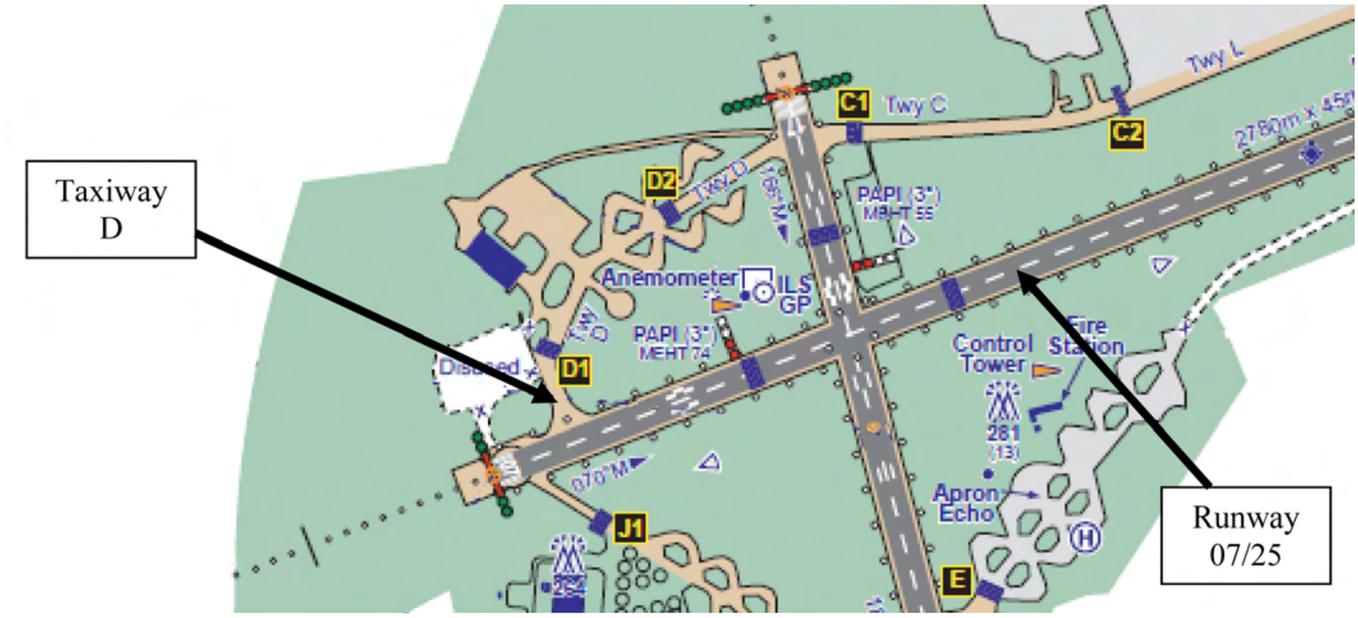


Figure 1

North-western area of Belfast Aldergrove Airport

In the rear galley, both cabin crew members became aware of the smoke and prepared to don their smoke hoods. In the forward galley, both the cabin manager and cabin crew member also noticed the smoke. The cabin crew member left his seat and ran part of the way down the length of the cabin, shouting to passengers "get your heads down", before he returned to the galley. The cabin manager, meanwhile, used the service interphone to contact the flight crew. The co-pilot answered the call, and the following dialogue took place:

Cabin manager: "HI, WE'VE GOT SMOKE IN THE CABIN"
Co-pilot: "YOU'VE GOT SMOKE IN THE CABIN"
Cabin manager: "YES"
Co-pilot: "OKAY"
Cabin manager: "OKAY"

The commander had selected the service interphone OFF on his audio selector panel and thus did not hear this exchange; he then switched it ON to hear any subsequent communications from the cabin. The co-pilot advised the commander of the cabin manager's communication, before asking him if he could smell anything. At about the same time, the thrust levers were moved from the idle reverse thrust position to the idle position. The aircraft had travelled approximately 270 m along Taxiway D by this time and its ground speed had reduced progressively to about 12 kt.

The cabin manager then saw that the smoke was becoming thicker and made another call on the service interphone during which the following exchange took place:

Cabin manager: "I THINK WE NEED TO EVACUATE"
Co-pilot: "WE NEED TO EVACUATE"
Commander: "OKAY"
Co-pilot: "OKAY"
Cabin manager: "BYE"

The commander brought the aircraft abruptly to a stop, set the parking brake, and called for the evacuation checklist. The co-pilot made a MAYDAY call, advising that the aircraft was being evacuated. However, he had not re-selected his audio panel transmit switch from the cabin interphone position to VHF 1, so the call was made over the interphone system and was not transmitted to ATC.

The commander confirmed the first item of the checklist while, simultaneously, the cabin manager issued an evacuation command over the public address system, saying: "UNFASTEN YOUR SEAT BELTS AND GET OUT". The cabin manager did not activate the evacuation alarm. The commander heard the forward doors opening behind the flight deck and, being concerned that evacuating passengers might be endangered by the engines, he immediately shut them down. As the engine-driven generators went off line, all lighting in the flight deck extinguished; there was very little ambient light. The flight crew found they were unable to read the evacuation checklist, so the commander carried out some items of the checklist from memory and by touch. The fire pushbuttons were operated and the extinguishing agents discharged.

The aerodrome controller called the aircraft with further taxi instructions and the commander replied, stating that an evacuation was taking place. The controller initiated the emergency plan and Rescue and Fire-fighting Service (RFFS) vehicles deployed to the aircraft.

Immediately after the evacuation command was made on the public address system, the cabin manager and cabin crew member in the forward galley checked the areas outside doors 1L and 1R for hazards and opened the doors. Both slides deployed correctly and passengers evacuated the aircraft.

On hearing the evacuation command from the cabin manager, the cabin crew at the rear galley put down their smoke hoods, checked for hazards outside doors 2L and 2R and opened those doors. The slide at door 2L deployed correctly. However, the cabin crew member who opened door 2R observed that the area outside the door was "pitch black" and he was unable to see whether the slide had deployed correctly. Bearing in mind that the aircraft was only one third full, he decided to direct passengers to the slide at door 2L. Once all passengers had evacuated, the flight and cabin crew followed them down the slides. The commander picked up a torch from its stowage as he left the aircraft. Once outside, he used his torch to identify himself to passengers and called them around him.

All the passengers and crew had evacuated the aircraft by the time the RFFS vehicles arrived. Some RFFS personnel attended to the passengers, handing out survival blankets and putting some passengers in their vehicles to keep warm. Other RFFS personnel, wearing breathing apparatus, accessed the aircraft using a ladder. Thermal imaging equipment was used inside and outside the aircraft to check for signs of heat or fire, but none were found.

Coaches were deployed from the airport terminal, to collect the passengers, and arrived at the aircraft approximately 20 minutes after the evacuation. The passengers were taken to a lounge in the terminal where they were reunited with their possessions and offered medical care. The coaches had been parked outside prior to their deployment and the windscreens were frozen over, delaying their deployment.

One passenger described sustaining bruising and suffering headaches and back pain during the evacuation, recalling that a female passenger wearing high-heeled shoes had been pushed onto her on the evacuation slide.

Flight recorders

A record of the incident was available from the FDR and CVR. Figure 2 is a plot of salient parameters from the FDR during the landing and taxi in. Both recordings stopped shortly after the engines were shut down.

Reverse thrust

The operator advised the AAIB that other recorded flight data indicated that the commander "routinely used idle reverse thrust beyond the landing roll and onto the taxiway down to approximately 15 kt to save brake wear".

The commander had held a command on the A319 aircraft for four years. His use of reverse thrust had not been commented upon during training or checking, or identified by flight data analysis during that period.

Runway and taxiway de-/anti-icing

Due to the inclement weather conditions, Runway 25/07 and Taxiway D had been treated with de-icing chemicals on several occasions prior to the incident. Table 1 is an extract from the log of chemical applications contained in the airport operator's report on the incident.

The potassium acetate was in the form of a thickened liquid and the urea was in the form of prills (small pellets). Following the incident, the Airport Duty Manager identified partially dissolved prills on the final third of Runway 25.

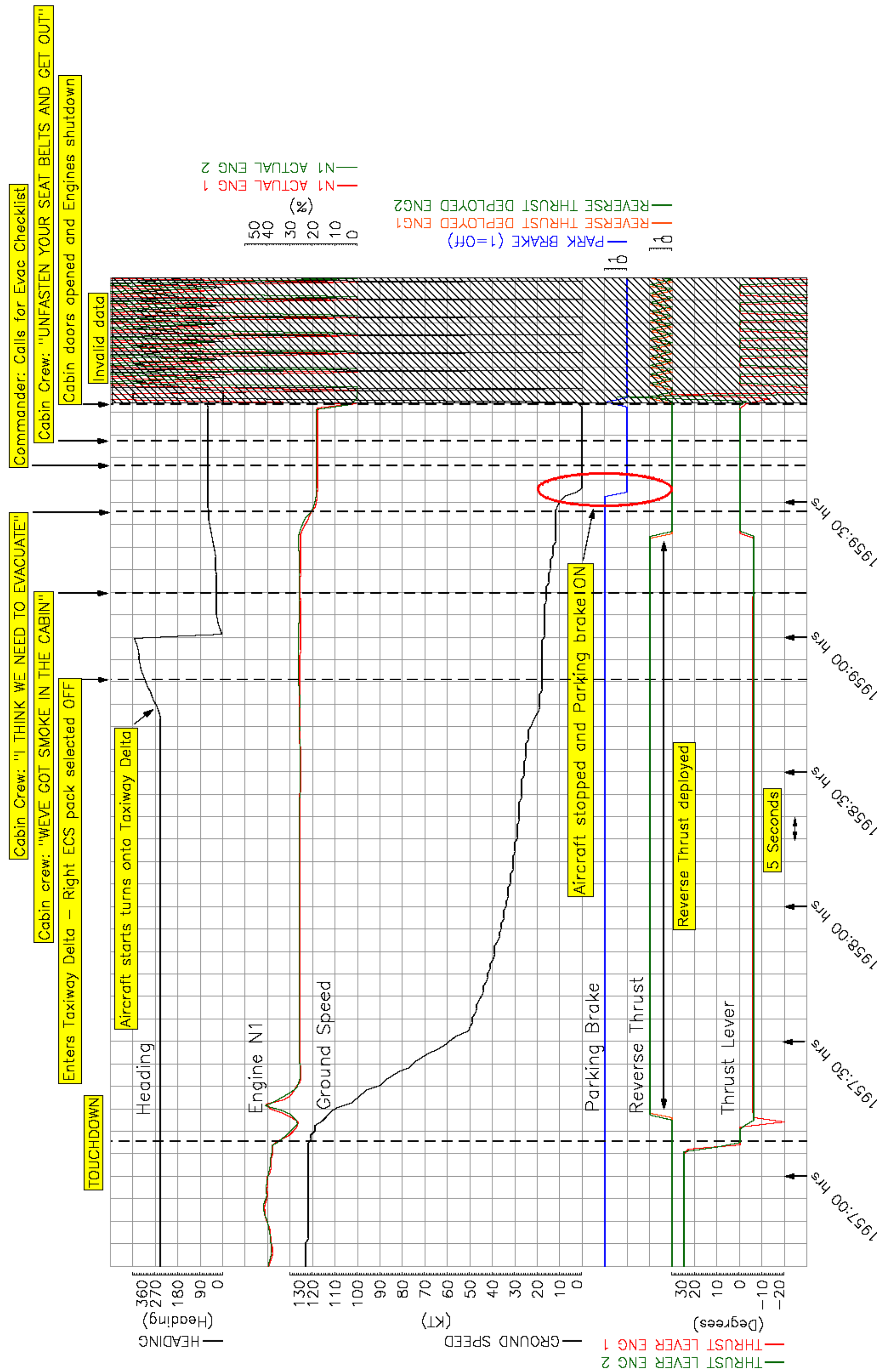


Figure 2

Recorded data for the landing and taxiing phases

Chemical applications Runway 07/25 and Taxiway D for 5th and 6th January 2011						
Date of application	Time of application	Chemical type	Application rate	Surface temp at time of application	Air temp at time of application	Surface state at time of application
05.01.11	23:28	Potassium acetate (Isomex3)	22g/m2	-1.4°C	0.0°C	Wet
06.01.11	05:55	Urea	100g/m2	-1.2°C	1.7°C	Wet
06.01.11	14:20	Urea	100g/m2	2.2°C	2.3°C	Wet

Table 1

Extract from airport operator's log of chemical applications on the manoeuvring area

Cabin air supply

During normal operation, bleed air is taken from the engine compressors and passed through an air conditioning system to provide a supply of temperature-controlled fresh air to the passenger cabin and flight deck. The air supply can also be provided by the APU or a ground source via an external connection, if required. The high temperature bleed air from the engine is cooled to approximately 200°C before entering the air conditioning system where it is further cooled to the temperature required in the passenger cabin and flight deck. A system of cabin fans and filters re-circulates the air within the cabin.

Investigation of smoke source

Engineers acting for the operator inspected the bleed air and air conditioning systems for defects and contamination. No anomalies were found and there was no recurrence of the smoke or fumes during the subsequent ground tests of the cabin air supply system.

The operator took a number of samples from the aircraft and passed them to a specialist laboratory for examination. These samples included seat headrest covers, air filters and wipes taken from the engine compressor blades. Seat headrest covers from another aircraft were also sent to the laboratory for comparison. The results showed that the seat headrest covers from G-EZFI contained significantly more potassium and acetate than those from the other aircraft. The samples from the No 2 engine compressor blades contained more potassium acetate than the other wipes, but the laboratory noted this result could be heavily influenced by the area wiped and efficiency of collection. Concentrations were found on the air filters but as no control filter was available, the laboratory was unable to comment on this finding.

Evacuation equipment

Each of the four main doors and each pair of over-wing escape hatches is equipped with an escape slide that will deploy and inflate automatically when the exit is opened in the emergency mode. The sides are fitted with lights, which illuminate automatically on inflation, and a manual inflation handle is provided in case automatic inflation does not occur.

The four main doors were opened by the cabin crew and all four escape slides deployed and inflated normally. The crew member at door 2R reported that they could not see the bottom of the slide as it was too dark and, as a result, they redirected passengers to the opposite door. Later, testing of the door 2R slide lights in a workshop found them to be serviceable. However, as the slide had been disconnected to recover the aircraft, no checks could be made on the integrity of the wiring connection to the slide assembly.

The cover over the operating handle of the rear right over-wing hatch had been removed but the hatch had not been opened. No attempt had been made to open any of the other over-wing hatches.

Procedures

Use of reverse thrust

Instructions and advice regarding the use of reverse thrust during and after landing appeared in a number of places in the operator's operations manual. The texts included instructions that reverse thrust should be de-selected after landing, when taxi speed was reached, and reversers should be stowed before leaving the runway to prevent foreign object ingestion. Figure 3 shows an excerpt from the operator's operations manual.

The flight crew training manual also stated:

> *'Stow the reversers before leaving runway to avoid foreign object ingestion.'*

AT TAXI SPEED:

THRUST levers .... **FWD IDLE**

Deselect the REV position upon reaching taxi speed. On snow-covered grounds, reversers should be stowed when the aircraft speed reaches 25 kt. When deselecting REV be careful not to apply forward thrust by moving the thrust levers beyond the FWD IDLE position.

CAUTION:

On taxiways, the use of reversers, even when restricted to idle thrust, may have the following effects:

The engines may ingest fine sand and debris that may be detrimental to both the engines and the airframe systems.

On snow covered areas, snow will re-circulate into the air inlet, which may result in engine flame-out or roll back.

Except in an emergency, do not use reverse thrust to control aircraft speed while taxiing.

Figure 3

Extract from the operator's operations manual

Runways treated with de/anti-icing products

The following statement about runways treated with de/anti-icing products was included in the operations manual:

> *'Engine ingestion of freshly treated runway with potassium acetate/urea may occur causing a nontoxic mist in the cabin. This mist can be misidentified as smoke. Therefore, consider briefing the Cabin Crew prior to landing.'*

Smoke in the cabin (aircraft on the ground)

Cabin crew procedures

The operator's cabin safety procedures manual included the following instructions to cabin crew, under the title: *'Crew co-ordination'*:

> *'Investigation has emphasised the importance of effective communication and coordination between the Pilots and Cabin Crew in increasing the chances of passenger survival following an emergency…*
>
> *Changes in performance of the aircraft, such as strange noises, vibration, smoke or any other indication, which is considered unusual, must be reported to the Commander.'*

The cabin safety procedures manual contained the following with respect to the crew call system and interphone:

> *'If the Cabin Crew wish to speak to the pilots via the interphone, they should pick up the handset and select "CAPT". The AIP* [Attendant Information Panel] *at the origin station will indicate "CAPTAIN". In the Flight Deck, a buzzer will sound for one second, and a light on the Audio Control Panel "ATT" will flash to alert the pilots to the call.*
>
> *'In an emergency, the Cabin Crew can contact the Pilots by selecting "EMER CALL" on the interphone handset. On the AIP nearest to where the call was made, the red indicator will flash and the message "EMERGENCY CALL" will appear. In the Flight Deck, the emergency "CALL" light flashes on the overhead panel and a buzzer sounds three times.'*

Flight crew procedures

The Flight Crew Training Manual contained the following advice to flight crew (Figure 4).

> **COORDINATION WITH CABIN CREW**
>
> **Applicable to: ALL**
>
> Good coordination between cockpit and cabin crew is a key element .
> In case of smoke in the cabin, it is essential that the cabin crew estimate and inform the cockpit concerning the density of smoke and the severity of the situation.

Figure 4

Extract from the Flight Crew Training Manual

Evacuation

Flight crew guidance and procedure

The operations manual contained the following checklist and information[1] (Figures 5 and 6).

As soon as an Emergency situation is recognised the CM1 should take control, stop the aircraft and set the parking brake on, then make a PA "ATTENTION CREW AT STATIONS". The following script details the procedure.

The checklist is to be accomplished as a crew in an orderly manner, expeditiously but not rushed.

CM1	CM2
Aircraft Stop	
Parking Brake Set ON	
PA "ATTENTION CREW AT STATIONS"	
Evaluate situation, initiate ECAM is appropriate and if necessary at any time call "EMERGENCY EVACUATION CHECKLIST"	Action ECAM if appropriate Locate the EMER EVAC Checklist
Notify ATC "MAYDAY MAYDAY MAYDAY *callsign* EVACUATING" See note 1	
	Announce "EMERGENCY EVACUATION CHECKLIST"
"STOPPED / ON"	"AIRCRAFT / PARKING BRAKE - STOP / ON"
"ALERTED"	"CABIN CREW PA - ALERT" (reminder of 'At Stations' PA)
"NOTIFIED"	"ATC NOTIFY"
"CHECKED"	"CABIN DIFF PRESSURE" - "NOT APPLICABLE" or "ZERO"
"CONFIRMED"	"ENG MASTER 1 AND 2 - OFF" If not already done move ENG MASTER 1 and /or 2 to OFF
"CONFIRMED"	"FIRE PUSHBUTTONS - PUSH" Push Engine and APU Fire pushbuttons
Order as appropriate e.g. "AGENT 1 ENGINE 1" or if already discharged "DISCHARGED"	"AGENTS - DISCHARGE" Discharge agents according to PF's command. See note 2
PA "EVACUATE UNFASTEN YOUR SEATBELTS AND GET OUT" Press EVAC COMMAND pushbutton	"EVACUATION - INITIATE"
	"EMERGENCY EVACUATION CHECKLIST COMPLETE"
EVACUATE	EVACUATE

Figure 5

Extract from operator's operations manual

Footnote

1 CM1 – Crew Member 1 (left seat pilot); CM2 – Crew Member 2 (right seat pilot).

NOTES:

1 "Mayday" prefix to call not required in case of RTO.

2 Agents are not required to be discharged unless there are positive signs of fire.

EVACUATION SIGNAL

The primary means of initiating an evacuation remains as the PA command "Evacuate. Unfasten your seatbelts and get out." The Evacuation Signal should be activated as confirmation of an evacuation command. If the evacuation signal is heard without the "Evacuate. Unfasten your seat belts and get out." PA command, the cabin crew will check with the flight crew before initiating an evacuation unless the situation is clearly catastrophic.

Figure 6

Notes related to extract from operations manual in Figure 5

Cabin crew - guidance and procedure

The cabin safety procedures manual contained the following instructions and advice regarding evacuations:

'The decision to evacuate

Although it is normally only the Commander who may order an evacuation of the aircraft, circumstances may dictate that any other Cabin Crew member may initiate such action.

In an emergency, after the aircraft has come to rest, the Commander would normally assess the situation and make the decision as to whether an evacuation is necessary.

However, there may be other factors, perhaps unknown to the Commander at that time and if there is an obvious, immediate life threatening situation i.e. catastrophic, any Cabin Crew member can initiate an evacuation.

If there is no communication from the Pilots in an emergency situation, after the aircraft has come to a complete stop, and if the Senior Cabin Crew Member finds the pilots incapacitated then the Senior Cabin Crew Member can initiate an evacuation.'

The cabin safety procedures manual contained the following definition of 'catastrophic':

'The term CATASTROPHIC is used to describe the situation where the aircraft has suffered serious structural damage and possible death or injury to any of the occupants.

Examples of catastrophic situations, which may require immediate independent evacuation actions by the Cabin Crew may include:

- *Ditching (landing on water)*
- *Uncontrolled cabin fire/smoke*
- *Severe structural damage to the aircraft (hole through fuselage, abnormal aircraft attitude possibly accompanied by the sound of severe scraping as the aircraft comes to a stop).*

> *In every case, Cabin Crew members must consider the immediate and potential consequences before initiating an evacuation; some serious injuries are likely to be sustained by the passengers from the evacuation itself.'*

Under the title: *'Engine danger areas'*, the cabin safety procedures manual contained the following:

> *'Cabin Crew must be aware that if any engine is still running during a ground evacuation, then the slide immediately aft of the operating engine may be damaged and any evacuating passengers are likely to suffer injuries from the jet blast.*
>
> *In the case of a slide being deployed forward of an operating engine, then the evacuating passengers would risk being drawn in to the air intake.'*

The cabin safety procedures manual contained the following with respect to the evacuation alarm:

> *'The aircraft is equipped with an evacuation alarm. This can be activated from both the Cabin and the Flight Deck…*
>
> *The switch in the Flight Deck has two positions, CAPT and CAPT & PURS.*
>
> *'Company SOP's state that the switch must be in CAPT position at all times. In this position when the EVAC button is pressed in the cabin it will only give a signal in the Flight Deck. The cabin command buttons are located on the [forward attendant panel].*
>
> *In the event of an evacuation commanded by the Cabin Crew they must press the EVAC button to inform the Pilots of the evacuation.'*

Flight deck lighting

The operator's flight crew training manual stated that:

> *'…on ground with engines stopped, only the right dome light is operational and the three positions (BRT, DIM, OFF) of the dome light sw remain available, allowing the emergency evacuation procedure completion.'*

Other events

A review of the CAA MOR database identified a number of previous events in which it appears that anti/de-icing products on the manoeuvring area caused smoke or fumes in the cabin. Although the brevity of some reports made any detailed analysis difficult, one report mentioned prolonged application of reverse thrust after landing. The operator's fleet experienced two similar events in January 2011, one in Budapest and the other also at Belfast. Urea was used at both airports as a runway de-icing treatment.

One report on the MOR database mentioned the CAA Notice to Aerodrome Licence Holders (NOTAL) 4/93, published in 1993, which stated:

> ***'PAVEMENT DE-ICING CHEMICALS – POSSIBLE SIDE EFFECT***
>
> *INTRODUCTION*
>
> *1 Following a routine landing on a recently de-iced runway at a major UK airport, the captain of a B737 reported to ATC the presence of smoke and fumes in the aircraft. The RFFS was dispatched, the aircraft shut down and the passengers disembarked using the integral airstairs.*

2 Subsequent investigation determined that de-icing compound had been ingested during the landing run and that the resultant smoke and fumes were dispersed throughout the aircraft by the air conditioning system.

3 This was one of a number of similar incidents reported last winter and whilst none has so far resulted in injury to crew or passengers, premature disembarkation under such circumstances would certainly result in inconvenience and distress to passengers as well as to disruption of routine aerodrome operations.

PURPOSE

4 The purpose of this NOTAL is to draw the attention of aerodrome operators to a side effect associated with the use of certain pavement de-icing chemicals.

SCOPE

5 The problem has so far been confined to turbo-jet aircraft following a landing run, during which reverse thrust was employed, on runways recently treated with UREA pellets.

IMPLEMENTATION

6 Aerodrome operators should review their pavement de-icing procedures with a view to ensuring that de-icing chemicals are properly prepared (UREA pellets should be thoroughly wetted immediately prior to use), applied in the correct quantities and that where UREA is used, ATC staff are made aware of its use and of the possible side effect reported in this NOTAL.'

The NOTAL was withdrawn in 2006. The CAA was not able to identify where the information contained in the NOTAL was then promulgated but commented that, because of environmental concerns, urea was much less widely used on the mainland UK after the mid-1990s.

The urea pellets applied at Belfast had not been wetted before application.

Analysis

Production of the smoke

No faults were found in the aircraft's bleed air or air conditioning systems. The relatively higher levels of potassium and acetate on the seat headrest covers were consistent with high levels of potassium acetate in the cabin environment. Both potassium acetate and urea based de-icing products had previously been applied to the runway and taxiway and they were most probably the source of the smoke/fumes. It seems likely that de-icing chemicals were ingested into the engine, before passing through the air conditioning system and entering the cabin though the overhead vents. Although evidence of potassium acetate was found in the cabin, information concerning previous and subsequent events suggested that urea pellets may also have been the source of the smoke.

Two factors probably influenced the production of smoke. First, the taxiway onto which the aircraft turned had been regularly treated during the period preceding the event but very lightly trafficked, so there was probably more de-icing product on this taxiway than on other parts of the manoeuvring area. Secondly, it is likely that the prolonged use of reverse thrust increased the volume of these products delivered to the cabin and the thickness of the smoke. The appearance of the smoke was coincident with the use of reverse thrust on the taxiway.

NOTAL 4/93 had informed aerodrome licence holders of this phenomenon but had been withdrawn without the information being incorporated into any document which would ensure its continued distribution. Of note, the NOTAL advised that urea pellets should be thoroughly wetted immediately prior to use.

Evacuation

The cabin manager's response to the smoke was driven by a concern that fire or smoke in an aircraft may be very hazardous to the occupants; the cabin safety procedures manual listed *'uncontrolled cabin fire/smoke'* as an example of a catastrophic situation which may require immediate independent evacuation action by the cabin crew.

However, at the time the cabin manager commanded the evacuation, the engines were running and the flight crew were in communication with the cabin manager. Therefore, it would have been appropriate for the cabin manager to wait for the commander to initiate the evacuation, according to the laid down procedure.

After the engines were shut down and all lighting in the flight deck extinguished, the right dome light was available to the flight crew but needed to be switched ON manually.

Communications

Effective communication between the cabin and flight crew is essential in dealing with hazardous circumstances; this was reflected in the guidance provided by the operator. The commander's attention would have been drawn to the first communication about smoke more effectively if the cabin manager had used the emergency call function of the interphone system, rather than the normal call.

In the cabin manager's second call to the flight deck, the co-pilot repeated the cabin manager's information to her, for confirmation. Both the commander and co-pilot responded to the cabin manager's statement "I THINK WE NEED TO EVACUATE" with "OKAY". In this context, the word 'okay' might have two meanings: an acknowledgement of understanding, or an agreement with the proposed course of action. It is possible that the cabin manager's subsequent actions were influenced by what she perceived to have been an agreement from the commander to evacuate.

Following a decision by the commander to evacuate, the appropriate checklist should be actioned to configure the aircraft for the evacuation. Of prime importance in this is the shutting down of the engines, which, if running, pose a significant hazard to passengers who have left the aircraft. The commander's action in shutting the engines down, immediately he heard the forward doors being opened, minimised this hazard.

Use of the evacuation alarm by the cabin manager would have provided a clear signal to the flight crew that an evacuation had been initiated.

Safety actions

Aircraft operator

The operator stated that its FDM[2] department would develop and implement a monitoring programme to identify non-standard use of reverse thrust. The programme would help determine whether this event was an isolated case. Also, the operator instructed the training captains on its Airbus fleet to be vigilant for *the non-standard use of thrust reverse during taxi … and correct any misconceptions* regarding its use.

Footnote

[2] Flight data monitoring.

Although the operator's cabin safety procedures manual stated the importance of effective communication, it did not expand upon this by giving techniques to achieve it. The operator's safety action, in introducing a CLEAR[3] briefing, appeared to address this.

The operator carried out its own investigation into the incident and published an internal report which included several safety recommendations in the following areas:

- Review of the operations manual
- Monitoring of flight data regarding use of reverse thrust
- Training in use of reverse thrust
- Introduction of a new briefing format CLEAR for cabin crew to use when communicating with flight crew in emergency situations

Airport operator

The airport operator compiled a report on the event, focussing on the airport's response to the evacuation and care of the crew and passengers. It explained that the response had been effective although it identified among other things the following difficulties:

- The buses used to transport the passengers and crew had been parked in the open and their windscreens were frozen. This delayed deployment of the buses;
- There was a further delay to the transport of the passengers to the terminal as their belongings were transported in the same buses, and recovering them from the aircraft took time;
- Although a passenger headcount was carried out after the evacuation, no headcount was carried out on the buses prior to them leaving the aircraft.

The report contained sixteen recommendations to improve the airport operator's response to a similar event in the future.

Footnote

[3] Crew name; location; event; actions taken; recommendation for further action.

SERIOUS INCIDENT

Aircraft Type and Registration:	Airbus A300-B4-622R, TF-ELK
No & Type of Engines:	2 x Pratt & Whitney PW4158 turbofan engines
Year of Manufacture:	1989
Date & Time (UTC):	10 January 2011 at 2150 hrs
Location:	East Midlands Airport
Type of Flight:	Commercial Air Transport (Cargo)
Persons on Board:	Crew - 2 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Tailskid and fuselage skin
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	45 years
Commander's Flying Experience:	5,282 hours (of which 4,600 were on type) Last 90 days - 103 hours Last 28 days - 45 hours
Information Source:	AAIB Field Investigation

Synopsis

An approach to East Midlands Airport was being flown in gusty crosswind conditions. Reverse thrust was selected immediately after touchdown, but the aircraft subsequently bounced and the commander decided to go around. During the go-around the No 2 (right) engine thrust reverser failed to stow, and the engine thrust was maintained at idle by the FADEC system. The aircraft's tail struck the ground during the rotation. The aircraft became airborne at low speed in a high drag configuration and its acceleration and climb performance did not increase appreciably until 47 seconds after lift off. The No 2 engine was subsequently shut down and the aircraft diverted to Stansted Airport, where a single-engine landing was carried out. The No 1 thrust reverser was selected during the landing at Stansted, but did not fully deploy. The investigation found that the most likely reason for the No 2 thrust reverser failure to stow was an intermittent loose connection in the auto-restow circuit. It was further determined that conflicting operational guidance exists with respect to selection of reverse thrust and go-around procedures. A number of safety actions have been taken as a result of this serious incident.

History of the flight

The aircraft took off at 2043 hrs for a scheduled flight from Belfast to East Midlands Airport. The commander acted as handling pilot for the sector. In addition to the co-pilot, a company engineer was also onboard, positioning as a passenger, and was seated in a designated area within the cabin.

The initial part of the flight proceeded without incident and the crew prepared for an ILS approach to Runway 09. The weather at East Midlands Airport, as reported by ATC, was: surface wind from 170° at 22 kt, visibility 15 km, cloud broken at 1,500 ft, slight rain with a wet runway and a temperature of 7°C. The surface wind report was later updated to 160° at 20 kt, gusting 30 kt[1].

The FMS calculated approach speed (V_{REF}) of 135 kt was increased by 9 kt to allow for the gusting nature of the wind, giving an FMS approach reference speed (V_{APP}) of 144 kt.

The crew were given radar vectors by ATC to establish on the ILS and they configured the aircraft for a normal full-flap landing. On passing about 1,000 ft the co-pilot requested a wind check which was given as 160° at 22 kt.

The commander stated that, as usual, he began to flare at about 30 ft agl and, at about 20 ft agl, closed the throttle control levers. However, he considered that the aircraft's rate of descent was excessive and so increased the nose-up pitch. The aircraft touched down and then bounced. The commander reduced the pitch attitude slightly to allow the aircraft to settle back onto the runway, without adjusting the thrust. The aircraft touched down again, heavily, before bouncing back into the air. Neither pilot recalled reverse thrust being selected during the landing attempt.

After the second bounce, the commander decided to go around and commanded full thrust on both throttle control levers. The aircraft remained configured with full flaps and the gear down as it commenced the go-around.

An air traffic controller who witnessed the landing stated that the touchdown had seemed firm and that he had seen a shower of sparks emanating from the rear of the aircraft. He described the aircraft appearing to fly very slowly over the runway during the go-around, rolling from side to side and not climbing above more than about 200 ft. He was sufficiently concerned that he pressed the crash alarm. He refrained from contacting the pilot, so as not to distract him, until the aircraft was about 3 nm to the east of the airfield, when it was then seen to be climbing.

The commander stated that he experienced considerable difficulty getting the aircraft to accelerate during the go-around. Eventually the speed started to increase and he instructed the co-pilot to reduce the flap setting to FLAP 20. The aircraft then started to climb, at which time the gear was raised, and as the aircraft continued to accelerate, the flaps were retracted fully.

The crew stated that at this point they noticed that the ECAM was showing an ENG 2 REVERSE UNLK caution message. The commander reported that as the aircraft continued to climb away he moved the No 2 throttle control lever to look for a thrust response and operated the No 2 thrust reverser lever to try and get the thrust reverser to lock. This appeared to have no effect. The crew stated that they completed the ECAM checklist, followed by the QRH checklist; finally shutting down the No 2 engine. After considering the weather conditions, the crew elected to divert to Runway 22 at Stansted where the wind was given as 170° at 19 kt. They carried out an uneventful single-engine ILS approach and touched down at 2203 hrs.

After landing, reverse thrust was selected on the No 1 (left) engine by the commander. The co-pilot believed that reverse thrust had not engaged properly and informed the commander, who then cancelled it.

Footnote

1 Equivalent to a maximum crosswind component of 28 kt. The Operator's crosswind limit was 30 kt.

Upon subsequent inspection at Stansted it was noted that the aircraft had suffered a tailstrike.

Damage to aircraft

The tailskid shoe on the underside of the rear fuselage showed evidence of scraping consistent with having contacted the runway. In addition there was a 3 mm deep dent and local buckling of the fuselage skin approximately 23 cm to the right of the tailskid shoe.

Background information

Thrust reverser system overview

The thrust reverser system provides aerodynamic braking during landing rollout by redirecting engine fan air to produce a forward airflow. The system is electrically controlled, pneumatically driven and mechanically actuated. When the thrust reverser is deployed, two translating sleeves move rearwards on tracks to expose a fixed cascade. Simultaneously, blocker doors are rotated into the fan airstream to block the normal fan airflow path and redirect the air outwards and forwards through the cascades. If a reverser is unlocked or in transit, logic in the Full Authority Digital Engine Control (FADEC) system limits the engine thrust, in some cases, to idle thrust. The reverser deployment stroke takes approximately 2.5 seconds and stowing takes about 5 seconds.

Thrust reverser controls

The thrust reverser levers, Figure 1, are mounted on the throttle control levers and can be operated when the throttle control levers are in the idle position. To deploy the system the thrust reverser levers are rotated upwards from the stowed position. A mechanical friction point indicates that the reverse idle threshold is reached. Electrical signals from microswitches under the throttle quadrant then command the thrust reverser actuation system and the translating sleeves move rearwards. For reverse thrust application, the mechanical friction point must be overridden and the thrust reverser levers pulled rearward towards the full reverse position; engine thrust increases accordingly. To cancel reverse thrust operation, the thrust reverser levers are returned to the stowed position.

Thrust reverser status indications

The status of the thrust reverser operation is indicated by two annunciator lights on the cockpit centre instrument panel. An amber REV UNLK warning caption illuminates in the cockpit, during the stow and deploy cycles, as soon as the translating sleeves are unlatched. The REV UNLK signal can be generated by the unlatching of the Pneumatic Drive Unit (PDU) primary brake or the master actuator secondary locks or the closing of the stow switch contacts. The REV UNLK caption remains on while the sleeves translate and until they have reached 93% to 97% (nominally 95%) of their travel. This indication is replaced by a green REV caption when the translating sleeves are

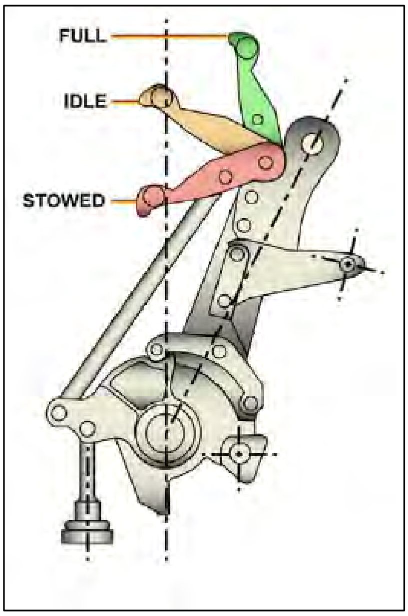


Figure 1

Throttle control levers showing reverse thrust controls beyond 95% of their travel on the deploy stroke, and the deploy limit switch in the master actuator feedback module is open. There is no cockpit indication when the sleeves are fully stowed. The REV UNLK and REV signals also generate discrete parameters recorded by the Flight Data Recorder (FDR).

Control speeds during go-around

A number of critical speeds are determined during certification of aircraft such as the A300 which must be achieved for full control to be assured. These take into account the loss of the 'critical engine', considered for aerodynamic reasons to be the engine on the into-wind side of the aircraft.

During a single engine go-around an aircraft should not be rotated below V_{APP} in order to ensure an adequate climb gradient is achieved. In addition, the aircraft must be flown above its minimum control speed in the air (V_{MCA}), with no more than five degrees of bank, to ensure that it remains controllable.

Recorded information

The aircraft was fitted with a Cockpit Voice Recorder (CVR) and FDR. Both recorders were downloaded by the AAIB. The operator also operated a Flight Data Monitoring (FDM) programme from which the Quick Access Recorder (QAR) download was also recovered.

The 30-minute voice recording downloaded from the CVR was of extremely poor quality, to the extent that the recording could not be used in the investigation. The FDM download revealed an empty data file which was later attributed to a hardware failure of the QAR.

The FDR recorded over 25 hours of operation, including the incident. The status of each thrust reverser lock (corresponding to the amber cockpit REV UNLK caption) was recorded once a second. The discrete confirming that each thrust reverser had achieved its deployed position (corresponding to the green REV caption) was recorded every four seconds. In addition, throttle control lever position and engine speeds were recorded every four seconds but thrust reverser sleeve position was not recorded. This parameter is normally available on the QAR recording.

The aircraft touched down on Runway 09 at a computed airspeed (CAS) of 135 kt and groundspeed of 138 kt (Figure 2). The aircraft bounced, characterised by the normal acceleration reversal; this was followed by a second, heavier, touchdown at 1.8g. At some point between the first and second touchdown, the recorded No 1 engine throttle resolver angle reduced to 24.5°. At almost the same time as the second touchdown, the No 2 engine throttle resolver angle reduced to 26°. According to the aircraft manufacturer, a throttle resolver angle of less than 32.4° will activate the thrust reverser deployment, and any angle below 30° represents commanded reverse thrust above idle. Due to the sampling rate of the engine speeds, it is unknown whether the engine speed advanced in line with the throttle control lever position.

The recorded landing gear squat switches did not register 'on ground' for the first touchdown[2] and one second after the second touchdown, both reversers became unlocked but neither achieved the deployed position. The throttle control levers were then advanced to the takeoff thrust position; again, the exact timing could not be confirmed due to the four second sampling rate of lever position.

Footnote

[2] Landing gear 'on ground' discretes are sampled once per second.

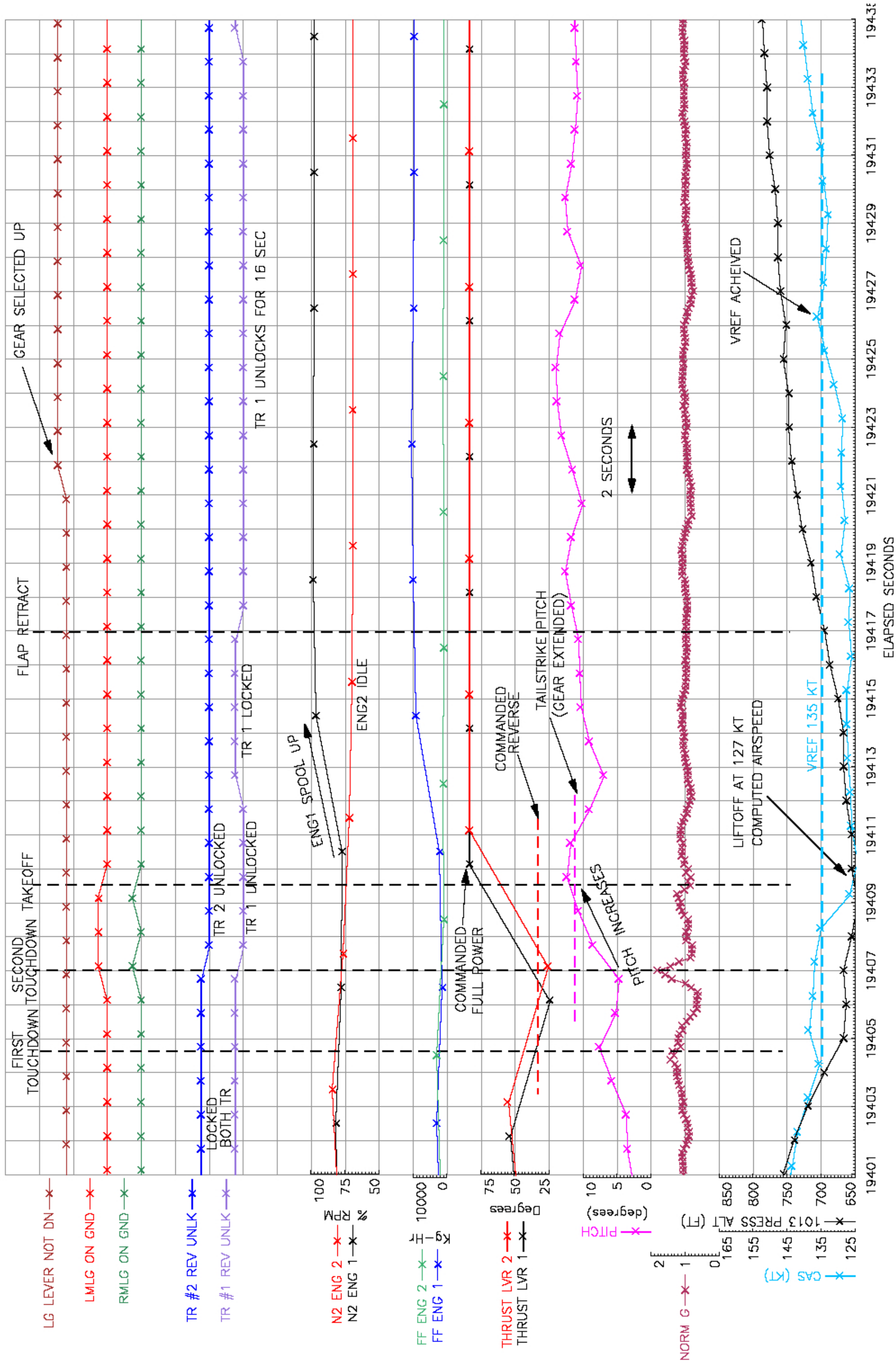


Figure 2

TF-ELK touchdown and go-around at East Midlands Airport: relevant FDR parameters

The main wheels remained on the ground for approximately two seconds, during which the aircraft pitched up from 5° to 12.5°, finally lifting off at an airspeed of 127 kt[3]. At no point did the nose landing gear oleo compress. The point at which the tailstrike occurred could not be identified from the recorded data, but the aircraft manufacturer confirmed that with the main landing gear oleos extended, a tailstrike can occur at a pitch attitude of 11.2°.

After both throttle control levers were advanced to the takeoff position, the No 1 engine thrust reverser locked but the No 2 engine thrust reverser remained unlocked for the rest of the flight. Engine thrust increased on the No 1 engine but the No 2 engine remained at idle thrust. The pitch attitude reduced and the aircraft began to climb away, gaining 92 ft during the first 13 seconds, during which the airspeed remained below the V_{REF} of 135 kt. Seven seconds after takeoff, the flaps were retracted one setting and five seconds later, the landing gear was selected to UP. During this period, the No 1 engine thrust reverser was recorded as being unlocked for 16 seconds, however the engine remained at full thrust. The aircraft then levelled for a few seconds and the speed increased to V_{REF} before the climb continued.

The next 100 ft of climb took a further 25 seconds and the speed increased to 152 kt. The aircraft then levelled off at approximately 200 ft aal for eight seconds as the speed increased to 160 kt, after which the rate of climb increased significantly.

Just over two minutes after lift off, the recorded No 2 engine throttle resolver angle reduced to the idle position. There were subsequently no further recorded movements of the No 2 engine throttle control lever.

Eleven minutes after the lift off from East Midlands Airport, the No 2 engine was shut down. During the landing at Stansted, reverse thrust was commanded on the No 1 engine. The thrust reverser unlocked but failed to achieve the deployed position despite being unlocked for 15 seconds, and engine speed did not increase in response to the reverse thrust command.

The 25-hour FDR recording contained data for 11 other landings which were reviewed. The landings on the two sectors prior to the incident flight revealed that the thrust reverser ‘lock’ and ‘deployed’ discretes recorded on the FDR behaved as expected. Reverse was successfully achieved on the No 1 engine but the No 2 engine speed did not increase in line with the command from the recorded throttle position. All other recordings of reverse thrust on landing were at reverse idle, so correct operation of the No 2 engine thrust reverser on these flights could not be confirmed.

Airbus Flight Operations Briefing Notes

In May 2005 Airbus published information on bounce recovery and rejected landings as part of a series of Flight Operations Briefing Notes. These were not formally made available to flight crews by the operator but were freely available online. The information emphasises that after thrust reversers have been selected the aircraft is committed to a full-stop landing. The information further states that thrust asymmetry resulting from one thrust reverser failing to restow have led to instances of significantly reduced rates of climb or departure from controlled flight.

The co-pilot stated that he had seen the relevant Briefing Note, although not recently, whilst the commander stated that he was not aware of its existence.

Footnote

[3] V_{MCA} for the aircraft in this configuration is 111 kt CAS (114.5 kt IAS).

Flight Crew Operating Manual (FCOM)

The operator used the Airbus A300-600 FCOM. The following sections are relevant to this investigation and both pilots reported that they were aware of their contents.

Landing Standard Operating Procedures - FCOM Section 2.03.22

These procedures state that the thrust reverser levers should be pulled to select idle reverse '*immediately after touch down of main landing gear'*. They further state that after reverse thrust is initiated a full-stop landing must be performed.

Additional notes include a warning not to move thrust reverser levers towards the stowed position while reversers are in transit as this may cause damage to the system.

General recommendations for takeoff and landing – FCOM Section 2.02.01

The FCOM recommends that in cases of light bounce (5 ft or less) at touchdown, landing should be completed. In cases of high bounce (more than 5 ft) a go-around should be initiated. Should a go-around be necessary it states that aircraft pitch and configuration should be maintained in order to soften any subsequent touchdown and prevent aircraft damage. The configuration should not be changed until the aircraft is '*safely established in the go-around and no risk of further touchdown exists*'.

The recommendations also include a warning that landing should not be attempted after a high bounce as the remaining runway may not be sufficient to allow the aircraft to stop.

Procedures in this section on rejected landings warn that if reverse thrust has been selected, a full-stop landing must be completed.

Go Around Standard Operating Procedures – FCOM Section 2.03.23

The go-around procedure requires that the aircraft be rotated at a typical rate of 3º per second up to an initial pitch angle of 18°.

Thrust reverser warnings - FCOM section 2.05.70

Abnormal configuration of the thrust reversers such as an in-flight thrust reverser deployment is accompanied by a master caution light and single aural chime and an ENG 1 (2) REVERSE UNLK ECAM message. In this incident the system logic would have inhibited the master caution and ECAM message until the aircraft had climbed through 400 ft agl.

The associated ECAM checklist actions, described in FCOM section 2.05.70, require the throttle control lever of the affected engine to be set to idle. If the engine thrust is automatically set to idle by the FADEC thrust limiting function, an ENG 1 (2) AT IDLE ECAM message is also displayed.

Thrust reverser system description

Thrust reverser actuation system

The key components of the actuation system are shown in Figure 3.

The Pressure Regulating and Shutoff Valve (PRSOV) regulates inlet bleed air pressure and airflow to the PDU and initiates the unlocking sequence of the master actuators. It is electrically controlled and pneumatically operated.

The electrical solenoid selector valve ports regulate air from the PRSOV to the deploy or stow ports of the PDU. This moves the directional valve to the deploy or stow position, causing the air motor to turn in the commanded direction and also pressurises the PDU brake release chamber to release the air motor brake. The two-position valve receives a 28 V DC signal from the throttle quadrant microswitches. There are two solenoids: one for the stow command and the other for the deploy command.

The PDU provides pressure-regulated air to the air motor which drives a series of flexible driveshafts at rotational speeds up to 20,000 rpm. These are connected to the master and slave ballscrew actuators that move the translating sleeves and blocker doors.

Three separate system locks prevent the reversers from operating unless commanded. The primary means of locking the translating sleeves in the stowed position is the PDU brake which locks the air motor. Normally the brake release chamber is depressurised and the brake is spring-loaded in the brake applied position.

The master actuators convert flexible drive shaft rotary motion from the PDU to linear motion for

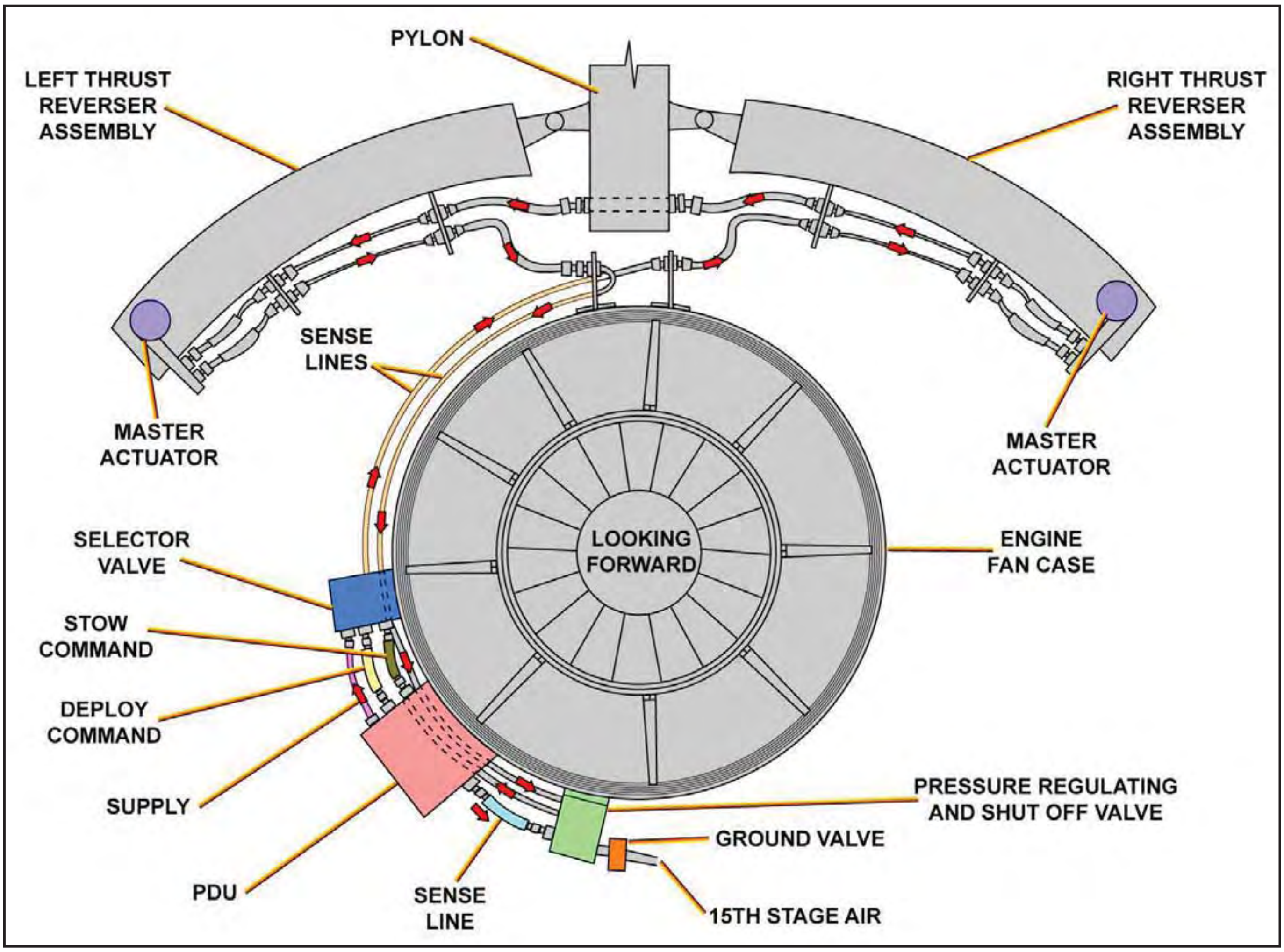


Figure 3

Thrust reverser system components (view looking forward) driving the translating sleeves via ballscrews. Each master actuator powers two slave actuators through flexible driveshafts. A feedback module located on the master actuator contains a Rotary Variable Differential Transducer (RVDT) and limit switches which indicate the stowed and deployed position and also control the arming solenoid of the PRSOV. The RVDT is driven by the master actuator internal gearbox in direct relation to the translating sleeve travel and provides a sleeve position signal to the FADEC system, proportional to the actuator percentage deployed.

The secondary system locks are incorporated into each master actuator. The master actuator locks only function when in the reverser stowed position and pressurisation of the lock actuator chambers is required to release the locks.

The third locking mechanism comprises two synchronous shaft locks, one per sleeve, installed between the master actuator and lower slave actuator and connected to them through flexible shafts. They are electrically controlled and the dedicated command circuit is independent from the other thrust reverser system controls. The synchronous locks are locked to restrain the flexible shaft system and hold the translating sleeves in the stow position, except when reverse thrust is commanded.

FADEC interface

The FADEC system interfaces with the thrust reverser system to provide engine thrust limiting when the reverser sleeves are in transit. The FADEC receives a signal proportional to the reverser sleeve position from each of the dual channel RVDTs in the master actuator feedback modules. During the deploy command, the FADEC software logic restricts the fuel flow to approach idle fuel flow until a signal indicating 78% of full deployment is received, regardless of throttle control lever position. Maximum fuel flow cannot be attained until 90% of full deployment is indicated. In the stow cycle, the FADEC software logic maintains idle fuel flow until an 85% stow signal is received. Maximum forward thrust cannot be attained until a 90% stow signal is received.

Auto-Restow circuit

During the deploy cycle the PRSOV arming solenoid is energised by an electrical signal from a microswitch in the throttle quadrant. A loss of electrical signal while the sleeves are translating will result in the arming solenoid becoming de-energised and the air supply to the PDU will be isolated causing the sleeves to stop their transit. The auto-restow circuit provides a continuous electrical path, independent of thrust reverser lever position, to energise the PRSOV arming solenoid when both stow switches are closed (ie thrust reverser sleeves not stowed). The stow switches remain closed throughout the entire thrust reverser operation cycle, from the deploy command until the reverser sleeves have been fully stowed. In this way, the auto-restow circuit ensures the closing operation during normal thrust reverser operations and also acts as a safety feature to return the thrust reverser sleeves to the stowed position in the case of an in-flight reverser deployment. A separate circuit provides the electrical path to energise the stow solenoid, when the thrust reverser levers are in the stow position.

Post-incident actions

After arrival at Stansted the engineer, who had been on-board during the incident flight, conducted an aircraft walk-round. He observed that the No 2 engine thrust reverser sleeves were deployed by approximately 25 cm (full deploy is 53 cm). After opening the fan cowl doors he noted that the upper flexible driveshafts from the splitter gearbox to the master actuators on both sides were twisted and the secondary locks were not engaged. The thrust reverser sleeves were then hand-cranked to the stowed position. As the flexible shafts from the splitter gearbox to the master actuators were still twisted, they were disconnected at the master actuator ends to release the tension and then reinstalled.

Aircraft examination

General

The aircraft was examined by the AAIB after the No 2 thrust reverser had already been stowed manually. It was therefore not possible to examine the No 2 thrust reverser in its immediate post-incident state. A FADEC ground test confirmed that the RVDTs on both reversers correctly indicated the stowed position.

No 2 Engine

Visual inspection of the No 2 thrust reverser system did not reveal any mechanical defects and the flexible shafts were all observed to be in good condition and adequately lubricated.

Electrical continuity checks revealed that, following a reverser stow command, no voltage was present on Pin 4 of electrical connectors DH16 and DH17 (synchronous lock solenoids). Voltage should have been present at these pins for a period of 10 seconds. The correct voltage was detected following a repeat test. These findings suggested the presence of a potential intermittent fault on relay 46 KM, which was removed for further testing and replaced. Relay 46 KM provides the electrical path, via two other relays to the synchronous locks and during the deploy cycle to the PRSOV arming solenoid. A disruption in voltage to relay 46 KM would result in an instantaneous loss of air to the PDU, causing the motor to stop turning and a loss of electrical signal to the synchronous lock causing the solenoids to de-energise. If this occurred while the sleeves were in a transit it would result in a 'crash engagement' of the synchronous locks, which would be evidenced by distinctive witness marks inside the lock.

A function check of the No. 2 thrust reverser was performed a number of times by pneumatically deploying and stowing the reverser using APU bleed air. The system operated as expected.

No 1 Engine

Visual inspection, electrical continuity checks and pneumatic functional checks of the No 1 thrust reverser system did not identify any defects that would have prevented correct operation of the system. However a temperature label on the PDU indicated that the unit had experienced an overheat and it was removed for further testing.

Engine runs

During post-incident engine ground runs both reversers were observed to deploy and stow correctly and to generate the appropriate REV UNLK and REV cockpit status indications, but the No 2 engine thrust did not increase above reverse idle when commanded. This was indicative of the FADEC system limiting the thrust, based on the RVDT feedback of reverser sleeve position.

Subsequent inspections

Following the initial aircraft examination the aircraft was returned to service with No 2 thrust reverser inoperative pending removal of components for testing. After removal of the components, the operator subsequently experienced further problems with thrust reverser operation resulting in a number of incidences of flexible shaft failure. These issues were determined to be related to rigging of the thrust reverser system following component removal and replacement, and were not considered relevant to the incident. In addition, subsequent electrical continuity tests were carried out to support the ongoing investigation. During these checks, upon inspecting the auto-restow circuit wiring and electrical connectors, a loose wire was found on Pin F of connector D5010P in the thrust reverser junction box (Figure 4). The effect of the loose wire would be an interruption of the electrical signal to the PRSOV arming solenoid during the stow operation. There was no relevant Trouble Shooting Manual (TSM) task to aid identification of such a fault.

Component Testing

Several components were tested at the respective manufacturers' facilities. The findings are outlined below.

No 2 thrust reverser components

Relay 46 KM was tested and it functioned correctly and conformed to specifications. Testing and internal examination of the synchronous locks did not reveal any evidence of a crash engagement, which would be apparent if the solenoids had instantaneously de-energised while the reverser sleeves were in transit.

Figure 4

Loose wire at Pin F of connector D5010P in the auto-restow circuit

The master actuators were received and examined in the stow position with the feedback modules attached. Although the actuators were visibly in the stow position, as confirmed by the stow switch and examination of the internal gearing, the Channel A and Channel B output voltage indications on both RVDTs were significantly outside limits, such that they indicated approximately 50% and 88% deployed, respectively. The master actuator gearbox drives the RVDT and the stow switch assemblies using the same input shaft; the disagreement between the RVDTs and stow switches was therefore considered abnormal. After the RVDT resolvers had been removed from the feedback module and physically reset to indicate the stow position, the test was repeated and the output voltages were found to be within limits. Electrical tests and examination of the internal gearing did not reveal any evidence which could account for the anomalous output voltages. The manufacturer considered that the only possible explanation for the gross anomalies with the RVDT output voltages was that the RVDT had been separated from the master actuator at some point, such that they were no longer aligned. However this could not be confirmed and there was no evidence of the RVDT mounting screws having been removed.

Further testing of the RVDT resolvers revealed that they did not conform to the manufacturer's specifications, displaying a small shift in alignment between Channel B and Channel A outputs. However the manufacturer considered that the results were not uncommon for RVDTs of that age (approximately 19 years). The findings on the RVDTs were not considered causal to the failure of the No 2 thrust reverser to stow as their only function is to provide feedback on thrust reverser sleeve position to the FADEC.

The PDU failed after the aircraft was returned to service. Inspection at a repair facility revealed an area of cut packing in an internal pneumatic line and dirt contamination in another. The PDU manufacturer determined that these findings may have resulted in insufficient air pressure to release the PDU brake fully, preventing the unit from functioning correctly. The unit performed satisfactorily after removal of the dirt and replacement of cut packing.

No 1 thrust reverser components

The PDU failed the manufacturer's Acceptance Test Procedures (ATP) as the pressures required to actuate the brake switch and the directional control valve exceeded the maximum permissible values. The air motor also failed the test which measured its stopping accuracy. The unit failed the minimum operating pressure test and was slow to function at low pressures. Although the temperature label had turned black, there were no indications of thermal distress to the unit.

Additional information

CVR serviceability

The operator's FCOM defined a daily test of the CVR system via a 'CVR TEST' pushbutton in the cockpit. There were no reported failures of this test prior to this incident and there was no reason for the operator to suspect a fault with the CVR. The fact that the recording quality was extremely poor suggests that this daily check, which records a test tone to each channel, was not capable of detecting a poor quality recording. The Airbus Maintenance Planning Document (MPD) also defined a detailed operational check by assessing the recorded quality of each recorded channel, required every 6,000 flight hours or four years. This operational check was successfully performed in July 2009.

Regulations concerning CVR serviceability are covered in several documents. ICAO Annex 6[4] Appendix 8 requires a daily check of the CVR built-in test (BIT) features in the cockpit (where fitted) and an annual read-out to assess the recording quality. EU OPS Part 1 contains no serviceability regulations for the CVR. The latest Minimum Operation Performance Specification (MOPS) for airborne recorder systems, ED112, recommends a daily activation of any test function/BIT monitoring, alongside a six-monthly operational test of the system and an annual recorder download.

As EU OPS Part 1 represents the mandatory regulations for this aircraft type aircraft operating from Iceland, the only requirement to perform CVR functional tests are through those imposed by the aircraft manufacturer. Some national airworthiness authorities, including the UK CAA, provide guidance notes[5] on the continued airworthiness of flight recorder systems which recommend operational checks, but these are not mandatory.

In December 2009, EASA issued Safety Information Bulletin 2009-28 highlighting the problem of dormant failures in flight recorders. In this bulletin it was recommended that the servicing interval guidelines in ICAO Annex 6 should be considered by design approval holders for the CVR installation, operators, maintenance organisations and national airworthiness authorities.

The detection capability of the daily CVR check on TF-ELK was insufficient to detect the poor quality audio recording. An annual download interval of 6,000 flight hours or four years for a system critical to accident investigation allows a significant exposure time for a dormant failure to appear in the CVR system. This is recognised by investigation authorities worldwide and is the reason why the ICAO and ED112 requirements are proposed.

The current EU OPS requirements do not reflect the current ICAO or ED112 operational requirements. EASA is in the process of revising EU OPS and draft proposals have included the introduction of a mandatory annual replay of the CVR.

Analysis

Operational aspects

Neither pilot believed reverse thrust had been selected after touchdown at East Midlands Airport, but the physical and FDR evidence showed that the reversers were selected and did deploy. However, the low sampling rate of throttle control lever position parameter on the FDR data did not allow an accurate determination of when during the landing sequence reverse thrust was selected. The only recorded sample of throttle resolver angle between the two touchdowns at East Midlands Airport suggests that reverse thrust was selected at some point between the first and second touchdowns. This is consistent with the standard procedures contained in FCOM section 2.03.22, which state that the thrust reverser levers should be pulled to select idle reverse '*immediately after touch down of main landing gear'*.

The wind conditions at the time of their attempted landing, whilst within the aircraft's operating limits, were challenging. It is likely the crew's lack of appreciation that reverse had been selected was due to distraction caused by the difficult handling conditions, the selection being an automatic and subconscious action by the commander on touchdown.

Footnote

[4] Ninth edition.

[5] CAP 731 Approval, Operational Serviceability and Readout of Fligt Data Recorder Systems and Cockpit Voice Recorders.

As a result of this incident the operator has provided a verbal brief on the circumstances of the event to all of its A300 pilots and has introduced a crosswind landing exercise into recurrent simulator training. They have also provided them with Airbus Flight Operational Briefing Notes relevant to this incident.

During the first touchdown, the landing gear squat switches did not register ‘on ground’ and there were no recorded indications of the thrust reverse becoming unlocked. This may be due to the low FDR sampling rates for these parameters. On the second touchdown, both main gear squat switches registered ‘on ground’ and both thrust reversers were recorded as being unlocked within one second, consistent with thrust reverser deployment.

Recorded data indicated that the second touchdown was harder than the first, with the normal acceleration reaching 1.8g. The commander, considering that conditions were not suitable to continue the landing, decided to execute a go-around. During the course of applying takeoff thrust and going around, the No 2 reverser failed to restow, seriously compromising the aircraft’s climb performance.

The absence of a functional CVR undermined the AAIB’s ability to determine crew actions during the landing and go-around phase.

The FCOM procedures caution against going around once reverse thrust has been selected, because of the possibility of damage occurring to the system. The Airbus Flight Operations Briefing Notes give more specific information about the possible effects of cancelling reverse thrust whilst the reversers are in transit and performing a go-around, stating that thrust asymmetry resulting from one thrust reverser failing to restow has led to instances of significantly reduced rates of climb or departure from controlled flight. In this case the crew were not fully aware of the contents of the Briefing Notes and it is possible that other crews may not be aware of the reported consequences. In order to remind all operators of A300 aircraft of the possible adverse effects of cancelling reverse thrust whilst it is in transit and the safety implications associated with performing a go-around should a reverser fail to restow, Airbus intend to deliver a presentation on this event to operators at their next annual Safety Conference in March 2012. In addition Airbus will publish an article about the event in the June 2012 edition of their safety publication ‘*Safety First*’.

FCOM section 2.03.22 states that the thrust reversers should be deployed immediately after touchdown. It also states that once the reversers are deployed, a go-around should not be attempted; advice which would appear to be justified in light of this incident but which may be interpreted to contradict the advice in FCOM section 2.02.01 regarding bounced landing recovery. By requiring the reversers to be deployed immediately, the existing procedures mean that flight crews are therefore committed to continuing with the landing, which may be unsafe in certain circumstances. On the other hand, as this incident shows, aborting the landing might bear considerable risks. This leaves no options available to the crew. In order to avoid this possibility, Airbus intend to update the FCOM section 2.02.01 ‘Bouncing at Landing’ to reflect the fact that the ‘At touchdown procedure’ supersedes the ‘Bouncing at Landing’ procedure, re-emphasising the need, under all circumstances, to complete a full stop landing if reverse thrust has been selected. These amendments will be incorporated in the June 2012 revision of the FCOM.

The commander reported that he had cycled the No 2 thrust reverser lever and throttle control lever during the climb. These actions were not in accordance with the required ECAM checklist actions. The recorded FDR data does not show any evidence of the thrust reverser lever or the throttle control lever being moved during the climb, but given the sampling rate it is possible that any such control lever movement occurred between samples.

Without the system protection afforded by a correctly functioning FADEC in limiting the No 2 engine thrust to idle, the effect of these actions on aircraft controllability would have been significant. Given the circumstances faced by the crew it is possible that they were not fully aware of the nature of the problem.

Aircraft performance

The decision to go around resulted in the aircraft becoming airborne in a high drag configuration at an airspeed of 127 kt. At the same time, whilst full power had been commanded on both engines, only the No 1 engine was providing full thrust. The No 2 engine thrust reverser remained unlocked with FADEC limiting power to idle.

Whilst the rotation speed was above V_{MCA}, it was considerably below the certified rotation speed required of 144 kt, and would have resulted in reduced control effectiveness. The higher angle of attack associated with the aircraft's low speed would have increased the aerodynamic drag, further compromising the aircraft's acceleration and climb performance, which were marginal. This was evidenced by the air traffic controller's observations of the aircraft's low rate of climb while rocking from side to side, the crew's observation that the aircraft was slow to accelerate, and the recorded data.

During the first 13 seconds of being airborne the aircraft climbed only 92 ft, with the airspeed failing to increase significantly and remaining below V_{REF}. The aircraft then levelled for a few seconds, allowing the airspeed to increase to V_{REF}, acceleration being further assisted by the reduction in drag afforded by selecting FLAP 20 and retracting the landing gear. A significant increase in the climb rate was finally achieved 47 seconds after lift-off, by which time the airspeed had increased to 160 kt and the aircraft was climbing through an altitude of 875 ft (approximately 220 ft aal). The absence of high ground in the path of the aircraft was fortuitous, given the aircraft's severely compromised performance.

During the go-around, pitch was not maintained but was allowed to increase to 12.5° at the normal rotation rate, with the main wheels still on the ground. Whilst the exact point at which the tailstrike occurred could not be identified, this pitch angle exceeded that required for a tailstrike to occur.

Thrust reverser behaviour

General

The FDR data showed that both thrust reversers became unlocked in response to the reverse thrust command. However neither thrust reverser had time to deploy fully prior to thrust levers being advanced to the takeoff position. The deploy stroke typically takes 2.5 seconds, therefore it is considered that the full forward thrust command occurred within this 2.5 second window, while the reverser sleeves were still in transit towards the deploy position. It is not possible to be more precise about the exact sequence of the reverse thrust commands and the response of the reverser sleeves, due to the limited FDR sampling rates.

No 2 thrust reverser

Inspection of the No 2 thrust reverser ruled out damage of the mechanical actuation elements of the thrust reverser system as a cause of its failure to restow. As the twisted flexible driveshafts had been uncoiled and the thrust reverser manually returned to the stow position by the mainenance engineer following the incident, evidence regarding the precise status of the components within the thrust reverser system was lost. It was not possible to determine whether the twisting in the flexible shafts was causal or contributory to the No 2 reverser's failure to restow, or simply a secondary effect of other components in the system stopping suddenly when the stow command was made.

The operational guidance in FCOM section 2.03.22 states that when reverse thrust is commanded, the thrust reverser levers must not be moved towards the stowed position while the sleeves are in transit as this may cause damage to the system. The thrust reverser manufacturer considered that binding or severing of a flexible driveshaft or a mid-stroke stall of the mechanical or pneumatic elements of the system were possible outcomes.

The pneumatic elements of the system were observed to function adequately during function testing and engine ground runs. However the PDU subsequently failed during function checks performed by the operator following component removal. Strip examination of the unit revealed an area of cut packing and some contamination, considered by the manufacturer to be sufficient to compromise the performance of the PDU. This may have resulted in insufficient air pressure to release the PDU brake and therefore could not be ruled out as a possible cause of the reverser sleeves stopping at mid-stroke.

Initial testing of the RVDTs revealed that the output voltages supplied to the FADEC system were grossly out of limits. In this condition, the FADEC would have been receiving anomalous signals regarding thrust reverser position and the engine could not have functioned effectively for any length of time in either the forward or reverse thrust regimes prior to the incident. Yet it is evident that FADEC functioned correctly to limit the No 2 engine thrust during the incident. It was therefore considered that this condition could not have existed prior to the incident. The manufacturer considered that the only possible explanation for the gross anomalies was that the RVDTs had been separated from the master actuators causing mis-alignment (possibly during component removal) and subsequently reinstalled.

The RVDTs indicate correctly the thrust reverser stowed position when the FADEC ground test was performed on initial examination of the aircraft, however thrust was limited on the No 2 reverser during engine ground runs. The RVDT resolvers underperformed when tested in isolation, but not significantly so. Recorded data for the two flights prior to the incident flight indicated that the FADEC thrust limiting function had activated on the No 2 engine despite the thrust reverser being fully deployed. This suggests that a possible issue with the validity of the RVDT feedback signals existed prior to the incident flight. In summary, there is contradictory evidence from testing, observations and flight data regarding the performance of the the RVDTs. However as their only function is to provide feedback to the FADEC on thrust reverser sleeve position, none of these findings can be considered causal to the failure of the No 2 reverser to stow. Correct RVDT output voltages are, however, fundamental to the FADEC logic with respect to thrust limiting. None of the observations made on RVDT performance appear to have adversly affected the operation of the FADEC thrust limiting function during the incident.

Interruption of the electrical path to the synchronous locks was ruled out as a cause of the reverser sleeves stopping mid-travel, based on the results of component testing.

The most significant finding was the identification of a loose wire in the auto-restow circuit, which is designed not only to ensure the stowing of the thrust reversers during normal operation, but also in the case of an in-flight thrust reverser deployment. Loss of electrical signal to the PRSOV arming solenoid following the mid-stroke stow command, as a result of the loose wire, is considered the most likely reason for the No 2 thrust reverser stopping in the mid-stroke position. The loose connection is considered to have been an intermittent issue; had this been a permanent condition, the normal stowing function of the thrust reversers would have been compromised prior to the incident and this would also have been evident during the post-incident function checks and engine runs and following the aircraft's return to service.

The loose connection on the auto-restow circuit was not detected during initial electrical continuity testing on the thrust reverser system, but was discovered after the aircraft had been returned to service. There were no TSM tasks specifically relevant to this circuit to facilitate identification of this fault. As a result of this incident, Airbus intends to update the TSM to include a specific electrical check of the auto-restow circuit.

No 1 thrust reverser

The No 1 engine fuel flow and engine speed increased as commanded during the go-around. The thrust reverser remained in the locked condition for a period of four seconds but then became unlocked for a period of 16 seconds, re-locking as the aircraft was passing through 180 ft aal. As the FADEC did not command a reduction in fuel flow on the No 1 engine, it was concluded that if the thrust reverser sleeves were out of position (stow switches closed), they were less than 10% deployed. Had the thrust reverser sleeves been more than 15% deployed, the FADEC would have also limited the fuel flow to the No 1 engine and both engines would have been limited to idle power during this critical phase of flight. The REV UNLK caption can be generated by release of the PDU or master actuator brakes, or if the translating sleeves leave the stow position and the stow switch contacts close. It was not possible to determine which of these conditions caused the REV UNLK indication. The aircraft manufacturer considered the most likely scenario was that the thrust reverser sleeves correctly achieved the full stow position when commanded, however vibration associated with the aerodynamic loads during the go-around manoeuvre caused a transient REV UNLK indication.

During the diversion landing at Stansted the No 1 thrust reverser never reached the fully deployed position when commanded, despite being unlocked for a period of 15 seconds. The PDU did not function adequately at low pressures when tested after the incident. The engine pneumatic system should have provided enough pressure to make up for any deficit but it could not be determined whether these findings may have contributed to the behaviour of the thrust reverser during the incident landing and the subsequent landing at Stansted.

The poor quality of the CVR recording, the absence of QAR data and maintenance intervention on the thrust reverser system immediately following the incident resulted in the loss of valuable evidence, which hampered the investigation.

Conclusions

This incident highlights the potentially serious consequences of attempting to go around after selection of reverse thrust. In this instance the failure of the No 2 thrust reverser to restow was most likely caused by a latent intermittent loose connection in the auto-restow circuit. However, even in the absence of this particular failure, the FCOM advises damage to the thrust reverser with equally significant consequences may still occur as a result of stow command being made while the reversers are in transit. The investigation identified a number of other anomalies with thrust reverser components, which may have contributed, either in isolation or combination, to the failure of the No 2 thrust reverser to restow.

This event also highlights the need for the operational procedures for use of thrust reversers and for performing a go-around to be unambiguous.

Furthermore, it illustrates the value of conducting annual downloads of CVRs in identifying dormant failures in these units, which have the potential to compromise the quality of safety investigations.

ACCIDENT

Aircraft Type and Registration:	Boeing 767-324, G-OOBK
No & Type of Engines:	2 General Electric CO CF6-80C2B7F turbofan engines
Year of Manufacture:	1995
Date & Time (UTC):	3 October 2010 at 0536 hrs
Location:	Bristol Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 12 Passengers - 258
Injuries:	Crew - None Passengers - None
Nature of Damage:	Significant structural damage to fuselage crown skins
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	49 years
Commander's Flying Experience:	14,433 hours (of which 1,355 were on type) Last 90 days - 225 hours Last 28 days - 92 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft landed heavily on Runway 09 at Bristol Airport, having encountered rain, reduced visibility and turbulence during the approach. The de-rotation was rapid and damage occurred as a result of the force with which the nose landing gear met the runway. The investigation found that a high rate of hard landings on that runway had not been identified through flight data monitoring, and that training material produced by the manufacturer in response to previous, similar, events had not been presented to the flight crew. The cockpit voice recorder was not disabled after the accident and thus the recording was not available to investigators. A momentary longitudinal deceleration at touchdown was reported by the flight crew and recorded by the flight data recorder. Four safety recommendations were made.

History of flight

The flight crew were operating a three-day duty from their home base at Glasgow to Cancun and then Bristol. They reported at Glasgow at 0945 hrs on 1 October and flew to Cancun, arriving there at 2030 hrs (1530 hrs Cancun time). They took rest until 1745 hrs (1245 hrs Cancun time) on 2 October, when they reported to operate to Bristol. Each crew member stated that he rested quite well during the period in Cancun.

The flight crew examined the available weather forecasts for the trip. The forecast for their destination stated that at the time of their arrival the wind would be from 180° at 9 kt with visibility 10 km or more, scattered clouds at 2,000 ft aal, temporarily broken clouds at 700 ft aal, and no significant weather.

The flight crew decided to load 45,300 kg of fuel, the minimum required being 44,100 kg. This enabled them to consider an additional diversion aerodrome should they not land at Bristol and provided some holding fuel over the minimum required.

The aircraft was serviceable with one deferred defect relating to the co-pilot's yoke-mounted flight interphone switch, which did not function. To overcome this, the flight crew operated with their headsets displaced from one ear, to allow conversation across the flight deck, and the co-pilot used an alternative switch, on an audio selector panel, to select the interphone when he needed to use it.

Approaching the top of descent, the co-pilot carried out a briefing for the approach to Runway 09, referring to the operator's aerodrome-specific (category B aerodrome) briefing as he did so. He determined the runway in use from the available forecast, as the flight crew had been unable to obtain the actual weather at Bristol at this stage of the flight[1]. At the end of his brief, the commander emphasised points regarding the ILS glideslope on Runway 09[2] and its possible effects during the latter part of the approach, and the longitudinal profile of the runway. The flight crew planned to land with flap 30 and autobrake 4[3] because of the length of the runway.

Shortly after the top of descent, the flight crew obtained the ATIS which stated that Runway 09 was in use, the wind was from 100° at 10 kt, visibility 1,400 m in rain and mist, with RVR in excess of 1,500 m, and cloud scattered at 100 ft aal and broken at 400 ft aal.

As the aircraft descended through FL300, the commander decided that, given the weather conditions at Bristol, he should carry out the landing himself, and took control. The flight crew were surprised at the poor weather reported at Bristol, as it was not consistent with the TAF presented to them at their briefing. An ATC report of "water patches" on the runway caused the second co-pilot to examine landing performance information for such conditions; he found the runway was sufficiently long for a landing to be attempted.

During the approach the commander commented that there was "a surprising amount of turbulence"; all three pilots wore their seat harnesses including shoulder straps, though they did not lock the shoulder straps' inertia reels. The commander configured the aircraft for landing earlier in the approach than usual, because of the challenging weather conditions. The aerodrome controller passed the latest weather conditions, including the surface wind which was from 120° at 12 kt, visibility 3,000 m in moderate rain, few clouds at 200 ft aal and broken clouds at 1,100 ft. The controller also reported that the runway surface was wet along its length. The co-pilot asked the controller to confirm that the water patches were no longer present, which she did.

The commander recalled that the FMC displayed a crosswind component of approximately 52 kt during the approach, with a considerable drift angle. The surface wind reports from ATC led the commander to expect the wind to change from a crosswind to a headwind during the approach, and he briefed that this might lead to a "balloon" or gain of energy. He asked the co-pilot to monitor the wind displayed on the FMC and report any substantial change.

At approximately 400 ft aal, the commander gained sight of the runway, although rain on the windscreen blurred

Footnote

1 The aircraft was out of range of the Bristol ATIS transmission, and the available VOLMET (ground to air meteorological information broadcast) services did not carry weather information for Bristol; the aircraft was not equipped with ACARS.

2 The ILS glideslope is not usable below 200 ft aal.

3 Flap 30 is the maximum flap setting for landing; the maximum autobrake setting is Max Auto.

his view. The windscreen wipers were selected ON. The co-pilot could not see the runway at this stage, as the aircraft's drift angle meant that the runway was obscured behind a windscreen pillar.

The commander disconnected the autopilot and autothrottle, and continued the approach. Two or three EGPWS 'glideslope' annunciations occurred below 200 ft; the pilots confirmed the PAPI indications were two white and two red. The pilots recalled that the automatic height callouts, made by the EGPWS computer, were in the sequence: 'FIFTY'; 'FORTY'; 'TWENTY'; 'TEN'. The 'THIRTY' callout was not made[4]. The commander recalled making a normal nose-up pitch input prior to touchdown, and that the touchdown was unusually hard. He commented that the profile of the runway meant that it was not possible to see the stop-end during the latter moments of the approach, and that the rain compromised his view.

Concerned that the hard touchdown had caused the aircraft to bounce, the commander recalled endeavouring to maintain a constant pitch attitude for a subsequent touchdown. However, both the commander and co-pilot reported that they were thrown forward during the touchdown, and that this resulted in the commander inadvertently moving the control column forward, to a nose down position. The aircraft then rapidly de-rotated before the nose gear contacted the runway.

The landing roll was completed uneventfully, and the aircraft was taxied to the apron and parked. The flight crew and cabin crew discussed the hard landing, the commander reported a suspected hard landing to the company's engineers, and an entry was made in the Tech Log.

Footnote

4 Previous experience suggested that the call was absent because the rate of change of radio altitude was greater than the relevant threshold for this callout to be made.

Definition of hard landing

The Aircraft Maintenance Manual (AMM) Chapter 05-51-01 states that a structural examination is required if the aircraft has experienced a hard landing. A hard landing is considered to have occurred if the pilot considers a hard landing has occurred or when an aircraft lands on its main landing gear and the peak recorded vertical acceleration exceeds 1.8 g, if recorded with at least eight samples per second However, for a hard nose landing, the peak recorded vertical acceleration can be significantly less than 1.8 g.

Examination of the aircraft

Phase one hard landing inspections were carried out by the operator in accordance with AMM 05-51-01. The most significant damage was to the crown skins between frames STA 610 and STA 632 and stringers 14 L and 14 R. See Figure 4.

Flight crew

All three pilots were rated on both Boeing 757 and 767 aircraft, although the operator's schedule meant that they flew the 767 less frequently than the 757. Their roster patterns meant they only operated to Bristol Airport approximately twice a year, and as the prevailing wind at Bristol favoured Runway 27, none of them had regular or recent experience of landings on Runway 09.

Meteorology

The Met Office supplied an aftercast of the weather conditions at Bristol at the time of the accident:

> *'In summary, the weather conditions at Bristol International Airport at 0541 UTC on 3rd October 2010 were characterised by periods of moderate (and sometimes) heavy rain, broken or overcast cloud cover and a moderate south easterly surface wind.*

> *In greater detail, the radar and satellite information suggests some convective cells within the cloud structure. This would imply vertical motion of air and, in association with moderate or heavy rain, some downward motion of air. This is likely to have caused some turbulence on the approach into Bristol.'*

The Met Office commented that '*relatively rapid*' changes of wind direction and speed with height suggested a potential for significant wind-shear induced turbulence and that:

> *'conditions were suitable (or very close to) for significant wind shear.'*

Between the time of the flight crew's briefing at Cancun and their arrival at Bristol, the Bristol TAF was amended and more up-to-date forecasts were produced, indicating increasingly inclement conditions. These forecasts were not available to the flight crew by their normal means.

Final approach speed

The operator's operations manual stated:

> *'If the autothrottle is disengaged, or is planned to be disengaged prior to landing, the approach speed correction ("wind correction") is to add one half of the reported steady headwind component plus the full gust increment above the steady wind, to the reference speed.'*

In light of the conditions at Bristol, the commander elected to use a final approach speed of 139 kt; the V_{REF} was 133 kt.

Landing technique

The operator's flight crew training manual for the Boeing 767 stated:

> *'When the threshold passes under the airplane nose and out of sight, shift the visual sighting point to the far end of the runway. Shifting the visual sighting point assists in controlling the pitch attitude during the flare. Maintaining a constant airspeed and descent rate assists in determining the flare point. Initiate the flare when the main gear is approximately 20 feet above the runway by increasing pitch attitude approximately 2° - 3°. This slows the rate of descent.*
>
> *After the flare is initiated, smoothly retard the thrust levers to idle, and make small pitch attitude adjustments to maintain the desired descent rate to the runway. Ideally, main gear touchdown should occur simultaneously with thrust levers reaching idle. A smooth thrust reduction to idle also assists in controlling the natural nose-down pitch change associated with thrust reduction. Hold sufficient back pressure on the control column to keep the pitch attitude constant. A touchdown attitude as depicted in the figure below is normal with an airspeed of approximately VREF plus any gust correction.*
>
> *Typically, the pitch attitude increases slightly during the actual landing, but avoid over-rotating. Do not increase the pitch attitude after touchdown; this could lead to a tail strike.*
>
> *Shifting the visual sighting point down the runway assists in controlling the pitch attitude during the flare. A smooth thrust reduction to idle also assists in controlling the natural nose down pitch change*

associated with thrust reduction. Hold sufficient back pressure on the control column to keep the pitch attitude constant.

Avoid rapid control column movements during the flare. If the flare is too abrupt and thrust is excessive near touchdown, the airplane tends to float in ground effect. Do not allow the airplane to float; fly the airplane onto the runway. Do not extend the flare by increasing pitch attitude in an attempt to achieve a perfectly smooth touchdown. Do not attempt to hold the nose wheels off the runway.

After main gear touchdown, initiate the landing roll procedure. If the speedbrakes do not extend automatically move the speedbrake lever to the UP position without delay. Fly the nose wheels smoothly onto the runway without delay. Control column movement forward of neutral should not be required. Do not attempt to hold the nose wheels off the runway. Holding the nose up after touchdown for aerodynamic braking is not an effective braking technique and may result in high nose gear sink rates upon brake application.

To avoid possible airplane structural damage, do not make large nose down control column movements before the nose wheels are lowered to the runway.'

Regarding bounced landing recovery, it stated:

'If the airplane should bounce, hold or re-establish a normal landing attitude and add thrust as necessary to control the rate of descent. Thrust need not be added for a shallow bounce or skip.' [See Figure 1]

The manual did not make reference to locking of shoulder harness inertia reels. Examination of the flight deck showed that with inertia reels locked, it was not possible to reach some controls from one or both pilots' seats. Discussion with the flight crew and other pilots working for the operator suggested that the operator's pilots seldom locked their harnesses' inertia reels.

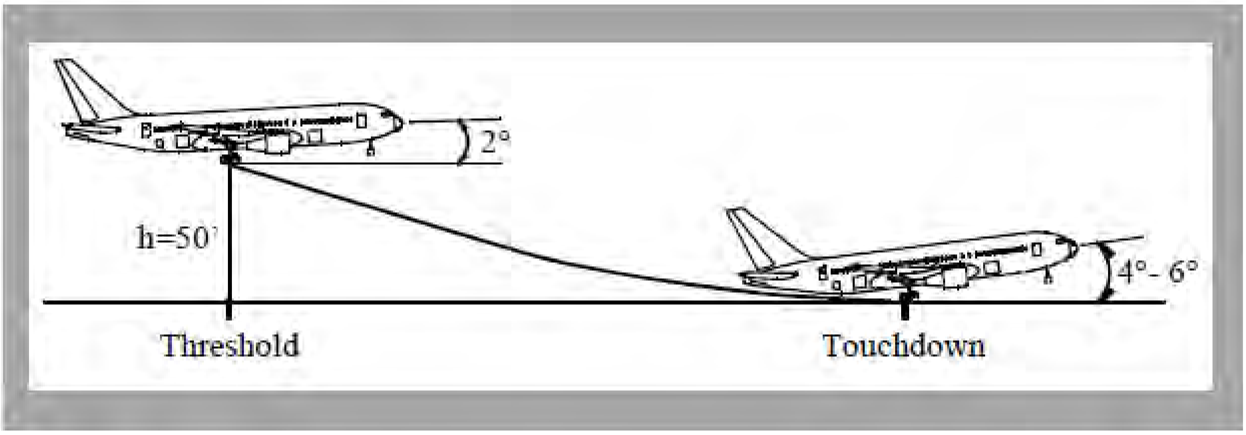


Figure 1

Graphic shown in Flight Crew Training Manual

Previous events and safety actions

In 1994, the US National Transportation Safety Board wrote to the US Federal Aviation Authority, making safety recommendations. The letter began:

> *'the [NTSB] has been involved in the investigation of three similar accidents involving B-767 airplanes…All three of the accidents occurred during landing when the nose wheel struck the runway after normal touchdown on the main landing gear. In each case, the airplane fuselage structure and nose wheel wells were damaged.'*

As a result of these accidents, Boeing introduced production modifications to strengthen the upper crown skins on aircraft from serial number 563 onwards. In addition a modified metering pin was introduced into the nose landing gear to help reduce the peak maximum stroke. Both these modifications had been incorporated onto G-OOBK.

The NTSB recommended that the FAA should:

> *'Modify initial and recurrent Boeing 757/767 pilot training programs… to include discussion of de-rotation accidents'*.

The flight crew of G-OOBK had undertaken training to fly the B767 with UK operators; this training had not included discussion of de-rotation accidents. The aircraft manufacturer had produced a training video on the topic of hard nose gear touchdowns, but neither the pilots nor the operator's management were aware of the video.

The aircraft manufacturer published a regular magazine to operators of its aircraft. The April 2002 edition included an article entitled *'Preventing hard nosegear touchdowns'*. The preface stated:

> *'In recent years, there has been an increase in the incidence of significant structural damage to commercial airplanes from hard nosegear touchdowns. In most case, the main gear touchdowns were relatively normal. The damage resulted from high nose-down pitch rates generated by full or nearly full forward control column application before nosegear touchdown. Flight crews need to be aware of the potential for significant structural damage from hard nosegear contact and to know which actions to take to prevent such incidents.'*

The flight crew of G-OOBK, and the safety management team at the operator, were not aware of this article.

Bristol Airport

Several factors placed additional demands on pilots of Boeing 767 aircraft landing on Runway 09 at Bristol.

The operator's airfield brief for Bristol stated:

> *'The UK Air Pilot states "the quality of ILS Glideslope guidance to R/W 09 does not permit the use of ILS glideslope below 200 ft AAL". This coincides with Category I minima.'*

The undulating nature of the terrain upon which the runway was built might cause an unusual visual perspective on final approach. The runway profile did not meet standards recommended in Civil Air Publication (CAP) 168 – *'Licensing of aerodromes'*, and the airport operator was taking action, from time to time when significant runway engineering was carried out, to improve the profile towards the recommended values.

Because of the terrain, the ILS glideslope on Runway 09 was unusable below 200 ft aal. Correct tracking of the

PAPI glideslope caused nuisance 'glideslope' warnings to be triggered in aircraft fitted with GPWS or EGPWS.

The terrain around the airport and its exposed position caused turbulence in strong winds.

These factors meant that the operator categorised Bristol as category B, and were highlighted in the operator's brief for the aerodrome.

The operator's flight data monitoring programme

The operator had an established programme to capture and analyse data from recorders on board its aircraft to monitor and improve safety.

One of the parameters tracked was normal g on touchdown, which is an indicator of hard landings. The operator analysed this data for each airport to which it operated, and used three different g thresholds to identify light, moderate, and severe hard landings. The operator had identified that Bristol Airport had an unusually high rate of hard landings, with evidence of seven hard landings in 2,855 arrivals there. At the AAIB's suggestion, the data was re-examined for each runway rather than each airport. This revealed that there had been six hard landings in 709 arrivals on Runway 09 at Bristol, and only one on Runway 27; therefore one in 118 landings on Runway 09 had been classified as 'hard'. Neither the operator, nor any regulatory body, had defined an acceptable maximum rate for hard landings on a given runway.

The specific analysis of hard landing data by runway, rather than by airport, was discussed with the CAA. There was evidence that the analysis of such data by airport rather than runway was commonplace amongst operators.

Examination of data from the commander's previous landings did not reveal any history of abnormal technique.

Human factors

A specialist in human factors in aviation was briefed and asked to comment on the event. He offered the opinion that the operator's flight crew training manual gave a clear description of the desirable pitch control technique during landing and that there was no evidence that the commander's technique differed from this.

The commander's ability to respond effectively to an unexpected longitudinal deceleration sufficient to cause upper body movement (and therefore unintended movement of the control column) would have been influenced by the visual cues available, which were degraded by the rain and the runway profile, and a natural concern that over-compensation might lead to a tail strike or float.

The specialist commented that:

> *'the response time required to compensate for an unexpected longitudinal deceleration large enough to cause upper body movement was likely to be at least a significant fraction of a second.'*

Flight recorders

The aircraft was equipped with a 25-hour duration Flight Data Recorder (FDR) and a 120-minute Cockpit Voice Recorder (CVR). FDR data was available for the entire accident flight. However, due to the time elapsed before the operator identified that the aircraft had been damaged, the entire audio record of the accident had been overwritten.

Salient parameters from the FDR included the normal and longitudinal acceleration, which were measured by a tri-axial accelerometer mounted near to the aircraft's centre of gravity, the control column position and pitch attitude. The pitch attitude was recorded once per second, control column twice per second, longitudinal acceleration four times per second and normal acceleration eight times per second. Figure 2 provides a plot of the final approach and landing.

The aircraft was established on the ILS for Runway 09 with the autothrottle and autopilot engaged. The target approach speed was set to 139 kt on the Mode Control Panel (MCP) and at 1,600 ft above airfield level (aal), the aircraft was fully configured for landing, with flap set at 30° and autobrake four selected. The aircraft was stabilised on the glide path at an average descent rate of about 680 ft/min (~11 ft/s), although there were fluctuations in airspeed, angle of attack and normal acceleration, indicative of turbulence.

As the aircraft descended through 200 ft aal, the autothrottle and autopilot were manually disconnected (Figure 2 point A). The airspeed was 141 kt at the time and the wind calculated by the FMC was from 138° at 25 kt. At approximately 120 ft aal, there was a slight increase in engine EPR and the airspeed also increased from 138 kt to 146 kt. At about the same time, the aircraft pitch attitude increased from 2.5° to just less than 4° nose up. This was followed by a momentary nose down input on the control column and a coincident reduction in engine EPR.

At a height of about 35 ft (just over three seconds before touchdown), the pitch attitude was just less than 1° nose up and airspeed was 142 kt. The descent rate was about 600 ft/min (10 ft/sec), with the wind, calculated by the FMC, from 116° at 20 kt. Aft control column was then applied and over the next three seconds the pitch attitude progressively increased to 3.5° nose up (Figure 2 point B). However, there was only a gradual reduction in the rate of descent before the aircraft touched down on the main landing gear, registering a peak normal load of 2.05g. The aircraft weight calculated by the FMC was 271,000 lb (~123,000 kg) and the airspeed was 141 kt.

Coincident with the touchdown of the main landing gear, a momentary longitudinal deceleration of -0.27g was recorded (Figure 2 point C). Less than 0.5 second later, the control column was recorded as having been moved rapidly to a nose down position (Figure 2 point D)[5]. The spoilers also started to deploy at this time. The aircraft then became 'light' on its main landing gear whilst also de-rotating in pitch at about three degrees per second. At a nose down pitch attitude of just less than 1°, a normal load of 2.05g was recorded as the nose gear contacted the runway. The aircraft then rapidly pitched up and down, from between 3° nose up to just less than 0.5° nose down (indicating bouncing of the nose gear), before the aircraft eventually settled on the landing gear.

Seven seconds after the initial touchdown, the thrust reversers were deployed, and the control column, which had remained in a forward nose down position since the initial touchdown, was progressively moved aft. Manual braking was then applied before the aircraft was taxied from the runway. There was no evidence from the FDR that the brakes had been applied during the initial touchdown phase.

Longitudinal deceleration at touchdown

To establish whether the momentary -0.27g longitudinal deceleration recorded during the accident flight

Footnote

[5] Due to the sample rate of the control column position, it was not possible to determine if the control column had been moved to a nose down position concurrent with the recording of a -0.27 g longitudinal deceleration.

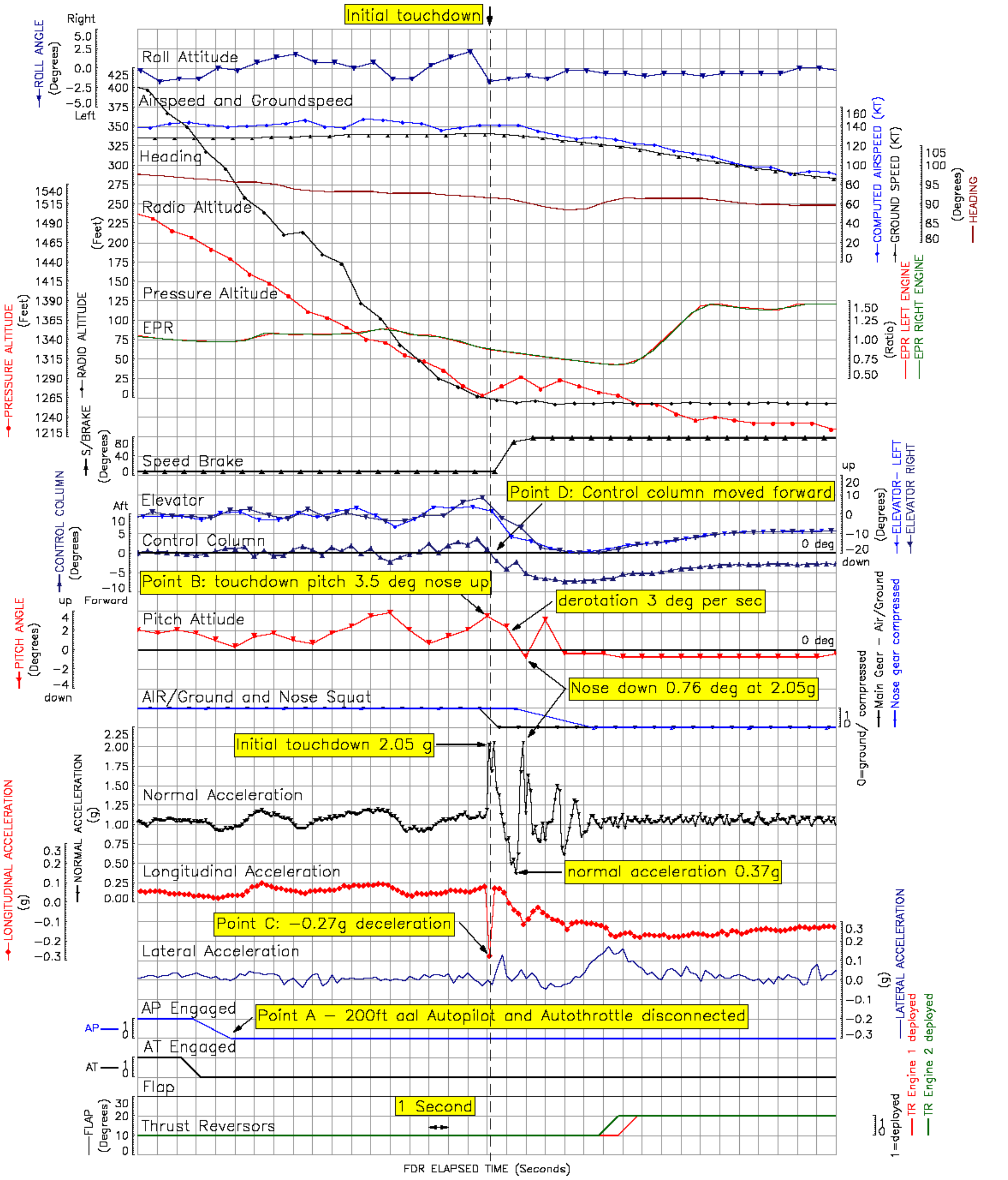


Figure 2

Final approach and landing at Bristol Airport Runway 09 touchdown was unique, the aircraft manufacturer was consulted and a review of the operator's FDM records conducted.

Aircraft manufacturer assessment

The aircraft manufacturer was provided with a copy of the FDR data for analysis. The aircraft manufacturer advised that the momentary longitudinal deceleration of -0.27g during the accident landing was both normal and not unique to the Boeing 767 aircraft.

At touchdown, the aircraft will experience a short duration longitudinal deceleration impulse as a function of tyre spin-up and subsequent landing gear assembly spring-back. During flight testing of the Boeing 767, longitudinal acceleration was recorded at fifty times per second from a sensor installed in the forward equipment bay, which is near to the cockpit. Each of the landings contained a longitudinal impulse coincident with main landing gear touchdown. Further, the manufacturer had observed similar records of a longitudinal impulse during analysis of lower sample rate FDR data. From a sample of five flight test landings, the maximum longitudinal deceleration impulse was approximately -0.27 g, which was recorded during a touchdown measuring a peak normal acceleration of about 2.1g. The lowest amplitude impulse was about 0.15 g, which occurred during a touchdown having a peak normal acceleration of approximately 1.3 g. The total duration of the impulse was typically 0.4 seconds, with 0.2 seconds being attributed to wheel spin-up and 0.2 seconds landing gear assembly spring-back. Figure 3 depicts the general shape of the longitudinal impulse based on the five flights provided to the AAIB. The manufacturer further advised:

'The amplitude and duration of the longitudinal deceleration impulse will be different for each landing due to a number of variables, including gross weight, sink rate, landing speed and staggered main gear touch down. Analysis has indicated though, that for a given gross weight and a wings level touchdown, the amplitude of the impulse will increase as a function of increasing sink rate at touchdown.

The amplitude of the longitudinal deceleration impulse may be slightly increased when landing on an up-sloping runway.

The amplitude of the longitudinal deceleration impulse will be reduced by approximately half when landing on a wet runway. The duration of the impulse will not be effected by runway friction.

The FDR recording rate of four samples per second is such that it is unlikely to capture the peak amplitude of the longitudinal deceleration impulse at touchdown. The probability of capturing within 10% of the peak is about 20%.'

The manufacturer stated that it had no record of pilots having inadvertently moved the control column to a nose down position as a consequence of being thrown forward following a heavy landing.'

The aircraft manufacturer considered that the longitudinal deceleration impulse at touchdown was of:

'insufficient magnitude and duration to cause a pilot to be thrown forward with sufficient force so that the control column would be inadvertently held in a nose down position.'

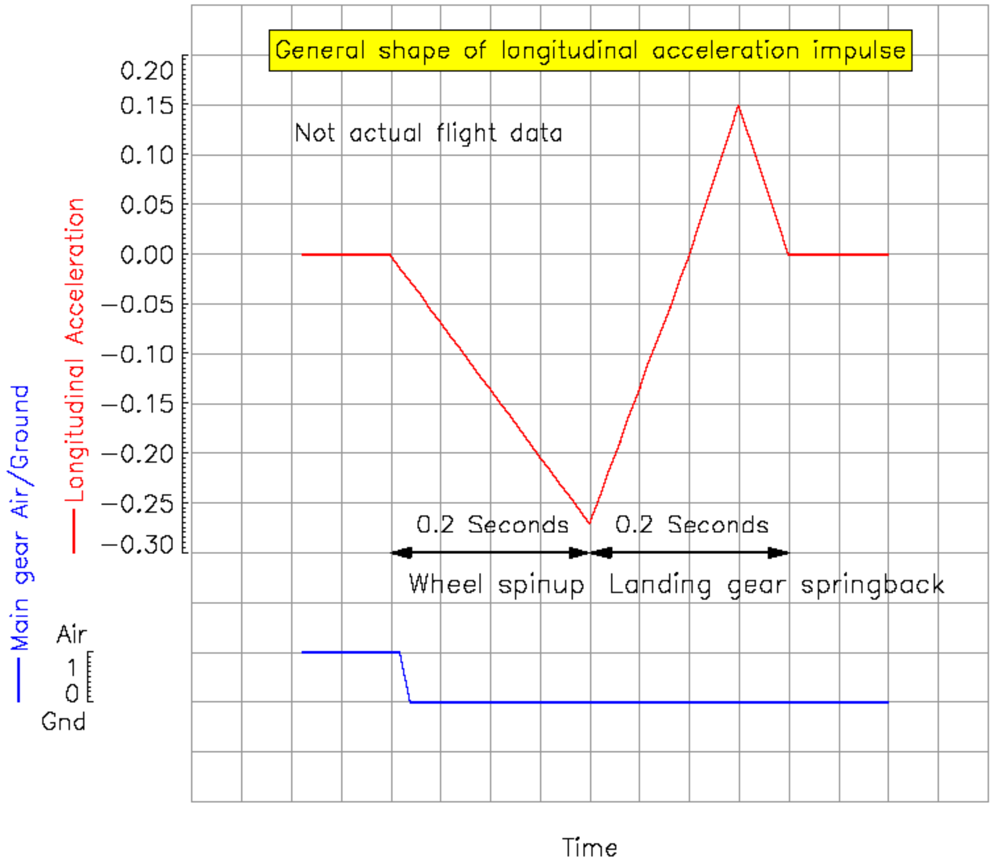


Figure 3

General shape of longitudinal acceleration impulse at touchdown

Assessment of additional Boeing 767 FDR data for the presence of longitudinal deceleration impulses at touchdown

A combination of FDR data from seven hard landings[6] and the 11 previous landings of G-OOBK were analysed. Six of the seven hard landings and four of the previous flights contained rapid, short duration changes in longitudinal acceleration at touchdown, indicative of the recording of an impulse. Excluding the accident flight, the maximum deceleration at touchdown was -0.26 g, which was recorded during a landing measuring a peak normal acceleration of 1.85g. From the small sample size, there was no apparent relationship between peak longitudinal deceleration at touchdown and runway gradient, although the three highest recorded values of longitudinal deceleration all occurred during landings at Bristol Airport (Figure 4). None of the hard landings, except that on the accident flight, exhibited rapid de-rotations after the initial touchdown.

Preservation of flight recordings (CVR)

Regulations require that the CVR starts to record prior to the aircraft being able to move under its own power and that it continues to record until the end of the flight, when the engines have been shut down. Some aircraft are equipped with automatic interlocks, with the intent of preventing unnecessary operation of the CVR after the engines have been shut down. However, many aircraft, including G-OOBK, operate the CVR

Footnote

6 Peak normal acceleration at touchdown, ranged from 1.81g to 2.14 g.

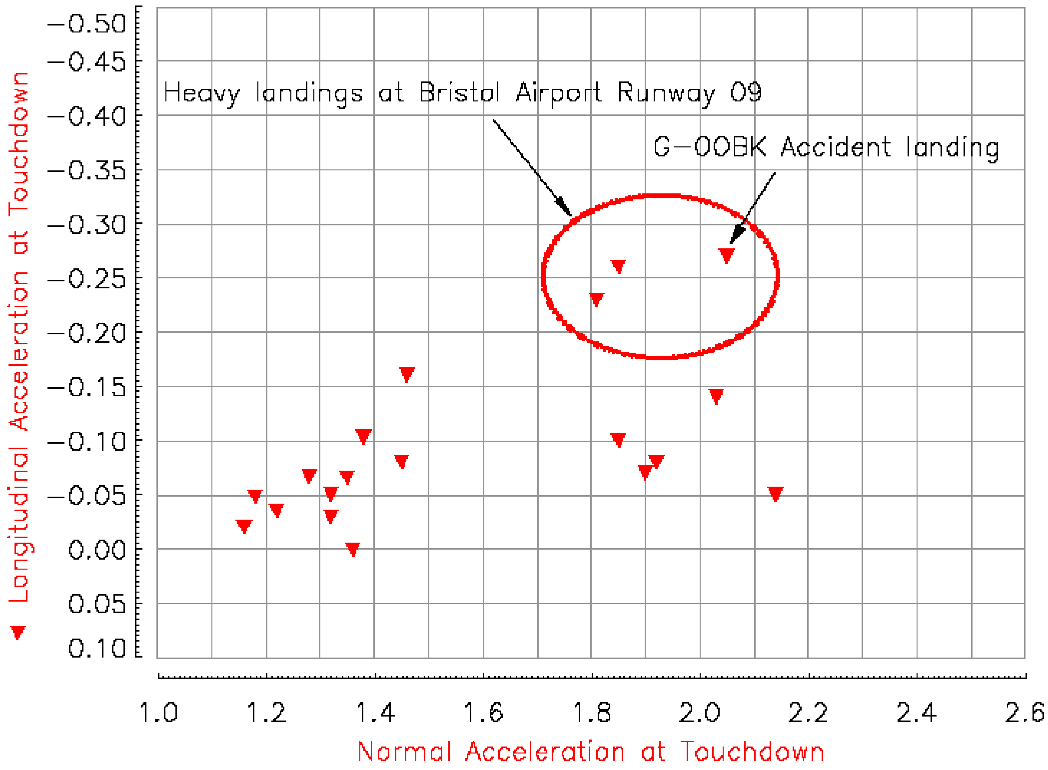


Figure 4

Peak normal and longitudinal acceleration at touchdown

whenever aircraft electrical power is on. Unlike the FDR, which is required to retain a minimum of 25 hours of data, the CVR retains only the last 30 or 120 minutes of audio, dependent upon type. It is therefore especially important that electrical power is quickly removed from a CVR if its information is to be preserved.

Commission Regulation (EC) 859/2008, referred to as EU-OPS, provides common technical requirements and administrative procedures applicable to commercial transportation by aeroplane. EU-OPS 1.160 '*Preservation, production and use of flight recorder recordings*', states:

> *'(2) Unless prior permission has been granted by the Authority, following an incident that is subject to mandatory reporting, the operator of an aeroplane on which a flight recorder is carried shall, to the extent possible, preserve the original recorded data pertaining to that incident, as retained by the recorder for a period of 60 days unless otherwise directed by the investigating authority.'*

EU-OPS 1.085 '*Crew Responsibilities'* states:

> *('f) The commander shall: (10) Not permit:*
>
> *(i) A flight data recorder to be disabled, switched off or erased during flight nor permit recorded data to be erased after flight in the event of an accident or an incident subject to mandatory reporting;*

> *(ii) A cockpit voice recorder to be disabled or switched off during flight unless he/she believes that the recorded data, which otherwise would be erased automatically, should be preserved for incident or accident investigation nor permit recorded data to be manually erased during or after flight in the event of an accident or an incident subject to mandatory reporting;[7]'*

Both EU-OPS 1.160 and EU-OPS 1.085 refer to the preservation of the FDR and CVR following an incident or accident that is subject to mandatory reporting. EU-OPS 1.420 *'Occurrence reporting'* defines:

> *'(1) Incident. An occurrence, other than an accident, associated with the operation of an aircraft which affects or could affect the safety of operation.*
>
> *(2) Serious Incident. An incident involving circumstances indicating that an accident nearly occurred.*
>
> *(3) Accident…..*
>
> *(ii) the aircraft sustains damage or structural failure which adversely affects the structural strength, performance or flight characteristics of the aircraft, and would normally require major repair or replacement of the affected component, except for engine failure or damage, when the damage is limited to the engine, its cowlings or accessories; or for damage limited to propellers, wing tips, antennas, tyres, brakes, fairings, small dents or puncture holes in the aircraft skin;…'*

Footnote

[7] There currently exists a discrepancy between ICAO Annex 6, Part 1 and EU-OPS 1.085. ICAO Annex 6, Part 1, which is the internationally-accepted Standard, states that flight recorders should not be switched off during flight, however, EU-OPS 1.085 states that a CVR may be disabled in flight under certain circumstances. This is due to be corrected, with the replacement of EU-OPS by EASA-OPS. In its draft form, EASA-OPS CAT.GEN.AH.105 (Responsibilities of the commander) states that flight recorders are not to be disabled or switched off in flight, and that they are to be deactivated immediately after the flight is completed.

The flight crew of the aircraft were aware that the landing had been heavier than normal and made an entry in the aircraft technical log *'Suspected hard landing. Check required'*. Unaware of the severity of the damage, the flight crew left the aircraft. During the following maintenance activities, the CVR continued to operate and by the time the damage was identified and the circuit breakers pulled, the entire CVR record of the accident had been overwritten.

The circumstances of this CVR overrun are not new to the AAIB. In 2009, a review of previous AAIB investigations identified that from 99 CVRs, 19 had been overwritten due to delays in removing electrical power, with seven CVRs being of 120 minute duration. Report EW/C2009/07/09, published in June 2010, concluded that operator's procedures concerning CVR preservation were ineffective, and the following safety recommendation was made to the UK CAA.

> **Safety Recommendation 2010-012**
>
> It is recommended that the Civil Aviation Authority review the relevant procedures and training for UK operators, to ensure the timely preservation of Cockpit Voice Recorder recordings of a reportable occurrence is achieved in accordance with the requirements of ICAO Annex 6 Part I, 11.6 and EU- OPS 1.160.

In August 2010, the CAA responded, publishing Airworthiness Communication (AIRCOM) 2010/10. In addition to reminding UK operators of their responsibilities under EU-OPS 1.160, the AIRCOM made the following recommendations:

> '4.1 *Operators and continuing airworthiness management organisations should ensure that robust procedures are in place and prescribed in the relevant Operations Manuals and Expositions to ensure that CVR/FDR recordings that may assist in the investigation of an accident or incident are appropriately preserved. This should include raising awareness of Flight Crew and Maintenance staff to minimise the possibility of loss of any recorded data on both the CVR and FDR.*
>
> 4.2 *When appropriate, the relevant circuit breakers should be pulled and collared/tagged and an entry made in the aircraft technical log to make clear to any airline personnel that an investigation is progressing. Furthermore, conformation from the investigating authority/operator is required to be obtained before systems are reactivated and power is restored.*
>
> 4.3 *Operators who contract their maintenance or ground handling to a third party should ensure that the contracted organisation is made aware of all their relevant procedures.'*

Considering the relatively short recording duration of the CVR, it is often the commander, rather than an operator's safety or engineering department, who is best placed to ensure the timely preservation of the CVR and FDR. This has been reflected by an Irish registered operator, which has issued its flight crew with comprehensive guidance concerning the types of incident or accident that may require the preservation of the CVR and FDR, with instructions to isolate the relevant circuit breakers as necessary. To ensure that the preservation of the CVR and FDR is recorded and that an aircraft is not returned to service with inoperative recorders, the flight crew are required to make an entry in the technical log. In a recent AAIB investigation it was determined that that procedure proved effective.

At the time of this accident, the operator's CVR and FDR preservation procedures referred to the regulatory requirement within EU-OPS, but they provided no formal guidance or instructions of how to ensure compliance. As such, the operator failed to preserve the CVR record of the accident. Since the accident, the operator has taken a number of steps to address this: to assist in the prompt identification of CVR circuit breakers, identification tags have been fitted; a notice has been issued to flight crew, prior to amendment of its operations manual, providing similar guidance and instructions as those of the aforementioned Irish operator. In light of this remedial action, the AAIB considers that a further Safety Recommendation on this subject to this operator is unnecessary.

A recent review of UK-based operators' preservation procedures has identified that instructions and guidance is varied, or in some cases, not available at all. Discussion with the UK CAA has also highlighted that when auditing an operator, it is difficult for National Aviation Authorities (NAA) to determine if an operator's procedures are likely to be effective as there is no regulatory guidance material. Although the publication of AIRCOM 2010/10 has raised awareness of UK operators' responsibilities, there remains no official guidance, when formalising or reviewing their procedures with NAAs. Until such guidance becomes available, it remains likely that accident investigators will continue to be faced with the loss of CVR information due to ineffective procedures. In order that effective safety investigations can be conducted it is essential that accident investigators have access to CVR recordings. Therefore, the following Safety Recommendation is made:

Safety Recommendation 2012–013

It is recommended that the European Aviation Safety Agency publishes guidance information that assists operators and National Aviation Authorities in the production and auditing of procedures to prevent the loss of Cockpit Voice Recorder recordings in accordance with the requirements of EU-OPS 1.160 and EU-OPS 1.085.

Examination of the aircraft

Phase one hard landing inspections were carried out by the Operator in accordance with AMM 05-51-01. The most significant damage was to the crown skins between frames STA 610 and STA 632 and stringers 14 L and 14 R. See Figure 5.

All the stringers in this area were cracked, bent or deformed and the skin was creased and wrinkled. Five frame segments were twisted and deformed, and the frame segment at STA 632 was cracked between stringer 13L and 14L. The intercostal was buckled at STA 645, stringer 1R. See Figure 6.

There was light creasing in the skin above and below the nose jacking point, though it was not possible to establish if this damage had occurred during this

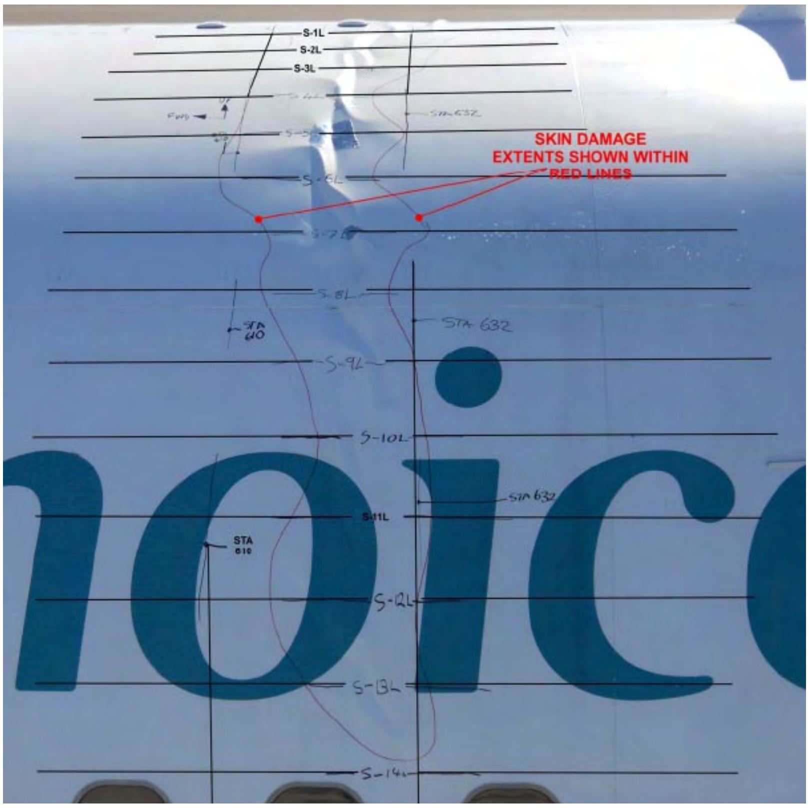


Figure 5

Buckling of skin between STA 610 and STA 632

Figure 6

Buckling of intercostal and cracking of frame

landing. The skin in the area of the nose landing gear was also found to be wrinkled between STA 276 and 303, stringer 28R to 30R, and stringer 25R-26R. See Figure 7. There was evidence of an oil leak from the lower seal on the nose oleo and the trunnion bushings showed signs of having been displaced.

The aircraft tyres exhibited normal wear and there was no physical evidence of heavy braking, or the wheel brakes having locked on landing. The operator advised that no significant faults other than the hard landing had been reported at the end of this flight.

After reviewing the flight data, the aircraft manufacturer determined that the damage to the aircraft was consistent with the aircraft either landing on the nose wheel or the nose wheel making contact with the runway following a rapid de-rotation.

Figure 7

Damage adjacent to nose jacking point

Previous damage and repair

On the 19 September 2000, when the aircraft was previously registered as S7-RGV and operated by another airline, it sustained similar damage to the upper crown skins. It was not possible to establish the circumstances of this accident. The repair was carried out by a team from Boeing. See Figure 8. The maintenance records revealed that since the operator had taken delivery of the aircraft in December 2004 and there had only been one other report of a hard landing that occurred on 16 March 2010.

The operator's actions following the accident

Both co-pilots continued their flying duties following the accident. The commander carried out a small number of flights in the Boeing 767 aircraft with training captains, in order to ensure his confidence in continuing to operate the aircraft; no abnormal techniques were apparent during these flights and the commander returned to his normal flying duties.

Safety actions taken by the operator included:

- revision of advice in the flight crew training manual relating to flare height and landing technique
- a recommendation that pilot flying should lock inertia reel shoulder straps during landing
- additional text in the aerodrome brief for Bristol airport stating that some automatic radio altitude call-outs may be omitted during approaches to Runway 09 and highlighting the runway's profile and increased risk of hard landings
- action to prevent loss of recorded data following a reportable occurrence, including providing tags to enable CVR and FDR circuit breakers to be identified more easily
- action to improve the company's efficiency in reporting accidents and incidents.

Figure 8

Previous damage to the crown skins

The operator's training management reviewed the training material previously produced by the manufacturer on the topic of rapid de-rotations, but considered it was somewhat out of date. Having also concluded that there was no evidence of a significant frequency of rapid de-rotation events in the company's operation, the training management decided not to issue the training material.

Analysis

The flight was unremarkable until the approach and landing at Bristol, where a number of factors made the pilots' task more challenging than usual.

Historical data was available to the operator, which indicated that the rate of hard landings involving Boeing767 aircraft landing on Runway 09 at Bristol was unusually high, but the operator's method of analysis (which was common in the industry) had not highlighted this. It is probable that other similar opportunities to identify unusual rates of events may similarly be lost, and therefore, the following Safety Recommendation is made:

Safety Recommendation 2012–014

It is recommended that the Civil Aviation Authority should advise operators of the benefits of analysing recorded flight data relating to landings not only by airport, but also by runway.

This accident might have been avoided if the unusually high rate of hard landings by Boeing 767 aircraft on Runway 09 had triggered safety action to reduce the rate or stop operations of the type onto that runway. No threshold value, at which action should be taken to reduce the rate of hard landings, had been established by the operator. Without a threshold value at which action is required, opportunities for safety improvement may be lost. Therefore, the following safety recommendation is made:

Safety Recommendation 2012–015

It is recommended that the Civil Aviation Authority should advise operators of the benefits of establishing, in conjunction with aircraft manufacturers, acceptable maximum rates within their flight data monitoring schemes for events such as hard landings, beyond which action should be taken to reduce the rate.

Despite the turbulence, the approach itself was stable and within normal parameters. The absence of a usable glideslope indication below 200 ft aal, the EGPWS 'glideslope' alerts, and the absence of an automatic height call-out at 30 ft aal were unhelpful. The profile of the runway deprived the commander of sight of the full length of the runway as the aircraft approached the flare, and probably contributed to the high rate of hard landings (the flight crew training manual emphasised the importance of shifting the visual sighting point to the end of the runway).

Touchdown on the main landing gear, at 2.05g, was classified by the aircraft manufacturer as a heavy landing. However the structural damage to the crown of the fuselage occurred as a result of the rapid de-rotation of the nose wheel onto the runway following the main wheel touchdown. There is no evidence to suggest that the repair following the previous occurrence contributed to the damage seen on the aircraft.

The sampling rate of the flight recorder meant that the longitudinal deceleration recorded (-0.27g) was probably not the peak value. However this value was the maximum recorded during flight testing using a sampling rate of 50 times per second, during a touchdown measuring a peak normal acceleration of about 2.1g. The aircraft manufacturer considered that the longitudinal deceleration impulse at touchdown was of insufficient magnitude and duration to cause a pilot to be thrown forward with sufficient force so that the control column would be inadvertently held in a nose down position.

The commander's stated action, in attempting to maintain a constant pitch attitude after this touchdown, was in accordance with the operator's guidance. His report, and those of the other flight crew members, of being thrown forward in their seats, offered a possible explanation for the nose-down pitch input which followed the main landing gear touchdown.

The flight crew could have locked the inertia reels of their shoulder harnesses, but did not. Had the shoulder harnesses been locked, it is possible that the degree to which they were thrown forward would have been reduced, and in the commander's case, any consequent movement of the control column would have been lessened.

There was a history of damage to Boeing 767 aircraft similar to that to G-OOBK following hard nose gear touchdowns, and the manufacturer had produced training and awareness material on the topic, but the operator was not aware of this material and it had not been made available to flight crew. The material was published outside the normal suite of operational information (it had not for example been included in the flight crew training manual), it was effectively uncontrolled, and no processes existed to ensure its continuing distribution throughout the remaining operational life of the aircraft type.

It is possible that this material regarding hard nose landing gear touchdowns is not the only material relevant to flight safety which has been lost from the 'corporate memory', and therefore, the following Safety Recommendation is made:

Safety Recommendation 2012–016

It is recommended that Boeing Commercial Airplanes review archived training and safety information, to ensure that relevant safety information is promulgated, and continues to be promulgated, to operators.

Conclusion

Damage to the fuselage occurred as a result of rapid de-rotation of the aircraft following a hard landing on the main landing gear. The runway profile, nuisance GPWS alerts and the meteorological conditions may have influenced the landing.

SERIOUS INCIDENT

Aircraft Type and Registration:	Britten-Norman BN2A-26, Islander, VP-MON
No & Type of Engines:	2 Lycoming O540 piston engines
Year of Manufacture:	1969
Date & Time (UTC):	22 May 2011 at 2154[1] hrs
Location:	John A Osborne Airport, Montserrat
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 1 Passengers -7
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	34 years
Commander's Flying Experience:	3,600 hours (of which 2,000 were on type) Last 90 days - 13 hours Last 28 days - 13 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft skidded after the pilot applied the brakes while landing on Runway 28 at Montserrat. As a result the pilot performed a touch-and-go and positioned for another approach to Runway 28. On landing after the second approach the aircraft skidded again when brakes were applied, and the pilot continued with the landing roll. However, believing there was insufficient runway remaining in which to stop the aircraft the pilot steered it onto a grass verge in an attempt to stop it before the end of the prepared surface. The aircraft came to rest beside the runway 46 m from its end. There were no injuries to the passengers and no damage to the aircraft. This was the pilot's first landing on Runway 28. No faults with the aircraft's brakes or braking system were found and there was no evidence that the aircraft had hydroplaned. An accurate runway friction assessment could not be obtained, but there had not been any pilot reports of poor friction prior to or after the incident. It was probable that a tailwind and/or a high touchdown airspeed caused the runway excursion. Issues identified by the investigation were pilot training, wind measurements, the aerodrome's weather limits, the APAPI approach angle, obstructions on the approach and the runway environment.

The AAIB published Special Bulletin (S2-2011) on 21 July 2011 concerning the VP-MON incident in which three Safety Recommendations were made. Three further Safety Recommendations are made in this final report.

Footnote

[1] All time are UTC. The local time is 4 hours behind UTC.

History of the flight

The aircraft was on a scheduled flight from VC Bird International Airport, Antigua, to John A Osborne Airport, Montserrat. Prior to departure the pilot checked the weather at Montserrat using a computer in Antigua. The departure and cruise from Antigua were uneventful. As the aircraft approached Montserrat the pilot was instructed to join left-hand downwind for Runway 10 and informed that the wind was from 090° at 5 kt. At the time there were two ATCOs on duty; the senior ATCO was taking a weather observation, the other was manning the Tower controller's position. Approximately three minutes later the ATCO advised the pilot that the wind was now from 360° at 3 kt. The pilot replied that he would nevertheless like to conduct an approach to Runway 10. However, the ATCO added that there were clouds at "APPROXIMATELY 600 FT[2] AND BELOW DRIFTING IN FROM THE WEST" with visibility of "LESS THAN 6 KM AT THE MOMENT". As a result the pilot requested Runway 28. He was instructed to report on final for Runway 28 and advised that the wind was from 350° at 4 kt. When the pilot reported that he was approximately 3 nm from landing the ATCO informed him that there was a light rain shower at the airfield. Shortly thereafter the ATCO reported that he could see VP-MON and cleared the aircraft to land on Runway 28, reporting a surface wind from 300° at 4 kt.

The pilot stated that he flew the approach at 70 kt and "felt" some updraughts and a tailwind component on short final. He added that the aircraft touched down in the area of the Runway 28 identification numbers. After he applied the brakes the aircraft skidded, so he decided to perform a touch-and-go and to make another approach to Runway 28. The passengers, the ATCOs and AFRS personnel stated that the aircraft appeared to have touched down approximately one third to halfway along the runway. At this point the senior ATCO took over the Tower controller's position in order to communicate with the pilot. After checking the pilot's intentions he transmitted to the pilot "YOU CAME IN A BIT TOO FAST THERE." The pilot replied "I COULD NOT SLOW DOWN, STILL……I GOT SOME WIND BEHIND ME." The senior ATCO remained at the Tower controller's position.

On short final during the second approach the ATCO informed the pilot that the wind was from 320° at 3kt. The pilot stated that he flew the second approach at 65 kt, and again experienced updraughts, possibly with a tailwind component on short finals, and touched down at 40 kt just past the runway threshold marker. The aircraft skidded again on the initial application of the brakes but he elected to continue with the landing roll. Most of the witnesses stated that the aircraft landed just before the Abbreviated PAPIs (APAPIs)[3] for Runway 28, which are located approximately 190 m from the Runway 28 threshold. During the landing roll he continued to "pump" the brakes but judged the aircraft might overrun the runway. Accordingly, he steered the aircraft right, onto a grass verge approximately 148 m from the end of the paved surface, in an attempt to slow the aircraft more effectively. The aircraft came to rest on the grass approximately 46 m from the end of the paved runway surface. The runway was described as "damp" by the pilot and most of the witnesses.

After the pilot had shut down the aircraft's engines he vacated the aircraft, followed by the passengers. There were no injuries to the passengers and no apparent damage to the aircraft. After the passengers had been

Footnote

2 Above aerodrome level.

Footnote

3 Abbreviated PAPIs consist of two lights to indicate the aircraft's runway approach angle to the pilot; PAPIs have four.

driven to the terminal in an airport vehicle the pilot started the aircraft's engines and taxied it to the apron without requesting permission from ATC. Having informed the operator's chief pilot and sought some engineering advice from an off-island maintenance engineer, the pilot left the airport by road.

The following morning the pilot flew the aircraft empty to Anguilla for a scheduled maintenance inspection.

Weather information

The Terminal Aerodrome Forecast (TAF) for John A Osborne Airport issued at 1000 hrs on 22 May 2011 stated that the surface wind was expected to be calm and the visibility in excess of 10 km, with scattered cloud at 2,200 ft aal. There was a 30% chance that between 1200 hrs on 22 May and 1200 hrs on 23 May of showers The surface wind was expected to become 10 kt from 120° between 1200 hrs and 1600 hrs.

The reported conditions at 2100 hrs were surface wind from 110° at 12 kt, visibility in excess of 10 km, broken cloud at 1,600 ft aal, temperature 26°C, dew point 25°C and QNH 1014 mb. There had been recent rain at the aerodrome and there was rain to the west.

The reported conditions at 2200 hrs were surface wind from 320° at 4 kt, visibility of 6 km, light showers of rain and thunderstorms, broken cloud at 600 ft aal, and few cumulonimbus clouds at 1,000 ft aal. The temperature and dew point were both 25°C and the QNH was 1015 mb.

The reported conditions at VC Bird International Airport, Antigua, just before departure at 2100 hrs, were surface wind from 100º at 8 kt, visibility in excess of 10 km, with few clouds at 1,900 ft aal. The temperature was 29ºC and the dew point was 25ºC and the QNH was 1013 mb.

Aircraft description and maintenance history

The aircraft, (Figure 1), was originally manufactured as an Islander BN2A and then later modified to a BN2A-26 which gives it a maximum takeoff weight (MTOW) of 6,600 lb and a maximum landing weight (MLW) of 6,300 lb. The aircraft is powered by two Lycoming O540 piston engines and can carry up to 10 people including the pilot. The aircraft is equipped with four conventional hydraulically operated brake units, one fitted at each main landing gear wheel, which are operated by toe brakes mounted on the rudder pedals.

Figure 1

The incident aircraft VP-MON

No anti-skid system is fitted. Normal tyre pressure is 29 psi in the nosewheel tyres and 35 psi in the main wheel tyres. An optional panel-mounted Garmin GPS150XL GPS was fitted to the instrument console on VP-MON. The aircraft was not equipped with a Flight Data Recorder or a Cockpit Voice Recorder and neither was required.

The aircraft had accumulated 21,625 flying hours at the time of the incident and its last 100-hr maintenance inspection had been completed on 22 April 2011.

Aircraft examination

The locally based Accident Investigation Manager (AIM) carried out an external examination of the aircraft on the evening of the incident while it was parked on the aerodrome apron. He did not notice any damage to the aircraft and he took photographs of the tyres which did not reveal any flat spots to the visible areas. The pilot carried out his normal pre-flight checks with emphasis on checking the brakes and then flew the aircraft to the operator's maintenance facility in Anguilla where a scheduled 50-hr inspection was carried out. During this inspection the aircraft's brake system was examined and tested with no faults found. The brake liners on both left main wheels and the right inboard main wheel were found to be worn and consequently replaced. However, the maintenance engineer reported that the liners were not worn beyond limits and would not have affected normal brake operation. Both right main wheel tyres were found to be worn to near the tread limit and replaced. The aircraft was examined for damage but none was found.

Aircraft performance

Aircraft weights

The aircraft's MTOW and MLW are 6,600 lb and 6,300 lb respectively. Depending upon air temperature and pressure altitude these weight limits are reduced to account for reduced aircraft performance – this is referred to as the WAT (weight, altitude and temperature) limit. At the time of the incident the temperature at the airport was 25°C and the pressure altitude was 500 ft; this reduced the aircraft's MTOW and MLW to 6,275 lb. The WAT limit at the time of takeoff from Antigua, at 29ºC and a pressure altitude of 62 ft, was 6,280 lb.

The operator's chief pilot, the incident pilot and some of the operator's other pilots were not aware of the WAT chart in the aircraft's Flight Manual. The operator has subsequently produced a reference chart for use by its pilots to ensure they comply with the WAT limits.

The pilot calculated the aircraft's takeoff weight to be 6,284 lb and its landing weight to be 6,224 lb. This was calculated using assumed weights for the passengers and 80 lb for the seven passengers' hold baggage.

Calculations by the AAIB indicate that the takeoff weight was 6,504 lb, 224 lb above the Antigua WAT limit, and the landing weight was 6,444 lb, 220 lb in excess of that calculated by the pilot and 144 lb above the authorised maximum of 6,300 lb and 169 lb above the Montserrat WAT limit of 6,275 lb. This was calculated using assumed weights for the passengers, as directed by the operator's operations manual, and the passenger estimated weights of the baggage, excluding hand baggage, which they stated they had checked in. One passenger commented that one of his two hold bags was not available for collection after the incident, and therefore was probably not aboard. As a result the weight of his heaviest bag was not included in these calculations. See Table 1 below.

Landing distance required

For the conditions at the time of the incident (25°C and 500 ft pressure altitude) and at MLW, 6,300 lb,

(All weights in lb)	Pilot's calculations	AAIB calculations
Aircraft basic weight	4,419	4,419
Weight of passengers	1,425	1,425
Weight of baggage	80	300 (8 bags)
Weight of Fuel	360	360
Takeoff weight	6,284	6,504
Sector fuel	60	60
Landing weight	6,224	6,444

Table 1

Pilot's and AAIB weight calculations

the factored[4] landing distance required (LDR), from a height of 50 ft, on to a dry runway, in calm wind was 440 m and 524 m with a 5 kt tail wind. On a wet runway these distances are increased by a factor of 1.15[5] which results in an LDR of 506 m in a calm wind and 603 m with a 5 kt tailwind. If a runway is reported as being 'damp', dry figures can be used. These performance figures assume that full flaps are used and an '*appropriate threshold speed*'. According to the flight manual the threshold speed for a landing weight of 6,224 lb and 6,444 lb are 58 kt and 59 kt respectively.

The manufacturer does not publish LDR for weights above MLW. However, it estimated that the LDR at 6,444 lb in calm wind was 445 m and 533 m with a 5 kt tailwind. On a wet runway these distances increase to 511 m and 613 m respectively.

The manufacturer estimated that the un-factored landing ground roll distance (from touchdown to rest), in calm wind, at 6,444 lb, is 146 m; 166 m with a 5 kt tailwind[6]. On a wet runway, using a factor of 1.3[7], this increases to 190 m and 216 m with a 5 kt tailwind. At 6,224 lb the landing ground roll in calm wind is 144 m and 187 m on a wet runway, and 168 m with a 5 kt tailwind on a dry runway and 193 m on a wet runway.

Aerodrome information

John A Osborne Airport was opened in July 2005 and was built to replace the previous airport after eruption of the Soufriere Hills Volcano destroyed the capital Plymouth in 1997. Approximately two thirds of the island is vulnerable to volcanic hazard which limited the available locations for the new airport. The runway at John A Osborne Airport is 596 m long – a distance which includes a 28 m displaced threshold at each

Footnote

4 For public transport operations all takeoff and landing distances are increased by a safety factor. The landing distance from a height of 50 ft is multiplied by 1.43 to get the factored landing distance required. It is this figure that is used in the planning stages to determine if a runway is of sufficient length to land on.

5 The aircraft manufacturer does not publish landing distance data for wet runways, but according to OTAR 91 when the runway is wet the landing distance available should be at least 115% (factor of 1.15) of the landing distance required.

Footnote

6 The tailwind ground roll estimates were calculated by the manufacturer using the actual wind strength rather than the scheduled performance requirement to use 150% of the tailwind.

7 The aircraft manufacturer does not provide landing ground roll figures for wet runways, but if the landing distance from 50 feet is increased by a factor of 1.15, then for the Islander aircraft the ground roll portion is increased by a factor of about 1.3 (because the airborne distance is not increased by the runway being wet).

end. The Eastern Caribbean Aeronautical Information Publication (ECAIP) states the declared distances for John A Osborne Airport shown in Table 2.

There are no overrun areas on either runway. At the end of each runway is a steep drop in excess of 200 ft. See Figure 2 for a diagram of the airfield.

There was one windsock located to the north of the Runway 10 threshold. In the AAIB's Special Bulletin (S2-2011) on the VP-MON incident published on 21 July 2011 the following Safety Recommendation was made:

Safety Recommendation 2011-077

The operator of John A Osborne Airport, Montserrat, should install a windsock and anemometer adjacent to the Runway 28 threshold.

Since this recommendation the airport operator has installed an additional windsock adjacent to the Runway 28 threshold. Furthermore, the airport issued NOTAM A1217/11 that stated:

'WIND INFORMATION GIVEN BY ATC MAY NOT TRULY REPRESENT CONDITIONS CLOSE TO OR IN THE VICINITY OF THE THRESHOLD OF RWY28. EXERCISE EXTREME CAUTION.'

In the ATC tower there was a stand-alone wireless weather station with an anemometer mounted on the roof. This was the primary device used to display the current wind to the ATCOs. There was also a mast-mounted anemometer on the grass between the fire station and the windsock, but this was only partially serviceable because the display, which was on the ATCO's console, received only wind direction information. There was another mast-mounted anemometer north of the tower, which had not been commissioned. The operator intended to relocate this on the grass west of the taxiway and put it into service. The aerodrome operator commented after the incident that it planned to complete this work by the end of August 2011. Air Safety Support International (ASSI)[8] stated that the anemometer has now been relocated and is operating.

RWY designator	TORA[1] (m)	ASDA[2] (m)	TODA[3] (m)	LDA[4] (m)	Remarks
10	553	553	623	540	THR DISP 30 M
28	553	553	830	540	THR DISP 30 M

Footnotes

1 Takeoff Run Available (TORA) is the length of runway declared available and suitable for the ground run of an aeroplane taking off.
2 Accelerate Stop Distance Available (ASDA) is the length of the TORA plus the length of the stopway, if provided and if capable of bearing the weight of the aeroplane under the prevailing operating conditions.
3 Takeoff Distance Available (TODA) is the length of the TORA plus the length of the clearway, if provided.
4 Landing distance available (LDA) is the length of runway which is declared available and suitable for the ground run of an aeroplane landing.

Table 2

Footnote

8 Air Safety Support International, a subsidiary company of the UK Civil Aviation Authority, has been designated by the Governor of Montserrat to perform the civil aviation regulatory tasks on behalf of the Governor.

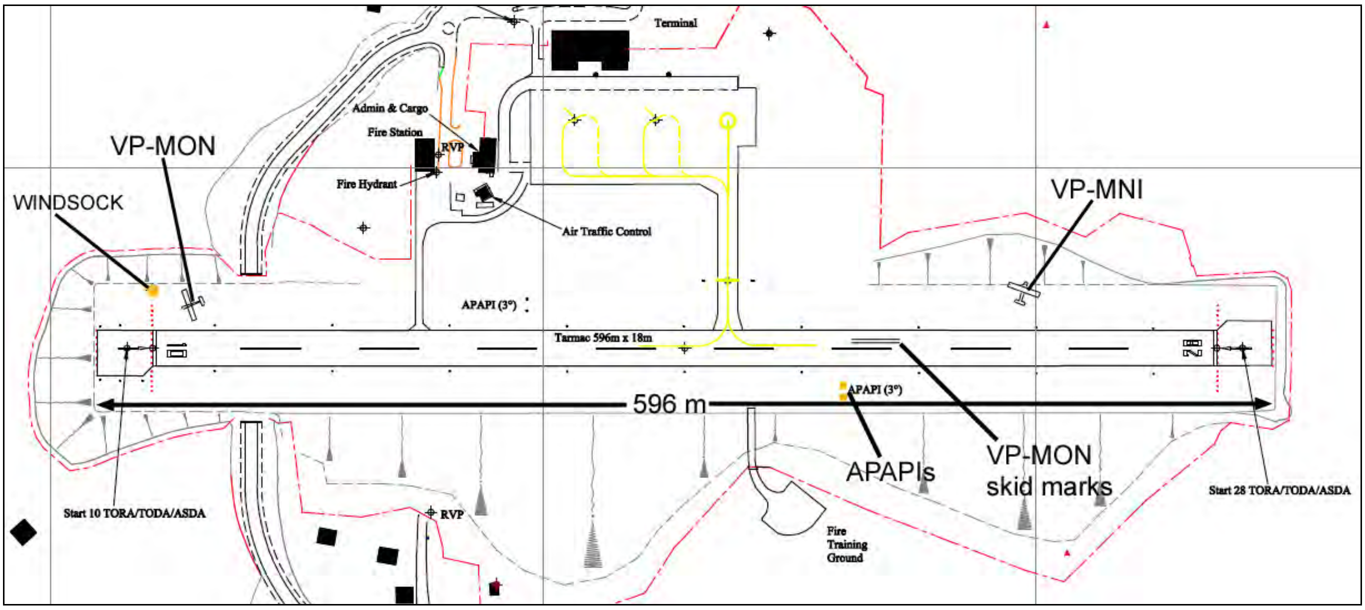


Figure 2

Aerodrome chart showing the post-incident location of VP-MON and the location of VP-MNI following its runway excursion accident on 17 April 2011

There are two sets of APAPIs positioned approximately 190 m from each runway threshold. These devices provide visual guidance to assist pilots to fly a specific approach angle. Both sets of APAPIs were set to an approach angle of 3°. When flying on a 3° approach path the pilot will see a red light and a white light. When flying below 3° they will see two red lights, and when flying above 3° they will see two white lights. 3° is a typical approach angle used at many airfields.

There is an aerodrome traffic zone, 5 nm in diameter centred on the airfield reference point from the surface to 4,500 ft aal, which is Class D airspace and operates VFR only. The VFR weather limits, as defined in the ECAIP, are 5 km visibility and 1,500 ft aal cloud base.

Local wind effects

It is not uncommon for the wind to be from significantly different directions at both ends of the runway with a northerly or southerly wind, because of significant terrain to the north and south of the airfield. Also, up and downdraughts are not uncommon on the approach to either runway.

Pilot approval

Prior to this incident the aerodrome operator required pilots to undergo a flight check before being permitted to operate at Montserrat Airport. This consisted of six takeoffs and landings at this airport under the supervision of a suitably qualified pilot, but there was no written requirement to be checked on the use of both runways, although the airport manager commented that he believed this requirement existed. The incident pilot had been checked on Runway 10 only.

In the AAIB's Special Bulletin (S2-2011) on the VP-MON incident published on 21 July 2011 the following Safety Recommendation was made:

Safety Recommendation 2011-078

The operator of John A Osborne Airport, Montserrat, in consultation with Air Safety Support International, should revise its operations manual to permit pilots to operate only to and from the runway on which they have been flight checked.

ASSI have subsequently issued *'Instructions for the Use of John A Osborne Airport'* detailing the training requirements for pilots using the airport. A copy of this instruction will be incorporated in the ECAIP and on the ASSI website. Since this incident the operator has flight checked all its pilots to use Runway 28.

Runway surface examination

The runway was inspected by the AIM the day after the incident and in June by the AAIB. There was a skid mark approximately 24 m long made by the aircraft's right main wheel tyres that started approximately 191 m from the beginning of the paved area of Runway 28 (163 m from the threshold), 12 m before the Runway 28 APAPIs. The aircraft's tyre marks continued along the runway until the left and right tyre marks left the paved surface about 115 m and 148 m from the end of the paved surface respectively.

The runway surface consisted of un-grooved asphalt and it was cambered to assist water drainage to the sides. A fire truck was used to spray water on the runway surface which revealed that the water drained to the sides of the runway, but there was some pooling of water at the runway edges where the surface joined the grass (Figure 3). Some runways at other airports have carrier drains, sometimes consisting of stone aggregate, between the runway surface and the grass surface which aides drainage.

Figure 3

Water sprayed onto the runway surface revealed some pooling at the edges

Hydroplaning

Dynamic hydroplaning can occur if an aircraft lands fast enough on a sufficiently wet runway. During hydroplaning the water cannot escape from the tyre footprint area, causing the tyre to be held off the pavement by a hydrodynamic force. The minimum hydroplaning speed for a wheel is based on its tyre pressure. For a rotating wheel the minimum hydroplaning speed, in knots, is $9\sqrt{p}$ where p is the tyre pressure in psi, and for a locked wheel it is $7\sqrt{p}$. If the main wheel tyres were inflated correctly to 35 psi, the minimum hydroplaning speed for a rotating wheel was 53 kt and the minimum speed for a locked wheel was 41 kt. The threshold speed for an Islander at maximum landing weight is 58 kt resulting in a touchdown speed of between 40 and 50 kt. Estimates on the minimum water depth required for hydroplaning vary from 1 mm to 3 mm.

Runway friction measurements

OTAR[9] 139.G.27 requires that:

> *'measurements of the friction characteristics of a runway surface shall be made periodically with a continuous friction measuring device using self-wetting features.'*

A 'continuous friction measuring device' continuously measures friction while it is being towed by a vehicle along the length of a runway. The operator of John A Osborne Airport used a 'continuous friction measuring' device called a 'GripTester'. The 'GripTester' is a three-wheel trailer (Figure 4), which measures friction using a braked wheel and the fixed slip principle. This braked wheel is fitted with a smooth tread tyre and is mounted on an axle instrumented to measure both the horizontal drag and the vertical load. From these measurements, the dynamic friction reading is calculated and transmitted to a data collection computer normally carried in the towing vehicle. The friction runs should be carried out on a dry runway using 'self-wetting' which involves spraying a controlled film of water in front of the measuring wheel that will result in a water depth of 1.0 mm.

According to OTAR 139.G.27:

> *'corrective maintenance action shall be taken when the friction characteristics for either the entire runway or a portion thereof are below a minimum friction level specified in ICAO Annex 14, Volume 1[10], Attachment A, Section 7.'*

Figure 4

'GripTester' continuous friction measuring device used by the airport operator

Footnote

[9] OTAR is the Overseas Territories Aviation Requirements and Part 139 concerns 'Certification of Aerodromes'.

Footnote

[10] Annex 14 Volume 1 is entitled '*Aerodrome Design and Operations*'

The minimum friction levels specified in Annex 14 for the 'GripTester' are:

- Design objective for new surface 0.74
- Maintenance planning level 0.53
- Minimum friction level 0.43

Corrective maintenance action should be initiated if the friction level drops below 0.53, and if the friction level drops below 0.43 the runway or a portion thereof should be notified as '*may be slippery when wet*'. According to OTAR 139.G.27:

> *'a portion of runway in the order of 100 m long may be considered significant for maintenance or reporting action'.*

ASSI have expanded on this by stating that:

> *'for a short runway where landing distance available may be limiting for a certain aircraft type, a 100 m length might be considered too long, and a 50 m length might be considered more appropriate for assessment of runway surface friction.'*

The airport operator carried out the first runway friction assessment on 20 June 2005 prior to the airport's opening using their 'GripTester'. With a dry runway and using 'self-wetting' the average friction measured was 0.52 and was fairly consistent both sides of the runway centreline. The following day the runs were repeated and the average friction measured was 0.71, with some variation. On the subsequent two days (22 and 23 June) the runway was wet and the average friction measured was 0.51 and 0.55 respectively. It is not known how soon after the runway surfacing these measurements were taken and there were no records of any corrective action. Between the airport opening in July 2005 and the VP-MON incident there was no record of any runway resurfacing works having been carried out.

On 30 March 2007 and 27 April 2007 some friction runs with self-wetting were carried out with average measurements between 1.0 and 1.2. 1.2 is the maximum possible measurement and is not normally achieved on a runway surface. Therefore, it is likely that an equipment or calibration problem caused these high readings. On 3 March 2009 some friction runs with self-wetting were carried out but the towing speed was too high to produce reliable results. The towing speed should be 65 km/hr with less than 5% variation, but the runs in March 2009 were carried out at speeds up to 94 km/hr. Due to staff changes no further information on the runs in 2007 or 2009 could be obtained.

Between 3 March 2009 and the VP-MON incident no further friction runs were carried out. The airport operator stated that this was due to an absence of trained personnel.

The John A Osborne Airport aerodrome manual stated:

> ***'9 Runway Surface friction Measurement***
>
> *9.1 A continuous friction measuring device is available.*
>
> *9.2 In order to provide a record of the reduction in friction characteristics with time, friction testing is carried out periodically but at not less than six-monthly intervals by the Operations Officer and the results reported to the Duty ATCO. Friction testing may also be carried out when the Aerodrome Manager so decides e.g. following a runway incident or particularly heavy rain.'*

In the AAIB's Special Bulletin (S2-2011) on the VP-MON incident published on 21 July 2011 the following Safety Recommendation was made:

Safety Recommendation 2011-079

The operator of John A Osborne Airport, Montserrat should ensure that a runway friction assessment is carried out at the earliest opportunity by a qualified person using suitable equipment.

The airport operator subsequently carried out some friction runs in July, August, September and October, but due to equipment problems no reliable data was obtained. It stated that it now has personnel trained to conduct friction measurements, and that technical problems with the equipment would be resolved on delivery of replacement parts.

The airport operator stated that apart from the VP-MON incident there had not been any other incidents where a pilot had reported poor braking performance due to a slippery runway.

Runway over-run areas

John A Osborne Airport is an ICAO Code 1 airport because its runway is less than 800 m long. A Code 1 airport with a non-instrument runway is not required to have a RESA[11] (Runway End Safety Area). The only ICAO Annex 14 and OTAR 139 requirement for the ends of a Code 1 non-instrument runway is that there is a 30 m 'Runway strip'. The definition of a 'Runway strip' is an area intended:

'to reduce the risk of damage to aircraft running off a runway; and to protect aircraft flying over it during take-off or landing operations'.

John A Osborne Airport satisfies this requirement by having a 28 m paved surface beyond each runway threshold in addition to a 2 m strip of grass. Beyond this 30 m strip there is a steep drop in excess of 200 ft at both ends of the runway, but this complies with ICAO and OTAR requirements. Figure 5 shows the steep drop at the end of Runway 28.

The ICAO and OTAR requirements for a Code 1 runway also specify that there is an obstruction-free area along the sides of the runway of at least 30 m from the runway centreline. The runway at Montserrat is 18 m wide and on both sides of the runway there is a flat area of grass about 23 m wide which satisfies the 30 m requirement. In the event of a possible over-run during landing, and assuming a safe go-around cannot be made, a pilot might attempt to steer the aircraft towards the sides of the runway rather than risk going off the end. However, at the end of Runway 28 where VP-MON came to rest there are steep drops beyond the 23 m grass area on both sides. The northern drop is shown in Figure 6, VP-MON came to rest 11 m from the edge of this northern drop.

Towards the end of Runway 10 there are steep embankments on both sides of the runway located 23 m from the runway edge (Figure 2 and 10). The gradients of these embankments are within ICAO limits, but would cause damage to an aircraft hitting them at speed as in the case of the VP-MNI incident described later in this report. Along the southern edge of the runway there is also a ditch where the flat area of grass meets the southern embankment (Figure 7). The ditch, which serves as a drain and is about 4 feet deep,

Footnote

11 A change to ICAO Annex 14 to require a 30 m RESA for a non-instrument code 1 runway is currently under consultation.

Figure 5

View looking south-east at the end of Runway 28. VP-MON came to rest 46 m from this end.

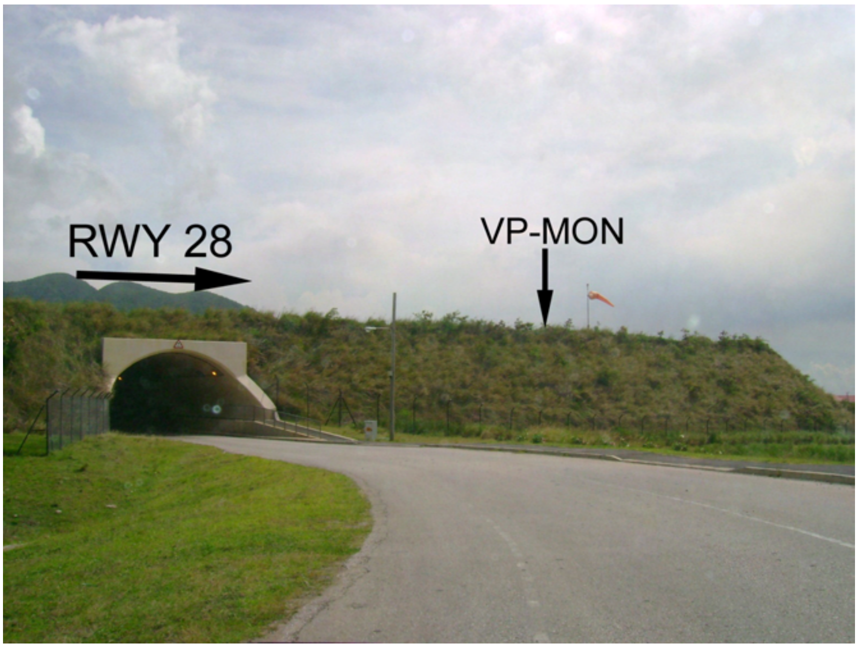


Figure 6

View looking south-west at the end of Runway 28 where VP-MON came to rest would cause damage to an aircraft hitting it at speed, but it is just outside the 30 m wide designated area and therefore in compliance with Annex 14. There is also a drain along the northern side of the runway, but it has been filled with earth and does not present a hazard to aircraft.

ICAO Annex 14 '*sets forth the minimum aerodrome specifications*' and states that '*the acceptable level of safety to be achieved shall be established by the State*.' OTAR 139 reflects these minimum specifications, but also requires that the operator has a Safety Management System. And according to OTAR 139.A.09 this Safety Management System shall include, as a minimum:

> '(1) *processes to identify actual and potential safety hazards and assess the associated risks; and*
>
> (2) *processes to develop and implement remedial action necessary to maintain agreed safety performance*'

The airport operator had not carried out a safety assessment on the risks associated with runway excursions.

Obstacle clearance areas

Below the approach area to Runway 28 there is a housing development on a hill called 'Lookout' located between 380 m and 650 m from the Runway 28 threshold (Figure 8). Its summit is approximately 40 to 50 ft above the runway. An aerodrome obstruction survey carried out in April 2009 revealed that there was a palm tree located on 'Lookout' which infringed the ICAO Annex 14 defined 'Approach surface' for a Code 1 airport. The 'Approach surface' is defined as an area extending from 30 m before the runway threshold out to 1600 m. According to ICAO no obstacle is

Figure 7

Ditch serving as a drain along the south side of the runway

permitted within a 5% gradient (2.86°) of this surface extending up from 30 m before the runway threshold. The palm tree penetrated this by 9 ft. In the two years since this survey was carried out the palm tree has grown and now penetrates this surface by a greater, as yet undetermined, amount.

ICAO also specifies obstacle clearance criteria for a 'Takeoff climb surface'. The dimensions and gradient of the 'Takeoff climb surface' are the same as for the 'Approach surface' for a Code 1 airport, but the 'Takeoff climb surface' starts at the 'runway end' (which includes the runway strip and/or clearway) and therefore is slightly more restrictive. According to the 2009 survey there were eight obstacles which penetrated the 'Takeoff climb surface', consisting of trees and bushes. The previously mentioned palm tree penetrated this surface by 16 ft.

Figure 8

Aerial view of approach area to Runway 28

The ECAIP entry for John A Osborne Airport contains an Aerodrome Obstacles table which states 'NO OBSTACLES'. The airport operator commented that it was attempting to have this information added to the ECAIP.

APAPI angle setting

The APAPIs were both set to an approach angle of 3°. According to ICAO Annex 14 the APAPI angle should be set to provide a safe margin from obstacles on the approach path when the pilot observes the lowest on-slope signal, i.e. one white and one red light. An illustration of an APAPI set to 3° is shown in Figure 9.

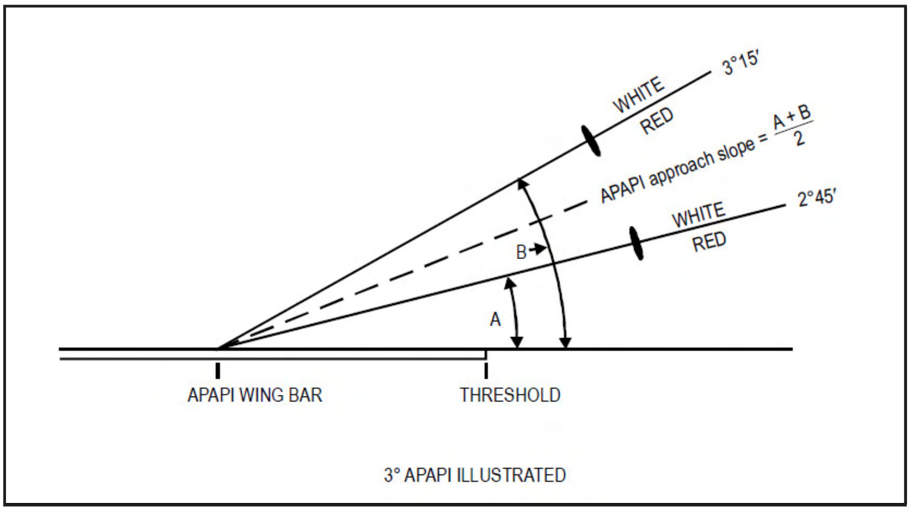


Figure 9

Illustration of a 3° APAPI angle setting (extract from ICAO Annex 14)

In the case of a 3° APAPI, the pilot should start to see two white lights if he flies above an approach slope of 3°15' (3.25°) and two reds if he descends below a 2°45' (2.75°) approach slope to the APAPI. According to the Annex 14 requirements any obstacle should be below A-0.9°. So in the case of John A Osborne Airport's APAPI settings, all obstacles should be below 1.85° (as measured from the position of the APAPIs rather than from the runway threshold). The previously mentioned palm tree extends to 2.06° (based on the 2009 survey) and therefore penetrates the obstacle protection surface. An aircraft flying on a 2.75° glidepath (seeing one red and one white) would clear the top of this palm tree by 24 ft.

There are numerous houses on 'Lookout' hill, all below the 1.85° obstacle protection surface for the APAPI. The house which comes closest to penetrating the surface is located on the extended runway centreline 395 m from the runway threshold. The roof of this house reaches to 1.54° from the APAPI. An aircraft flying on a 2.75° glidepath would clear the roof of this house by 40 ft. There are no obstacles on the approach to Runway 10 so a 3° APAPI setting is within limits.

On 28 February 2011 a commercial flight inspection organisation conducted an in-flight assessment of the APAPIs at John A Osborne Airport. This company was contracted with the agreement of the ECCAA (Eastern Caribbean Civil Aviation Authority) to conduct annual flight testing of navigation aids, including PAPIs, for most of the Eastern Caribbean nations. In the case of Montserrat this was also agreed with ASSI. The company's flight inspection report for the APAPIs at John A Osborne airport included pilot comments which stated '*Approach on 28 too close to houses, appearance of boxes on 10 is not clear*. In this report the flight inspector stated:

> *'Fly ability check only no actual angle measurement done. Runway 10 there appeared to be not a large enough space (angle wise) between the two light boxes and they appeared quite pink rather than having a clear red/white definition. Runway 28 was clearer and spacing appeared to be better but following approach angle was not comfortable and with known wind shear at airport – quite dangerous.'*

Both the pilot and flight inspector rated the APAPI systems as '*Unsatisfactory*', although the overall assessment was deemed '*Satisfactory with consideration to the limitations and restrictions stated*', although no limitations or restrictions were stated in the report.

No action was taken by the operator of John A Osborne Airport when this report was issued. The airport manager in post at the time of the VP-MON incident had taken over in April 2011 and had not been aware of this report until he initiated an investigation in September 2011. ASSI were also not aware of this report until they were sent a copy by the airport manager in September 2011.

In September 2011, at the request of the airport manager, the flight inspection organisation provided some clarification of the conflicting conclusions of '*Unsatisfactory*' and '*Satisfactory*' in their report. The company stated that with hindsight they should have separated the reports for the Runway 10 APAPI and the Runway 28 APAPI. They had concluded that the Runway 10 APAPI system was not performing correctly and should not be used in its current state and was '*Unsatisfactory*'; whereas they determined that the Runway 28 APAPI system was performing correctly but was set too low. They stated:

> *'Local pilots have reported that they usually fly a higher glidepath angle and we recommend that the PAPI angle should be set higher to accommodate this operational environment.'*

Following verbal discussions between the previous airport manager and the organisation at the time of the inspection, it was considered that the Runway 28 APAPIs could continue to be used with consideration to the local conditions, but that the Runway 10 APAPIs should not be used in their current state.

Aircraft operator's operations manual

The aircraft operator's operations manual (OM) contained a section on accident and incident reporting detailing their definitions and actions to be taken in the event of any such occurrence.

The OM states the following in the section on flight procedures:

> *'Approach to Land Procedures*
>
> *All Company aircraft are to be operated in such a way that they are stabilised on final approach to land with landing flap selected within +15 kts of the threshold speed at 500' AGL.'*

The pilot stated that, though he possessed a copy of the OM, he was not aware of the contents of these sections.

Pilot's experience

The pilot of VP-MON had over 2,000 hrs experience on the Britten-Norman Islander. He started working for the operator on 11 May 2011 and on 13 May 2011 successfully completed a flight check to operate at Montserrat. However, he only completed takeoffs and landings using Runway 10. This incident occurred on the pilot's first landing on Runway 28.

The pilot commented that he had considerable experience flying around mountains, having operated at airports in Jamaica and Santa Domingo on several occasions. He had also worked in the Turks & Caicos Islands for approximately six years.

Pilot's comments

The pilot commented that he did not use the panel mounted GPS in the aircraft to give him an indication of the aircraft's ground speed on the approach.

He added that he was not aware of the VFR weather limits to operate into Montserrat. He stated that he made an assessment of whether to make an approach on the conditions passed by ATC. He also stated that he would not land on either runway if a tailwind were reported.

Chief pilot's comments

Training

The operator's chief pilot commented that he taught pilots to fly an initial 6-8º approach to Runways 28 and 10 that reduces as the aircraft approaches the runway, when it would be clear of the worst turbulence. However, this is not intended for every eventuality. He commented that this was to try to keep the aircraft above the worst turbulence and added a safety factor for the windshear frequently encountered on short final. He also instructed pilots to monitor the GPS ground speed readout on short final to get an indication of tailwinds.

The chief pilot added that he taught pilots to flare the aircraft as close as possible to the white threshold line. He stated that, depending on speed, the touchdown point would normally be abeam the tower on Runway 10 (which is 166 m from the runway threshold). This is a similar distance from the threshold of Runway 28 to where VP-MON probably touched down, based on the skid marks.

ATCOs comments

The senior ATCO stated that during his training he learnt that the weather limits for operations at Montserrat were 5 km visibility and a minimum cloud base 1,500 ft aal. However, when he returned to Montserrat to start controlling, the previous Airport Manager instructed controllers that it was acceptable for aircraft to operate in 5 km visibility and clear of cloud with the surface in sight[12]. This instruction was published in the ATC tower.

Since this incident the current Airport Manager has instructed the ATCOs that the correct minima are 5 km visibility and a cloud base of 1,500 ft aal.

Runway reporting

The Aerodrome Manual states that ATCOs are to report the degree of contamination by water to pilots using the following terminology:

> *'DAMP — When the surface shows a change of colour due to moisture*
>
> *WET — When the surface is soaked but no significant patches of standing water are visible*
>
> *WATER PATCHES — When significant patches of standing water are visible*
>
> *FLOODED — When extensive standing water is visible.'*

Previous serious landing incident

On 17 April 2011 another Britten-Norman Islander, registration VP-MNI, operated by the same operator as VP-MON, departed the side of the runway at John A Osborne Airport[13]. The aircraft had departed from VC Bird Airport, Antigua, and was making an approach to Runway 10 at John A Osborne Airport at about 1915 hrs. After a normal touchdown the pilot applied the brakes and noticed that there was no response from the right brake pedal. While maintaining directional control with the rudder the pilot tried to 'pump' the brake pedals but this had no effect on the right brakes. To avoid departing the end of the runway the pilot allowed the aircraft to turn left onto grass just beyond the taxiway exit. The aircraft struck the embankment located 23 m north of the runway edge, approximately 150 m from the end of the runway. The impact, which was estimated by the pilot to be at approximately 10 kt, resulted in damage to the nose structure and caused the nose landing gear leg to collapse (Figure 10). The left wing tip leading edge was also damaged when it struck the embankment. The seven passengers were able to exit the aircraft via the main door after the aircraft came to rest. The loss of right braking was attributed to trapped air in the hydraulic lines which was probably introduced during a right brake O-ring seal replacement prior to the accident flight. Following this repair work the right brakes had not been bled in accordance with the aircraft maintenance manual (AMM).

ASSI oversight of John A Osborne Airport

ASSI is responsible for the oversight of John A Osborne Airport which includes carrying out annual audits. The last audit of the airport prior to the VP-

Footnote

12 'With the surface in sight' means the pilot being able to see sufficient surface features or surface illumination to be able to maintain the aircraft in a desired attitude without reference to any flight instrument.

Footnote

13 For full details see AAIB report in Bulletin 2/2012.

Figure 10

Northern embankment near the end of Runway 10 where VP-MNI came to rest (southern embankment visible in the distance)

MON incident was carried out on 22 to 23 July 2010 and the findings were published in October 2010[14]. The primary findings were that the airport operator needed to establish a maintenance programme, and develop a Safety Management System Manual, and that there were some deficiencies in the Aerodrome Manual. The inspection did not cover all aspects of the airport operation and did not mention the lack of recent friction measurements or note any issues surrounding obstacle clearance or APAPI angle settings.

In October 2011 ASSI carried out another audit of the airport operator and their findings included the following:

(1) runway friction monitoring should be resumed as soon as possible

(2) all aerodrome obstacles should be assessed and then removed or marked, and obstacles that cannot be addressed are to be documented in the AIP and Aerodrome manual

Landing incidents and accidents

The Flight Safety Foundation published a report "*Reducing the Risk of Runway Excursions - Report of the Runway Safety Initiative*" in May 2009.

It stated that during the 14-year period from 1995 to 2008, commercial transport aircraft were involved in a total of 1,429 accidents involving major or substantial damage. Of those, 431 accidents (30%) were runway-related. Of these, 417 (97%) were runway excursions.

The number of runway excursion accidents was more than 40 times the number of runway incursion accidents, and more than 100 times the number of runway confusion accidents. Over the past 14 years,

Footnote

14 ASSI have stated that alhough the report was not issued until October 2010, the findings were issued and signed as accepted by the airport manager at the end of the audit on 23 July 2010.

there has been an average of almost 30 runway excursion accidents per year for commercial aircraft, while runway incursion and confusion accidents combined have averaged one accident per year.

Forty-one of the 431 runway accidents involved fatalities. Excursion accidents accounted for 34 of those fatal accidents, or 83% of fatal runway-related accidents. Over the 14-year period, 712 people died in runway excursion accidents, while runway incursions accounted for 129 fatalities and runway confusion accidents accounted for 132 fatalities.

During the 14-year period, the number of takeoff excursion accidents decreased. However, the takeoff excursion accident trend has levelled off. During the same period the number of landing excursions showed an increasing trend.

An in-depth study was conducted of all runway excursion accidents from 1995 to March 2008 to investigate the causes of runway excursion accidents and to identify the high-risk areas. Landing excursions outnumber takeoff excursions approximately 4 to 1 with the principal risk factors being a fast approach and touching down long.

The Flight Safety Foundation published the following in its Approach and Landing Accident Reduction Briefing Note 7.1, Stabilized Approach:

'**Recommended Elements of a Stabilized Approach**

All flights must be stabilized by 1,000 feet above airport elevation in instrument meteorological conditions (IMC) or by 500 feet above airport elevation in visual meteorological conditions (VMC). An approach is stabilized when all of the following criteria are met:

1. *The aircraft is on the correct flight path;*
2. *Only small changes in heading/pitch are required to maintain the correct flight path;*
3. *The aircraft speed is not more than VREF + 20 knots*[15] *indicated airspeed and not less than VREF;*
4. *The aircraft is in the correct landing configuration;*
5. *Sink rate is no greater than 1,000 feet per minute; if an approach requires a sink rate greater than 1,000 feet per minute, a special briefing should be conducted;*
6. *Power setting is appropriate for the aircraft configuration and is not below the minimum power for approach as defined by the aircraft operating manual;*
7. *All briefings and checklists have been conducted;*
8. *Specific types of approaches are stabilized if they also fulfil the following: instrument landing system (ILS) approaches must be flown within one dot of the glideslope and localizer; a Category II or Category III ILS approach must be flown within the expanded localizer band; during a circling approach, wings should be level on final when the aircraft reaches 300 feet above airport elevation; and,*

Footnote

[15] This report is primarily focused on public transport aircraft larger than an Islander. The recommended maximum speed for the Islander is V_{REF} +15 kt as stated in the operator's OM.

> 9. *Unique approach procedures or abnormal conditions requiring a deviation from the above elements of a stabilized approach require a special briefing.*
>
> *An approach that becomes unstabilized below 1,000 feet above airport elevation in IMC or below 500 feet above airport elevation in VMC requires an immediate go-around.*
>
> *Source: Flight Safety Foundation Approach-and-landing Accident Reduction (ALAR) Task Force (V1.1, November 2000)'*

Analysis

General

Based on the position of the initial skid marks, VP-MON touched down at a point that under normal conditions and at a normal touchdown speed should have enabled to aircraft to stop safely on the runway. During the incident the pilot reported difficulty decelerating the aircraft; he steered the aircraft off the runway because he was concerned that it would not stop before the end of the prepared surface. No technical faults with the brakes or braking system were found so the possible factors considered were: hydroplaning, runway surface friction and high touchdown speed resulting either from a tailwind or excessive airspeed on approach, or from both.

Although there had been a light rain shower at the airport prior to the incident, the runway surface was described as 'damp' by the pilot and by the majority of the witnesses. For hydroplaning to occur a water depth of at least 1 mm to 3 mm is required, which would give the appearance of a 'wet' runway rather than a 'damp' one. Furthermore, the skid marks on the runway indicated that there was good friction contact between the runway surface and the tyres, which would not occur had the aircraft hydroplaned after touchdown.

Runway friction

When the runway friction was first assessed in 2005 the friction level was determined to be at the limit of the maintenance planning level of 0.53, although there was one day when the friction was measured as high as 0.71. Due to the variation in results it is difficult to determine what the new runway friction level was. Subsequent measurements in 2007 and 2009 were not carried out correctly, either because the equipment was not calibrated correctly or the towing speed was too high. The airport operator has made a number of attempts to obtain accurate friction measurements since the VP-MON incident but have been unable to do so because of equipment problems and a lack of staff training.

There have not been any other pilot reports of a slippery runway since the VP-MON incident or prior to the incident. When runway surfaces start to become slippery in the wet it is usually followed by a number of pilot reports – as in the case of the runway excursion incidents investigated by the AAIB at Bristol International Airport in 2007 (see AAIB Formal Report 1/2009). Since there were also no obvious surface defects or unusual surface deposits on the runway, it is probable that the friction level was at an acceptable level.

Nevertheless, it is important that an accurate friction assessment is carried out and therefore Safety Recommendation 2011-079 is still considered open. ASSI have supported this recommendation and have raised friction measuring as a finding in their latest audit of the airport operator.

Weather

At 2100 hrs the cloud was broken at 1,600 ft aal. As the aircraft commenced its first approach the ATCO reported the cloud base was "APPROXIMATELY 600 FT AND BELOW DRIFTING IN FROM THE WEST". Just after the incident there were light showers of rain and thunderstorms, and broken cloud at 600 ft aal. It can thus be seen that at the time of the incident the cloud base was likely to have been below 1,500 ft aal. The ATCO's were working to 5 km visibility and clear of cloud. Had they been operating to a 1,500 ft aal cloud base the airfield could have ceased VFR operations, albeit temporarily, until the weather improved. Additionally had the pilot known of the 1,500 ft cloud base weather limit he might have decided either to hold until the weather improved or divert to Antigua.

An anemometer placed closer to the Runway 28 threshold would have enabled the ATCO to provide the pilot with a more representative indication of the wind there as recommended in Safety Recommendation 2011-077.

There is only one windsock located close to the Runway 10 threshold. Had there been one close to the Runway 28 threshold the pilot may have had a visual indication of any tailwind present.

Training

The pilot had not been flight checked to operate from or to Runway 28. Had he been he would have been familiar with the approach over the hill at 'Lookout', and the associated local conditions on the approach to Runway 28 and may have been more adept at making an approach to Runway 28. Had there been a requirement for pilots to use only runways on which they had been flight checked he might have held off until Runway 10 was suitable, or diverted to Antigua.

Aircraft handling

The chief pilot commented that he instructed pilots to monitor the GPS ground speed readout, on short finals, to get an indication of tailwinds. Had the pilot made use of the GPS's ground speed readout he might have gained an appreciation of any tailwind component.

The pilot stated that he "felt" a tailwind during both approaches. If there was a tailwind it would have increased the aircraft's ground speed, which would have required an increased rate of descent to maintain an appropriate approach path. If not monitored closely, and without timely reduction in the aircraft's power to maintain the appropriate approach speed, this would have further increased the aircraft's ground speed and landing roll. The pilot had sufficient fuel to delay further approaches until the weather and wind were more suitable to make an approach on Runway 10, or to divert to Antigua.

The operator and its pilot were not aware of the WAT limit at the time of the incident. The operator has since produced a reference chart to ensure they comply with it.

The AAIB calculated that the aircraft landed 144 lb above the MLW of 6,300 lb and 169 lb above the WAT limit for the conditions at the time. However, the calculated effect of being above MLW and above the WAT limit was a minimal increase on the ground roll of about 3 m. Although it appears to have touched down at an appropriate distance from the threshold, at the operator's suggested touchdown point, the witnesses stated that it was "fast" when it did so. While the aircraft's actual airspeed could not be determined it is likely that, due to a tailwind and possible excessive approach speed, the aircraft's ground speed would have been fast, leading to an increased landing roll. The landing roll would also have been increased by the aircraft's excessive weight.

The pilot stated he was not aware of the conditions for a stabilised approach. Awareness of the requirement to fly a stabilised approach and the associated conditions might have informed a decision to go-around, as he did after his first approach. With the cloud base likely to have been below 1,500 ft the pilot would not have had the opportunity to establish the aircraft on an appropriate approach angle from a suitable distance. He would have had to intercept it, having flown below the low cloud base, at a shorter distance from the runway. This would have complicated the task of establishing a stabilised approach in the prevailing conditions.

Runway over-run areas

VP-MON came to rest 46 m from the end of the paved surface of Runway 28, beyond which is a steep drop, and 11 m from the edge of the steep drop on the northern side of the runway. When landing on Runway 10 the options for preventing a runway over-run are to veer to the left into a steep embankment or to the right into a ditch followed by a steep embankment. Although the runway environment is compliant with the minimum specifications in ICAO Annex 14, there are significant hazards associated with an aircraft departing the ends or the sides of the runway. In light of the incidents to VP-MON and VP-MNI the airport operator should carry out a risk assessment of the hazards associated with runway excursions as part of its Safety Management System. Accordingly, the following Safety Recommendation is made:

Safety Recommendation 2012-010

It is recommended that the operator of John A Osborne Airport, Montserrat, carry out a risk assessment of the hazards associated with runway excursions and implement any necessary mitigating action.

Obstacles and APAPIs

A survey carried out in 2009 revealed a palm tree obstacle which infringed the 'Approach surface', as defined in ICAO Annex 14, and a total of eight obstacles, consisting of trees and bushes, which infringed the 'Takeoff climb surface'. The airport operator had not taken any action either to remove these obstacles or have them listed in the ECAIP. Therefore, the following Safety Recommendation is made:

Safety Recommendation 2012-011

It is recommended that the operator of John A Osborne Airport, Montserrat, remove the obstacles that infringe the ICAO Annex 14 'Aerodrome Design and Operations' takeoff and approach surfaces.

Even after removing these obstacles to gain compliance with Annex 14, the houses on 'Lookout' hill will remain; one of these houses will be cleared by about 40 feet if a pilot flies the 3° APAPI approach path to Runway 28. The flight inspection company reported that the APAPI angle of 3° resulted in an approach that was too close to houses, and was '*quite dangerous*' when also taking into account the known wind shear issues. No action was taken by the airport operator in response to their report. Pilots often fly a steeper approach than 3° towards Runway 28 because of the houses and wind shear, but in these cases the APAPI provides limited visual guidance because above an approach path of 3.25° the pilot will only see two white lights.

If the APAPI angle had been set higher it might have assisted the pilot of VP-MON in judging his approach towards an unfamiliar runway without worrying about flying too close to the houses. However, any effect on landing distances must also be taken into account when evaluating an increase in APAPI angle. Consideration should also be given to relocating the APAPIs closer to the Runway 28 threshold to reduce any increase in landing distance. Therefore, the following Safety Recommendation is made:

Safety Recommendation 2012-012

It is recommended that the operator of John A Osborne Airport, Montserrat, review the Runway 28 APAPI position and angle setting to improve obstacle clearance on the approach.

The airport operator has changed the APAPI angle for both runways to 3.5°. The installation was found satisfactory by a commercial flight inspection organisation and a further review of the APAPI positioning is planned.

Conclusion

No faults were found with the aircraft's braking system and there was no evidence that the aircraft had hydroplaned. An accurate runway friction assessment could not be obtained, but there were no pilot reports of poor friction prior to or after the incident. A tailwind and/or high touchdown airspeed would have increased the landing distance required by the aircraft. Issues identified by the investigation were pilot training, wind measurements, the aerodrome's weather limits, the APAPI approach angle, obstructions on the approach and the runway environment.

ACCIDENT

Aircraft Type and Registration:	MD Helicopters MD900 Explorer, G-CEMS
No & Type of Engines:	2 Pratt & Whitney Canada PW207E turboshaft engines
Year of Manufacture:	2001
Date & Time (UTC):	29 July 2011 at 0801 hrs
Location:	Leeds Bradford Airport
Type of Flight:	Aerial Work
Persons on Board:	Crew - 4 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Landing gear forward cross tube fractured, area of fuselage delamination
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	37 years
Commander's Flying Experience:	2,235 hours (of which 1,007 were on type) Last 90 days - 43 hours Last 28 days - 14 hours
Information Source:	AAIB Field Investigation

Synopsis

Approximately one minute after landing, and whilst stationary on the ground, the forward cross tube of the helicopter's skid landing gear fractured, damaging the helicopter but not causing any injuries to the crew onboard. The forward cross tube had failed due to a fatigue crack beneath the right side stop clamp. It was determined that although the clamp had not been removed from the cross tube during scheduled maintenance, as required by the Rotorcraft Maintenance Manual, the maintenance instructions were ambiguous regarding the requirement to inspect the area of the forward cross tube beneath the side stop clamps. Two Safety Recommendations have been made.

History of the flight

Prior to departure for an air ambulance flight, ATC cleared the commander to hover taxi the helicopter from its parking position to Hold Y and await further clearance. After an uneventful takeoff and hover taxi the helicopter landed at Hold Y. However, after being stationary for approximately one minute with the engines set at FLIGHT IDLE, a loud "bang" was heard and the helicopter pitched nose down and to the right. The commander shut down both engines and the crew vacated the helicopter without further incident. Once outside, the commander observed that the forward landing gear cross tube had broken close to the right saddle clamp bracket, and the fuselage was in contact with the broken cross tube.

Description of the MD900 landing gear

The MD900 helicopter is equipped with a tubular aluminium alloy landing gear, comprising left and right skid tubes that are supported by fore and aft cross tubes (Figure 1). The cross tubes provide elastic deformation during normal landings and are attached to fuselage fittings by means of four saddle clamp assemblies. The fore and aft cross tubes are restrained from moving laterally by four side stop clamp assemblies (Figure 2), that are attached immediately inboard of each saddle clamp. The internal face of the side stop clamps makes a metal-to-metal contact with the mating cross tube, allowing electrical current to flow in the event of a lightning strike. An electrical bonding strap is secured between the side-stop clamp and the saddle clamp assembly to provide electrical continuity.

The forward cross tube is constructed from drawn 7075 T6 aluminium alloy tubing, with a nominal outer diameter of 2.4” and a nominal wall thickness of 0.350”. After forming and chemical milling operations, the cross tube’s inner and outer surfaces are chemically film-treated to MIL-DTL-5541. The production drawing for the forward cross tube requires that both the inside and outside surfaces of the tube are painted with an epoxy primer, prior to exterior paint finish application. The areas of cross tube beneath the side stop clamps had not been not primed or painted, due to the requirement for electrical bonding to the side stop clamps.

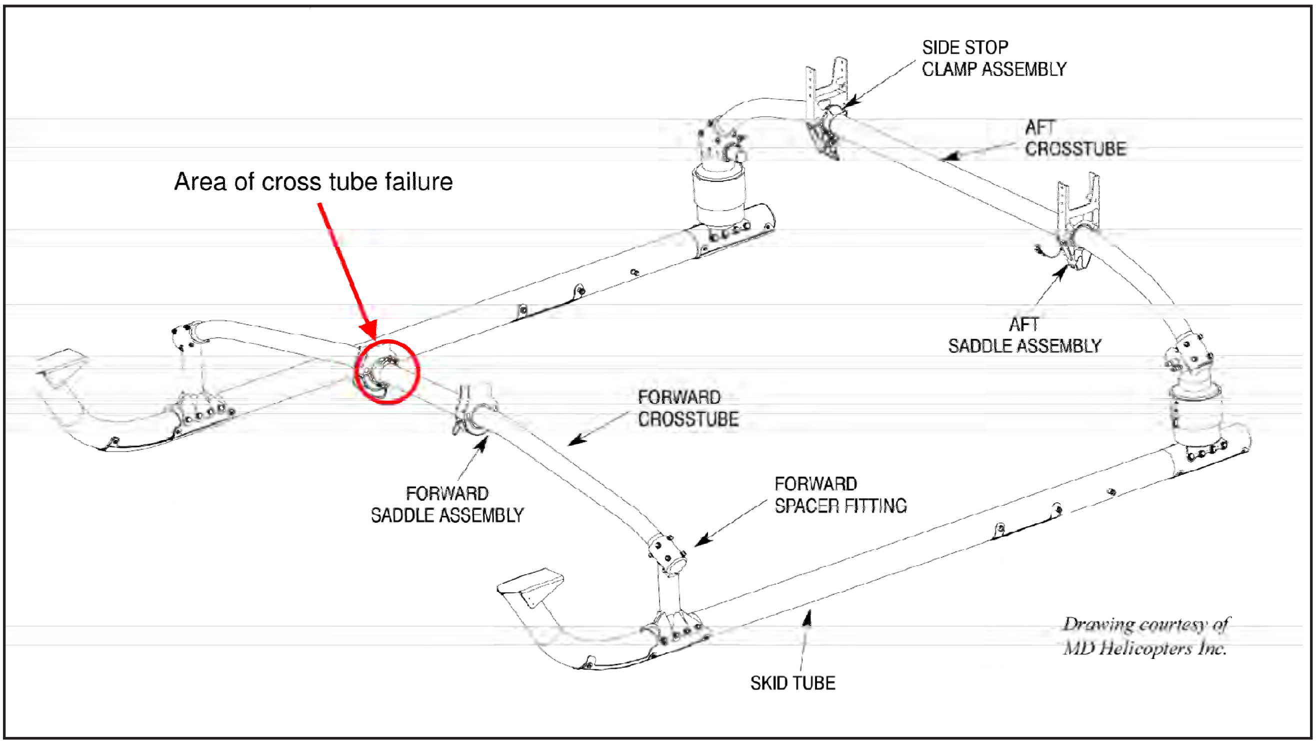


Figure 1

MD900 landing gear showing location of the forward cross tube failure

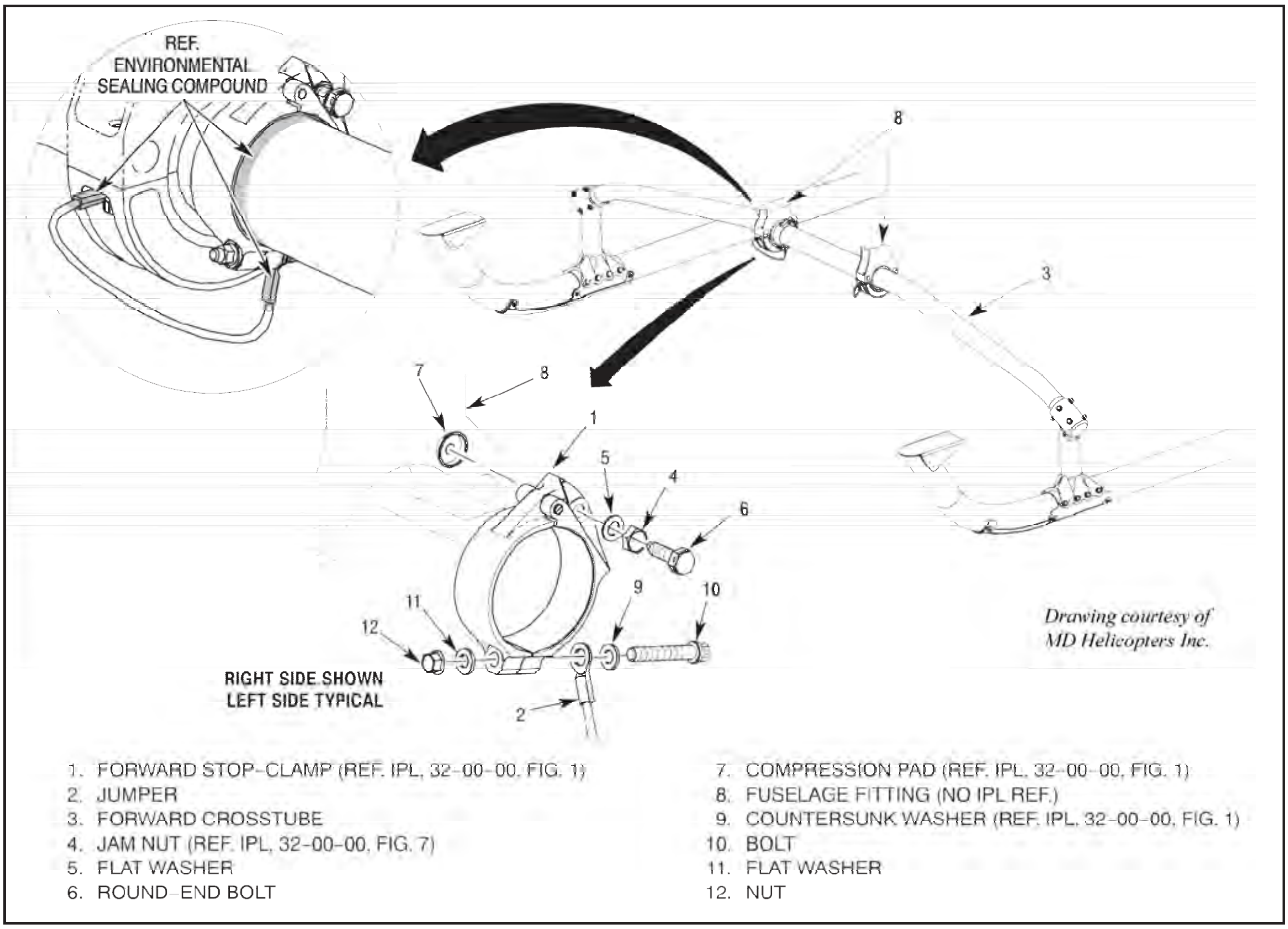


Figure 2

Forward side stop clamp detail

Aircraft damage

The forward cross tube had completely fractured immediately inboard of the right forward saddle assembly and the fracture originated at the lower surface of the cross tube, underneath the side stop clamp. The resulting contact between the helicopter's fuselage and the broken forward cross tube resulted in delamination of the fuselage skin and right keel beam, both of which are constructed from composite materials.

Detailed examination

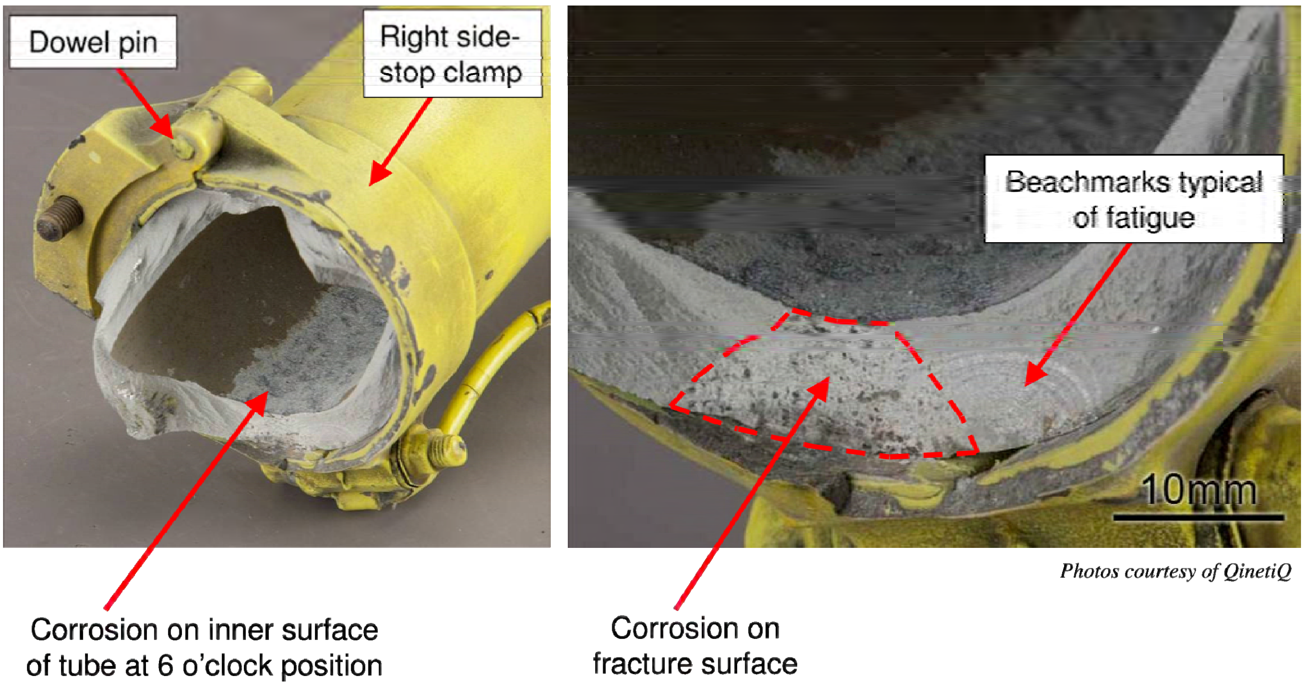
The forward cross tube, complete with the left and right side-stop clamp assemblies still attached, was sent to the AAIB for detailed examination. The inboard side of the fracture surface (Figure 3) exhibited a clear area of fatigue crack propagation, originating at the bottom of the cross tube, approximately 3 mm into the area covered by the side stop clamp. The circumferential length of the fatigue crack at the surface of the tube was 17 mm and the area of fracture surface away from the fatigue region had a dull grey appearance, indicative of tensile overload. The inside surface of the cross tube had not been painted with epoxy primer and was not in conformance with the

MD Helicopters production standard. The cross tube's inside lower surface was significantly corroded and the width of the corroded area decreased towards the outer ends of the cross tube, indicating that an accumulation of moisture had occurred inside the tube around a central low point. Some of the accumulated moisture had penetrated the fatigue fracture, causing a tapered area of corrosion on the fracture surface.

Both the forward cross tube side stop clamps had intact paint covering the environmental sealant around the circumferential joints between the clamp edge and the cross tube. Following removal of both clamps, the paint covering the sealant was examined in detail, revealing a lower layer of yellow paint, covered by an upper layer of lime green paint matching the helicopter's current paint scheme. The lower yellow paint finish was applied when the helicopter was manufactured in July 2001 and the intact paint layers demonstrate that the sealant on the side stop clamps had not been renewed since this date.

Removal of the clamps revealed significant surface corrosion on both the exposed area of the cross tube and on the mating clamp surfaces (Figure 4).

The fatigue crack origin was examined using both visual and scanning electron microscopy (SEM) which showed that, despite the presence of local corrosion pits, the fatigue crack had actually initiated from a shallow, curved machining mark in the tube's outer surface (Figure 5). The SEM analysis showed that the crack had initially propagated in fatigue, with at least 16 separate visible 'beachmarks', before subsequently progressing through a series of five 'static jumps' (Figure 6). A static jump is a ductile overload phenomenon in which a high load event causes a fatigue crack to propagate by localised tensile overload, before reverting back to progressive fatigue propagation under lower cyclical loading conditions. Analysis of the fracture surface away from the fatigue region revealed three 'arrest' marks within the overload failure surface.



Photos courtesy of QinetiQ

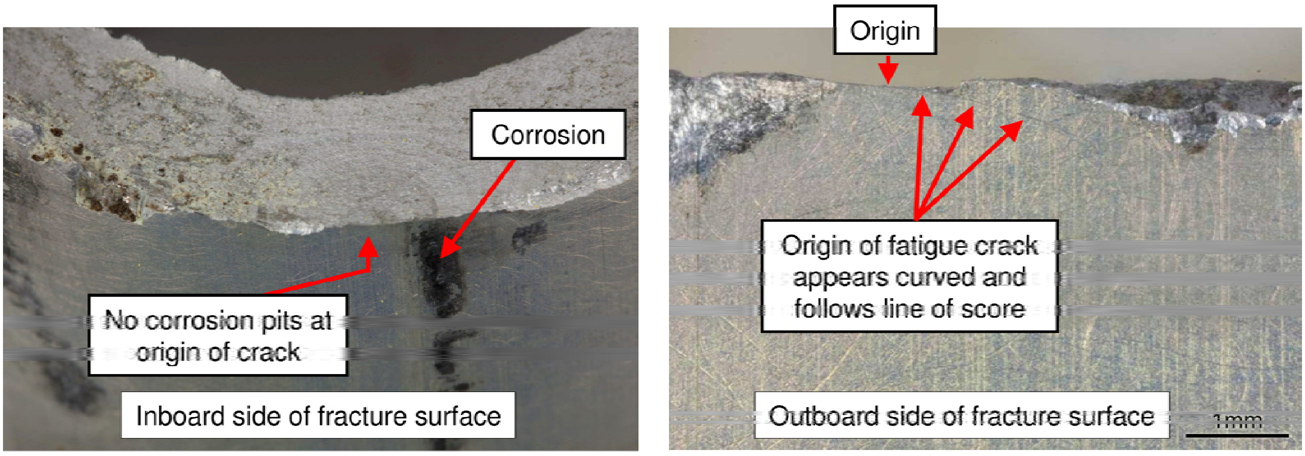
Figure 3

Visual examination of the inboard side of the fracture surface

Photos courtesy of QinetiQ

Figure 4

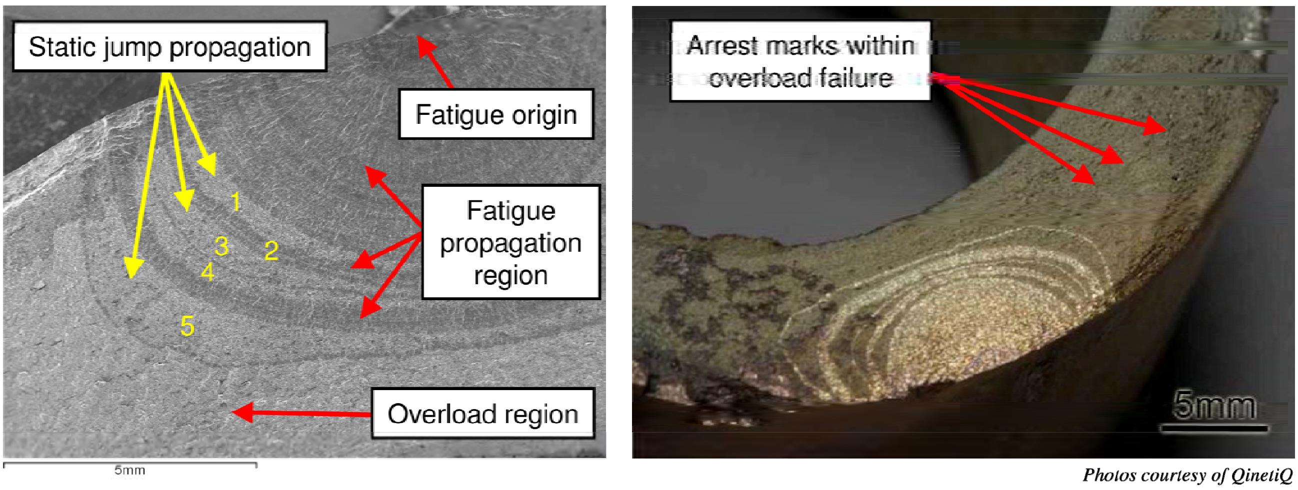
Surface corrosion beneath right side stop clamp



Photos courtesy of QinetiQ

Figure 5

Visual examination of the fatigue crack origin



Photos courtesy of QinetiQ

Figure 6

Propagation of the primary fatigue crack away from the crack origin

A significant number of secondary fatigue cracks were visible adjacent to the primary fatigue crack, with many of these originating from curved surface machining marks (Figure 7).

A 20 mm long section of the cross tube, immediately inboard of the primary fracture surface, was removed and polished to facilitate examination of the material's microstructure. A total of 64 secondary surface cracks were visible in this section, ranging in depth between 16 µm and 290 µm. The section's material characteristics were assessed by hardness testing and energy dispersive X-ray analysis and were determined to be within the 7075 T6 specification for hardness, chemical composition and electrical conductivity. The section exhibited extensive corrosion on the internal surface of the cross tube and in some areas this corrosion was intergranular, which is characteristic of exfoliation.

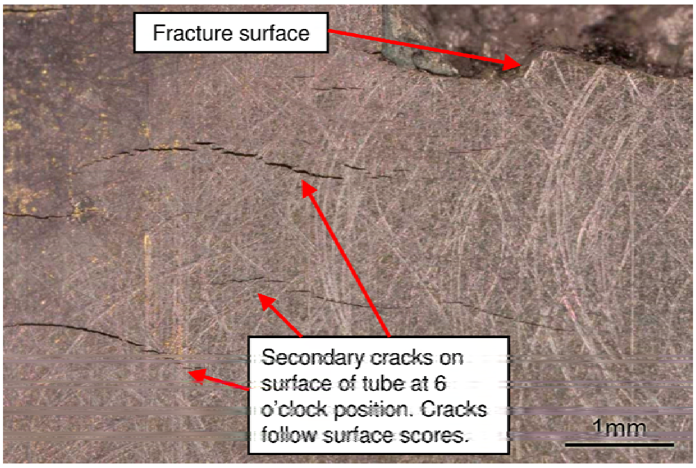


Photo courtesy of QinetiQ

Figure 7

Secondary cracking of the cross tube

Maintenance history

The helicopter was built in July 2001 and exported to Indonesia in November 2001, where it was used as a crew transport helicopter in the offshore oil industry. In November 2003, having accumulated 2,294 hours and 9,129 landings, it entered a prolonged period of hangar storage before being exported to the UK in March 2007, for reconfiguration as an air ambulance. The helicopter was repainted in July 2007 into its current colour scheme and had accumulated 3,308 hours and 12,397 landings at the time the accident occurred. The landing gear assembly installed on the helicopter was the original unit fitted during manufacture.

The helicopter manufacturer's records showed one prior occurrence of a crosstube fracturing and this fracture had occurred about 3 inches outboard of the saddle clamp. The failure mode was fatigue, followed by overload, with mechanical damage at the fatigue origin. The manufacturer had not received any reports of cracking of the crosstube or reports concerning the dowel pin hole on the side stop clamp.

Maintenance requirements

Content of the Rotorcraft Maintenance Manual

Chapter 05-20-20 of the Rotorcraft Maintenance Manual (RMM) contains tabulated worksheets summarising the inspections required for completion at the annually recurring Airframe Periodic Inspection Program (APIP). The requirement to comply with RMM instructions during scheduled inspections is stated in Section 2 of this chapter:

> *'This section contains requirements for scheduled inspection. Compliance with the Rotorcraft Maintenance Manual (RMM) information is required, and the manual consulted when using the inspection schedules for specific maintenance activity or inspection requirements and procedure.'*

The worksheet relating to the APIP landing gear inspections is provided in Table 208 in Chapter 05-20-20, and includes the following two tasks that are relevant to detection of a crack in the forward cross tube:

> *'Examine forward and aft cross tubes, fuselage attach fittings, and saddle clamps for damage, indication of failure and condition'*

> *'Examine side stops for damage and condition'*

Both of these tasks further refer to Chapter 32-00-00 of the RMM for additional detailed instructions.

Inspection of the forward side stop clamp assemblies

Section 3A of Chapter 32-00-00 describes the procedure to be carried out to inspect the forward side stop clamp assemblies. In addition to an external visual inspection, to identify damage and missing hardware, tasks 6 and 7 of the procedure require removal of the side stop clamps from the forward cross tube to facilitate examination of a dowel pin hole. The side stop clamps are an assembly of two components joined at a hinge by means of a dowel pin:

> *'(6). Remove side-stop clamps (ref. Section 32-00-00, Removal/Installation). (7). Examine dowel pin hole for damage, deformation and corrosion.'*

The procedure does not contain an instruction to inspect the area of the forward cross tube revealed once the side stop clamps are removed, and whilst step 6 of the procedure requires removal of the side stop clamps, for access, there is no positive instruction given regarding their re-installation. Re-installation of the side stop clamps is covered in Section 1B of Chapter 32-00-00 and requires, amongst other tasks:

> *'(2)(f). Environmentally seal jumper connection and perimeter of forward stop-clamp with sealing compound (C211) (ref. CSP-SPM, Section 20-50-00)'*

Inspection of the forward cross tube

Section 4B of Chapter 32-00-00 contains the inspection procedure to be followed for the forward cross tube, which includes the following task:

> *'(1). Examine the forward cross tube for cracks, dents, gouges, and corrosion. (a) No cracks, dents, gouges or corrosion permitted.'*

Whilst this task requires that the forward cross tube is inspected, it does not explicitly state that the area beneath the side stop clamps is made accessible for inspection, at this stage, by removal of the clamps.

Section 4B also contains instructions on measurement of the distance between the ends of the forward and aft cross tubes, whilst the helicopter is raised on jacks, to determine whether permanent deformation of the cross tubes has occurred during a heavy landing. Maximum allowable values of this 'cross tube spread' are provided to allow a comparison to be made.

Content of the customised Maintenance Program

Following import to the UK, the helicopter was maintained to a customised maintenance program that was closely based on the manufacturer's APIP program, together with certain additional Special Inspection Schedules relating to additional hourly and calendar-based inspection requirements. The customised program was approved under the maintenance organisation's EASA Part 145 approval and contained worksheets listing maintenance *'Actions Required'* for individual components. The worksheet task relating to the forward and aft cross tubes was:

> *'ITEM 0115: LANDING GEAR – Forward and Aft Crosstubes; Fuselage attachment fittings and saddle clamps. Inspect for apparent defects, evidence of failure and general condition.'*

The worksheet task relating to the side stop clamps was:

> *'ITEM 0117: LANDING GEAR – Side Stop Assemblies and attaching hardware; Adjustment bolts; Stop Pads; Bonding jumpers. Inspect for apparent defects and general condition. Visually inspect for general condition and security. Inspect for general condition and proper mechanical connection.'*

Both the above worksheet tasks listed Chapter 32-00-00 of the RMM as the *'Publication Reference'*, but neither made specific mention of the RMM requirement to remove the side stop clamps during maintenance.

Maintenance actions

The helicopter's most recent annual maintenance inspection occurred in April 2011 and the work was certified by an EASA Part 66 B1 licensed engineer. The maintenance workpack records were examined and they showed that all tasks on the worksheets relating to the landing gear were initialled and stamped to indicate completion by the certifying engineer. The landing gear 'cross tube spread' measurements for both forward and aft cross tubes were certified as being within RMM limits; the actual spread measurements were not recorded and there was no requirement in the RMM to do so.

Discussion

Nature of the failure of the forward cross tube

The large number of additional fatigue cracks identified in the vicinity of the main fatigue crack indicates that there had been either a reduction of the fatigue strength of the cross tube material, or higher than expected tensile stress levels in this area of the cross tube, or a combination of these effects. The fatigue strength of 7075 T6 aluminium alloy has been shown to be sensitive to exposure to saline environments[1], and the helicopter had operated in the offshore environment for two years between 2001 and 2003, during which the sealant between the cross tube and side stop clamp components had not been renewed as required by the RMM. The presence of corrosion on the unpainted cross tube surface, beneath the side stop clamps, demonstrates that the sealant between the components was insufficient to protect them from moisture ingress.

The investigation could not accurately determine the age of the main fatigue crack due to the difficulty of correlating the fatigue beachmarks with landing cycles, loading applied to the cross tube during any one landing event being variable. Whilst it is considered probable that the main fatigue crack had been present in the cross tube for a considerable period of time, it is uncertain whether a visual examination of the tube surface would have been sufficient to detect the crack before it reached a critical length, prior to the overload failure of the tube. The following Safety Recommendation is therefore made:

Footnote

[1] B. Sarker, M. Marek and E.A. Stacke, Journal of Metallurgical and Materials Transactions A, p. 1939, Vol 12A, 1981.

Safety Recommendation 2012-004

It is recommended that the Federal Aviation Administration require MD Helicopters to determine a suitable inspection method and interval for periodic detailed examination of the landing gear cross tubes on the MD900 helicopter.

Removal of the side stop clamps during inspections

Had the side stop clamps been removed during the previous annual maintenance inspection, it is likely that the presence of surface corrosion on the cross tube would have been readily apparent, triggering remedial action as required by the *'Corrosion Removal'* section of the helicopter's Standard Practices Manual. It is also possible that the fatigue crack in the cross tube may have been detected by visual inspection of the cross tube at this time, as the inspection occurred only 169 landings before the eventual overload failure of the cross tube.

The intact paint on the environmental sealant between the side stop clamps and the forward cross tube indicates that the clamps had not been removed since the helicopter was built, approximately ten years prior to the accident. Therefore the failure to remove the side stop clamps was not an isolated incident.

Whilst the lack of a specific prompt to remove the side stop clamps on Item 0117 of the customised maintenance program worksheet is considered to be a contributory factor, the worksheet correctly referenced the definitive task instructions in Chapter 32-00-00 of the RMM, which required removal of the side stop clamps.

Ambiguity in the RMM maintenance instructions

The RMM is ambiguous with regard to inspection of the area of the forward cross tube beneath the side stop clamps. Section 3A of Chapter 32-00-00 required the clamps to be removed to allow examination of each clamp's dowel pin hole, but no requirement is stated for inspection of the inside surface of the clamp or the mating surface of the cross tube, or for the clamp's reinstallation. Section 4B of Chapter 32-00-00 required that the cross tube was inspected for *'cracks, dents, gouges and corrosion'* but the maintenance instructions did not explicitly state that the side stop clamps had to removed during this part of the inspection. The following Safety Recommendation is therefore made:

Safety Recommendation 2012-005

It is recommended that the Federal Aviation Administration require that MD Helicopters amend the MD900 Rotorcraft Maintenance Manual to require visual examination of the area of forward and aft cross tube, exposed when the forward and aft side stop clamps are removed, as part of the periodic maintenance schedule.

Safety actions

In addition to the above Safety Recommendations, the manufacturer is investigating the omission of epoxy primer on the inside of the forward cross tube, to determine whether the non-conformance was an isolated occurrence.

ACCIDENT

Aircraft Type and Registration:	Avions Pierre Robin R2100A, G-BGBA
No & Type of Engines:	1 Lycoming O-235-H2C piston engine
Year of Manufacture:	1978
Date & Time (UTC):	3 February 2012 at 1350 hrs
Location:	Gloucestershire Airport
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nose undercarriage pivot arm bent
Commander's Licence:	Private Pilot's Licence
Commander's Age:	64 years
Commander's Flying Experience:	110 hours (of which 96 were on type) Last 90 days - 4 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot and occurrence report submitted by ATC

Synopsis

The aircraft's approach was higher and faster than normal. It bounced a number of times and landed on its nose undercarriage, causing the undercarriage pivot arm to bend.

History of the flight

Following a local flight, the aircraft joined the right-hand circuit for Runway 27. When the aircraft was downwind, the pilot was instructed by ATC to fly an orbit to ensure separation from an aircraft flying an instrument approach. After the orbit, and as the aircraft reached a position from which to commence an approach, it was evident to the pilot that the aircraft was now too high, so she requested and flew a further orbit.

The aircraft established on finals but it was still high and fast, so the pilot attempted to lose excess height by weaving. A flying instructor from the pilot's flying club observed the approach and landing. He reported a steep and fast approach followed by a flat flare and the aircraft nodding or porpoising before touching down slightly nose-low, followed by a series of bounces. The pilot attributed the accident to a loss of concentration and an incorrect flare.

The flying instructor reported that, although the surface wind was a very light westerly, the wind above about 400 ft was south-easterly at 7 to 10 kt, thus giving a tailwind on approach which would make it difficult to correct an approach that was too high. He also observed that a go-around would have been the best course of action.

Comment

The accident probably occurred because the unstable approach was allowed to continue. CAA Safety Sense Leaflet 01: '*Good Airmanship Guide*', Section 30 'Landing' gives the following advice:

> *'A good landing is the result of a good approach. If your approach is bad, make an early decision and go-around…'*

ACCIDENT

Aircraft Type and Registration:	Breezer B600, G-OLSA
No & Type of Engines:	1 Rotax 912ULS piston engine
Year of Manufacture:	2010
Date & Time (UTC):	25 June 2011 at 1600 hrs
Location:	Membury Airfield, Berkshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to nose landing gear, left main landing gear, one propeller blade, engine mount, firewall and wings
Commander's Licence:	Private Pilot's Licence
Commander's Age:	36 years
Commander's Flying Experience:	2,225 hours (of which 31 were on type) Last 90 days - 58 hours Last 28 days - 11 hours
Information Source:	AAIB Field Investigation

Synopsis

Shortly after takeoff the engine stopped due to a loss of fuel pressure and the pilot made a forced landing which resulted in a heavy touchdown. The engine stoppage was probably caused by a fuel restriction when a placard blocked the fuel tank outlet. The fuel tank outlet was not fitted with a strainer or filter as none was required by the regulations for a 'Light Sport Aeroplane' (LSA). The aircraft manufacturer has taken safety action to install a fuel strainer at the fuel tank outlet of all new aircraft and is offering the same modification for retrofit. Two Safety Recommendations are made.

History of the flight

The pilot had completed some general handling and two circuits at the airfield with no problems. Shortly after the third takeoff from Runway 31 the FUEL LOW PRESSURE alarm sounded with a visual alert on the instrument screens. The pilot checked the fuel pressure gauge and saw it briefly indicate in the normal/green section while the aircraft continued to climb. There was no engine rough running or noticeable loss of power, but the alarm continued to sound. The pilot reported that, a couple of seconds later and as the aircraft approached the end of the runway, the engine "died briefly", caught again and then stopped completely. Due to the aircraft's high nose attitude the airspeed reduced rapidly. The pilot lowered the nose as far as he thought safe to regain some airspeed, and then raised the nose to arrest the aircraft's descent rate just prior to touchdown. The aircraft had some sideways drift at touchdown due to a crosswind and this caused the nose landing gear and left main landing gear to fail. As the aircraft hit the long grass at the side of the runway the wings also sustained some damage. Once the aircraft came to rest, the pilot turned off the electrics and fuel and vacated the aircraft with the passenger.

Description of the aircraft

The Breezer B600 is a factory-built 'Light Sport Aeroplane' (LSA) and is operated under a European Aviation Safety Agency (EASA) Permit to Fly (Figure 1). The 'LSA' is a new category of aircraft that originated in the USA. To qualify as an LSA the aircraft must have a maximum takeoff weight of 600 kg or less, no more than two seats and a stall speed of less than 45 kt. LSAs are designed to an ASTM[1] code F2245 '*Standard Specification for Design and Performance of a Light Sport Airplane*'. EASA have issued some aircraft with a Permit to Fly on the basis that they comply with this voluntary code. EASA have also developed CS-LSA which is a new Certification Specification for LSA that references F2245, but with some differences, and this will be used in the future to provide some LSA aircraft with an EASA Certificate of Airworthiness.

The aircraft is powered by a Rotax 912ULS engine which is supplied fuel from a single tank located between the engine firewall and the instrument panel. Fuel exits through a hole at the base of the tank and then passes through an electric fuel pump, a fuel filter and an engine-driven fuel pump. There is no fuel strainer fitted at the outlet of the fuel tank.

Figure 1

Accident aircraft G-OLSA
(photograph courtesy Brian G Nichols)

Footnote

[1] ASTM International, formerly known as the American Society for Testing and Materials (ASTM), develops international voluntary consensus standards. About 12,000 ASTM standards are used around the world.

Aircraft examination

The aircraft was examined by a maintenance engineer who focussed his initial investigation on the fuel system due to the low fuel pressure warning that had been received. There was sufficient fuel remaining in the fuel tank so he removed the in-line fuel filter inside the engine compartment and this was found to be clear. He then disconnected the fuel pipe at the engine-driven pump and turned on the electric fuel boost pump and this resulted in fuel flowing. He then examined the fuel tank more closely and noticed that there were remains of a placard lying at the base of the tank near the outlet hole and partially covering the drain hole (Figure 2).

The placard was identified by the aircraft manufacturer as being part of the fuel quantity sender. Before the fuel sender is installed in the fuel tank a safety pin needs to be removed and this placard warns the installer to remove the safety pin. The placard should also have been removed prior to installation. In the case of G-OLSA the placard had not been removed and the fuel would have acted as a solvent on the placard adhesive until it eventually detached and sank into the base of the tank. Although the placard was not blocking the outlet hole at the time of examination, the action of sucking fuel from the outlet hole could have drawn the placard towards it when it detached from the fuel sender.

Fuel strainer requirements

The requirement for fuel straining or filtering in ASTM F2245-11[2] is as follows:

> *'7.3.7 A fuel strainer or filter accessible for cleaning and replacement must be included in the system.'*

The Breezer B600 satisfied this requirement with the installation of a fuel filter in the engine compartment.

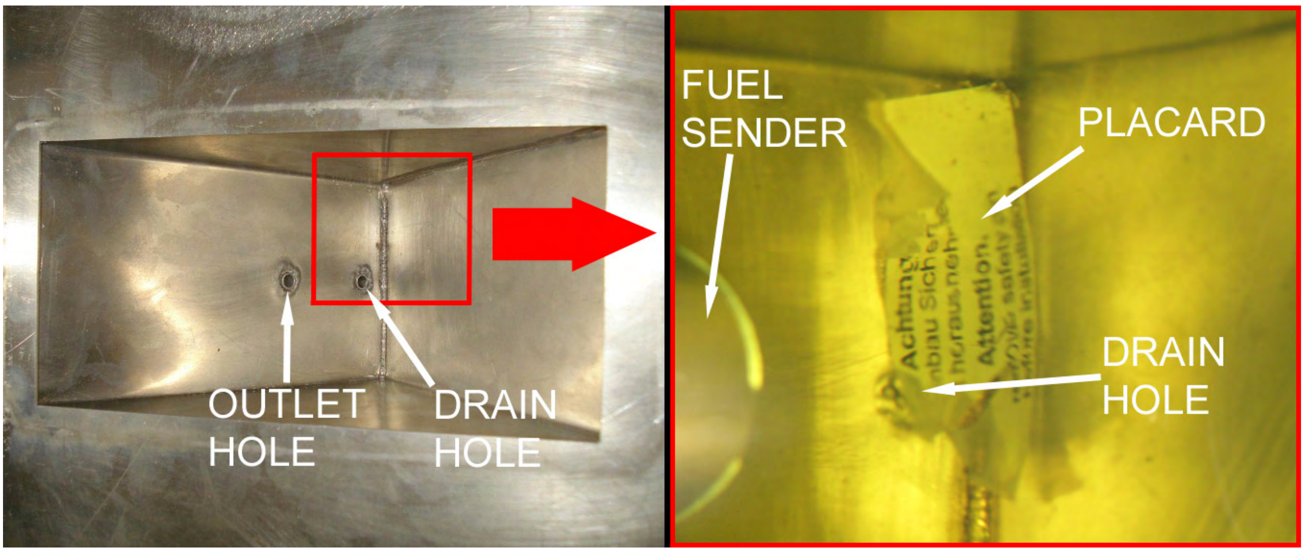


Figure 2

Base of fuel tank (left) showing outlet and drain holes; placard partially blocking drain hole in G-OLSA (right) – outlet hole not visible due to location of fuel quantity sender

Footnote

[2] F2245-11 is the latest 2011 version of the code. The aircraft was designed to F2245-08, but this section had not changed.

There was no requirement for a filter or strainer to be installed at the fuel tank outlet. CS-LSA contains no additional requirements for fuel straining/filtering beyond the ASTM F2245 requirement.

A requirement for a strainer at the fuel tank outlet exists for Very Light Aeroplanes (VLA[3]) as specified in CS-VLA 977 as follows:

> *'CS-VLA 977 Fuel strainer or filter*
>
> *(b) There must be a strainer at the outlet of each fuel tank. This strainer must –*
>
> *(1) Have 3 to 6 meshes per cm;*
>
> *(2) Have a length of at least twice the diameter of the fuel tank outlet;*
>
> *(3) Have a diameter of at least that of the fuel tank outlet; and*
>
> *(4) Be accessible for inspection and cleaning.'*

A similar requirement for a fuel strainer exists for UK microlight aircraft that comply with British Civil Airworthiness Requirement (BCAR) Section S:

> *'S977 Fuel strainer or filter*
>
> *b) There must be a strainer at the outlet to each tank. This strainer must have at least 6 meshes per cm (15 meshes per inch), and must be of such proportions that blockage of the fuel supply by objects entering the tank will be extremely unlikely.'*

Footnote

[3] VLAs have a maximum takeoff weight of up to 750 kg which makes them slightly heavier than LSAs.

Safety action by the aircraft manufacturer

In response to this accident the aircraft manufacturer published a Safety Alert (SA11-001) on 8 July 2011 which required the following actions prior to the next flight:

> *'1. Close examination of the fuel tank for foreign bodies with the help of a torch and mirror*
>
> *2. Close examination of the fuel tank for foreign bodies during the pre-flight check.'*

The Safety Alert was applicable to the Breezer CR, CL and B600. The manufacturer has also designed a fuel strainer modification that is being incorporated in all newly-built aircraft and has published a Service Bulletin (SB11-002) for a strainer retrofit kit for existing aircraft. The manufacturer has also introduced further checks in the assembly process to ensure that the placard on the fuel sender is removed prior to installation.

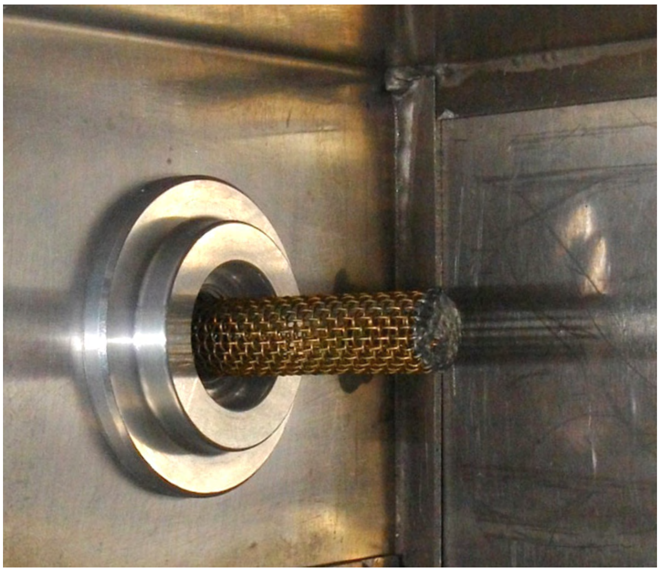


Figure 3

Strainer modification fitted to the fuel tank outlet (Breezer Service Bulletin SB11-002)

Analysis

The engine stoppage was probably caused by a fuel restriction when the placard from the fuel sender blocked the fuel tank outlet. The aircraft manufacturer was not able to establish why the placard had not been removed from the fuel sender prior to installation, but it has introduced further checks to ensure that the placard is removed in future. Although not required by CS-LSA or ASTM F2245, the manufacturer has taken safety action to install a fuel strainer at the fuel tank outlet of all new aircraft and is offering the same modification for retrofit.

UK microlight aircraft designed to BCAR Section S and EASA-certified Very Light Aircraft (VLAs) are required to have a fuel strainer fitted at the fuel tank outlet. Without a fuel strainer a foreign object in the tank, such as a piece of paper or a leaf, could completely restrict the fuel flow and result in engine stoppage. Therefore the following two Safety Recommendations are made.

Safety Recommendation 2012-020

It is recommended that the European Aviation Safety Agency (EASA) amend '*Certification Specifications for Light Sport Aeroplanes*' (CS-LSA) to require the installation of a strainer at the fuel tank outlet, to reduce the risk of foreign objects in the fuel tank restricting the fuel supply.

Safety Recommendation 2012-021

It is recommended that ASTM International amend the '*Standard Specification for Design and Performance of a Light Sport Airplane*' (ASTM F2245) to require the installation of a strainer at the fuel tank outlet, to reduce the risk of foreign objects in the fuel tank restricting the fuel supply.

ACCIDENT

Aircraft Type and Registration:	Corben Junior Ace Model E, G-BSDI
No & Type of Engines:	1 Continental Motors Corp A75-8F piston engine
Year of Manufacture:	1981
Date & Time (UTC):	25 February 2012 at 1200 hrs
Location:	White Ox Mead Airstrip, near Bath
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Main landing gear cross-member broken
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	64 years
Commander's Flying Experience:	320 hours (of which 60 were on type) Last 90 days - 12 hours Last 28 days - 6 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft suffered a significant reduction in engine power during takeoff, following which the pilot landed the aircraft in a field close to the departure runway, damaging the landing gear. The engine continued to run following the field landing and shortly afterwards it was able to produce full power again. Despite the application of carburettor heat prior to takeoff, it is probable that the power reduction was caused by carburettor icing.

History of the flight

After starting the engine, the pilot taxied the aircraft along the grass Runway 24 at the private airstrip, a distance of approximately 510 m, to the Runway 06 threshold. The pilot reported that the grass was damp following overnight rain and that he applied carburettor heat fully on two occasions during taxiing, observing a 100 rpm drop on each application. During his pre-takeoff checks at the Runway 06 threshold the pilot set the carburettor heat to HOT for 30 seconds, before re-selecting it to COLD for takeoff. The aircraft took off but, after climbing to 50 feet aal, the engine lost power although it continued to run at reduced rpm. The pilot closed the throttle and, having determined that the remaining runway length was insufficient, landed the aircraft in a stubble field adjacent to the right of the runway, damaging the main landing gear cross-member. Following the landing the engine continued to run roughly, although with sufficient power to allow the pilot to taxi the aircraft across the field and onto the airstrip. On reaching the airstrip the pilot felt the engine run smoothly again and, holding the aircraft with the wheel brakes, he applied full power for three minutes without further difficulty.

The pilot examined the carburettor and performed a fuel flow check following the accident, neither of which revealed any defects. He considered that the loss of power on takeoff was due to carburettor icing and that the application of carburettor heat for 30 seconds prior to takeoff was insufficient to remove any residual carburettor ice that had built up during taxiing to the Runway 06 threshold.

Meteorology

No weather observations were recorded at the airstrip. Bristol Airport, however, located 12.5 nm east-north-east of the airstrip, recorded a surface temperature of +9ºC and a surface dewpoint of +5ºC shortly before the accident, indicating that the risk of carburettor icing in the area was serious at any power setting (Figure 1).

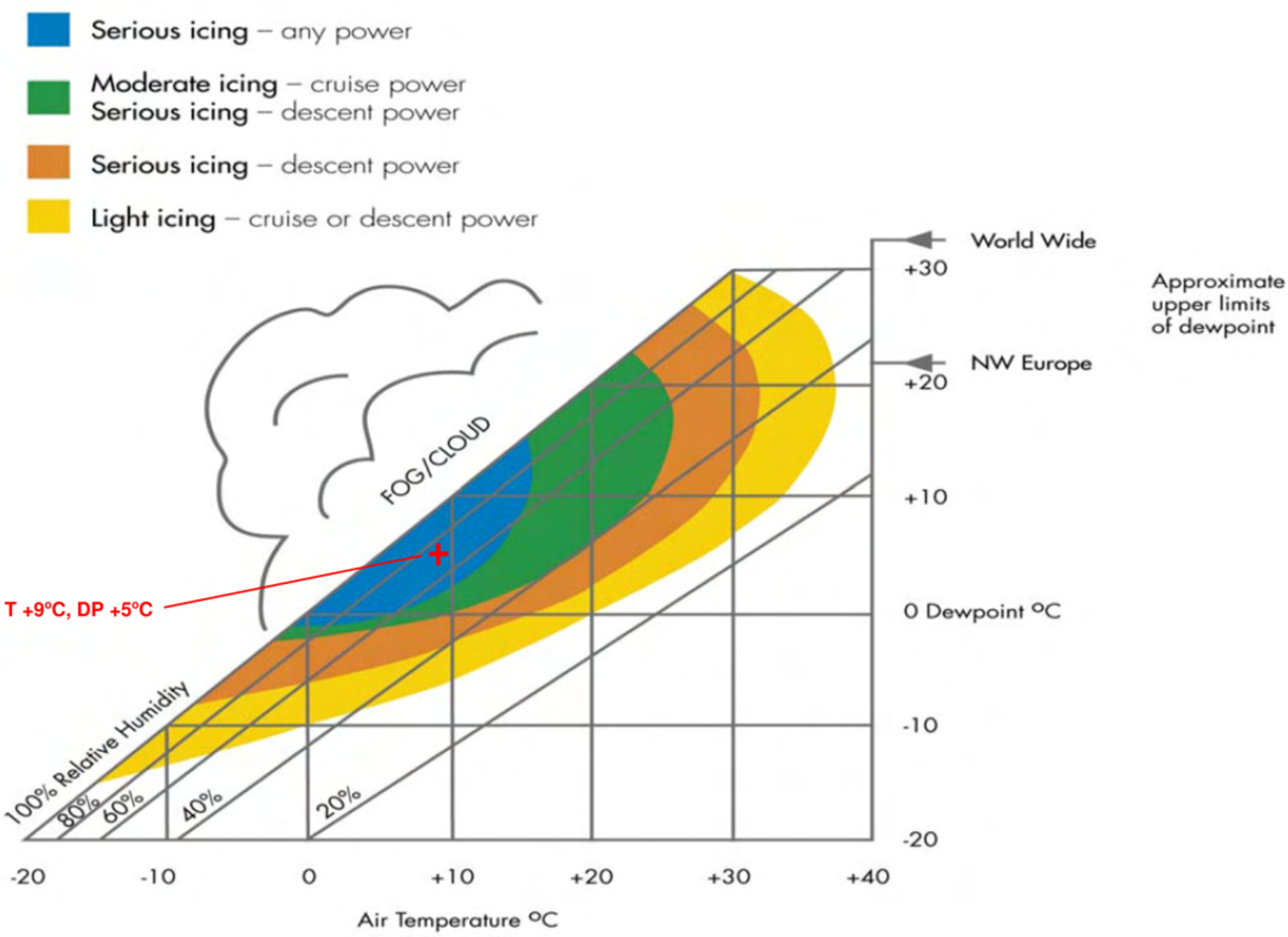


Figure 1

Carburettor icing chart

Piston engine icing

The CAA's Safety Sense Leaflet 14, *'Piston Engine Icing'* (available from www.caa.co.uk/safetysense) provides useful information to pilots on the hazards of piston engine icing. Section 7 'Pilot Procedures', subsection (e) states:

> *'Immediately Prior to Take-Off: Since icing can occur when taxiing at low power settings, or when the engine is idling, select carb hot air ON for a minimum of 15 seconds and then OFF, immediately before take-off at a high power setting to clear any build-up. If the aircraft is kept waiting at the holding point in conditions of high humidity, it may be necessary to carry out the run-up drill more than once to clear ice which may have formed.'*

Subsection 7(g) of the leaflet also contains the following advice on how to perform the carburettor heat check:

> *'If icing has caused a loss of power, and the hot air disperses it, re-selection of cold air should produce an increase in rpm or manifold pressure over the earlier reading. This is a useful check to see whether ice is forming, but does not prove that all the ice has melted! Carry out further checks until there is* ***no*** *resultant increase, monitor the engine instruments, and increase the frequency of the routine checks, as it may re-occur. Absence of carb icing should produce no increase in rpm or manifold pressure beyond that noted prior to the use of hot air.'*

Discussion

The reduction of engine power after takeoff was likely to have been caused by carburettor icing as the engine ran normally, at full power, shortly after the aircraft landed and no mechanical defects were subsequently discovered with either the carburettor or the aircraft's fuel system. Piston-engine aircraft operating on damp or wet grass surfaces are more susceptible to carburettor icing than those operating from paved surfaces, due to the high moisture content of the air in contact with the grass. It is likely that, during the long taxi manoeuvre to the Runway 06 threshold, ice formed in the carburettor that did not completely melt during the application of carburettor heat during the pre-takeoff checks. As the engine initially produced sufficient power for takeoff, it is likely that additional carburettor ice formed during the takeoff roll, adding to any residual ice remaining from taxiing. Atmospheric conditions at the time of the accident were conducive to severe carburettor icing at all power settings, including takeoff power.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28-161 Cherokee Warrior II, G-BOFZ
No & Type of Engines:	1 Lycoming O-320-D3G piston engine
Year of Manufacture:	1978
Date & Time (UTC):	4 February 2012 at 1150 hrs
Location:	Newcastle Airport
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - 3
Injuries:	Crew - None Passengers - None
Nature of Damage:	Fire damage to nose section
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	1,458 hours (of which 686 were on type) Last 90 days - 27 hours Last 28 days - 12 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot reported that, as the outside air temperature was 1°C and this was the first flight of the day, the engine required priming prior to start. This was accomplished by operating the primer five times. The starter was then operated on three occasions, after which the pilot recalled seeing smoke and decided to evacuate the aircraft. All occupants evacuated successfully and there were no injuries. The fire service attended and extinguished the fire.

The pilot considered that she may have over-primed the engine leading to ignition of the excess fuel in the exhaust.

BULLETIN CORRECTION

The original report incorrectly specified the commander's flying experience as being 1,458 hours (of which 1,243 were on type). The correct number of hours on type is 686.

This was corrected on the online version of this report on 22 May 2012.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28-161 Cherokee Warrior II, G-BRBB
No & Type of Engines:	1 Lycoming O-320-D3G piston engine
Year of Manufacture:	1981
Date & Time (UTC):	11 March 2012 at 1245 hrs
Location:	Caernarfon Airport, Gwynedd
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Leading edge of both wings and propeller
Commander's Licence:	Private Pilot's Licence
Commander's Age:	53 years
Commander's Flying Experience:	211 hours (of which 48 were on type) Last 90 days - 5 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft touched down beyond the normal landing point and the pilot inadvertently applied less than the required brake pressure to decelerate the aircraft in the remaining distance available. It overran the runway before being brought to a stop.

Description of the event

The aircraft was landing on Runway 26 at Caernarfon Airport following a flight from Gloucestershire Airport. Runway 26 was 938 m in length, with a Landing Distance Available after the displaced threshold of 759 m. The runway was dry with a surface wind from 330° at 10 kt. Airport elevation was 14 ft.

The pilot reported turning base leg at 1,150 ft and onto finals at 950 ft, achieving a normal approach speed. Full flaps were selected for landing, with an approach speed of 65 to 70 kt. The aircraft floated for an extended period in the flare. Just after touchdown, the pilot heard a wheel skid, so reduced his applied brake pressure before reapplying it firmly. He estimated that the aircraft was about halfway along the available landing distance at this stage. He realised that he would be unable to stop the aircraft in the remaining runway, but also that there was insufficient runway available to reject the landing safely.

The pilot continued to apply pressure to the brake pedals, but with limited effect, and the aircraft ran off the runway end at a running pace. With a raised embankment ahead, the pilot was able to steer the aircraft to the right. It passed through a wire and wooden post fence before coming to a stop at 90° to the runway centreline. The pilot carried out a normal shutdown procedure and then he and his passenger, who were uninjured, vacated the aircraft. The airport emergency services responded and were quickly on scene.

The pilot considered that he had placed his feet incorrectly on the rudder pedals, such that he could not apply full braking effort. He felt that this, and the extended float and a very narrow window of opportunity to reject the landing, were contributory to the accident.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28R-180 Cherokee Arrow, G-AWBA
No & Type of Engines:	1 Lycoming IO-360-B1E piston engine
Year of Manufacture:	1968 (Serial no: 28R-30528)
Date & Time (UTC):	2 January 2012 at 1420 hrs
Location:	Stapleford Airfield, Essex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Serious) Passengers - 1 (Minor)
Nature of Damage:	Starboard wing detached, landing gear damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	66 years
Commander's Flying Experience:	202 hours (of which 50 were on type) Last 90 days - 2 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft became very low on final approach and struck bushes some distance short of the runway threshold. The pilot believed that windshear may have been a factor in the accident.

History of the flight

The accident occurred as the aircraft was approaching to land at Stapleford following an uneventful general handling flight. On board were the pilot and his passenger, also a qualified private pilot. Runway 22L was in use, with a west-south-westerly surface wind of about 13 kt. The weather was fine, with good visibility and scattered clouds.

The aircraft joined the circuit and established on what appeared to be a normal, stabilised approach at 87 mph IAS, with the landing gear and three stages of flap extended. The pilot recalled the wind starting to buffet the aircraft and his next recollection was of being at very low height with bushes immediately ahead. The aircraft struck the bushes and stopped abruptly, in a nose-down attitude, about 20 m before the start of the runway (the actual threshold was displaced by 177 m).

While the pilot secured the aircraft, his passenger kicked the cabin door open, as it was obstructed by the bushes. Both occupants vacated the aircraft, although the pilot needed to lower the flap lever as it impeded his exit in the raised (flap lowered) position. They alerted Stapleford radio room by mobile telephone and the airfield fire and rescue vehicle arrived on scene a few minutes later. An air ambulance, which was flying in the vicinity, also attended the scene. Both men were subsequently taken to hospital; the pilot was found to have a broken arm while his passenger had sustained cuts and bruises.

The pilot opined that the aircraft had been affected by windshear, possibly a result of the local airflow over and around the airfield buildings and nearby trees located to the west of the final approach to the runway threshold. The presence of such windshear was reportedly confirmed by the doctor on board the air ambulance, who was also believed to be a qualified private pilot.

SERIOUS INCIDENT

Aircraft Type and Registration:	Piper PA-34-200T Seneca II, G-BOCG
No & Type of Engines:	2 Continental Motors Corp TSIO-360-EB piston engines
Year of Manufacture:	1978
Date & Time (UTC):	15 February 2012 at 1025 hrs
Location:	Birmingham Airport
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Electrical connector in cabin heater power supply overheated
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	44 years
Commander's Flying Experience:	3,894 hours (of which 1,045 were on type) Last 90 days - 58 hours Last 28 days - 18 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and AAIB enquiries

Synopsis

During the approach, wisps of smoke were seen to come from the area of the cabin heater selector switch. The system was isolated, the cabin fire extinguisher was discharged and the aircraft made an uneventful landing. The source of the smoke and acrid smell was an overheated and partially melted electrical connector.

History of the flight

An instructor was conducting an instrument training flight with one student flying the aircraft and a passenger, who was also a student, in a rear seat observing the flight. The student had been given clearance for a low approach and go-around. The aircraft was approximately six miles from Birmingham Airport, established on the ILS for Runway 33, when the passenger reported that there were wisps of smoke rising from the cabin heater switches located on the centre console, which is situated between the two front seats. The instructor did not see the smoke, but was aware of an acrid smell. He immediately took control of the aircraft and instructed the student to remove the instrument flying screens. The student in the rear then reported that he could see a flame beneath the console. The instructor passed the details of the incident to the Birmingham Tower controller and informed him that he wished to land from the approach. The instructor visually checked the Circuit Breaker (CB) for the cabin heater, which had not tripped. He switched off the heater, opened the vents and instructed the passenger to use the cabin fire extinguisher, which was stored between the two front seats. The passenger retrieved and then operated the extinguisher, while holding it at an angle. He advised the instructor that the discharge rate was poor, but sufficient to extinguish the flame.

The aircraft was now within four miles of the threshold for Runway 33 and the instructor updated the Birmingham Tower controller of the emergency and that the fire had been extinguished. The controller cleared the aircraft to land and alerted the emergency services who met the aircraft on landing. The landing was uneventful.

The instructor later discharged the remainder of the contents of the fire extinguisher onto the dispersal and noticed that full discharge pressure was only achieved when the extinguisher was held in an upright position.

Examination of electrical connector

The source of the fumes and flames was a partially melted plastic electrical connector, located in the centre console, through which the electrical power passes to the cabin heater. (See Figure 1) From an examination of the connector it was established that a pin in the connector, through which the electrical power from the CB to the heater selector switch is routed, had overheated.

Due to the extent of the damage it was not possible to identify why the pin had overheated. However, the organisation that maintained G-BOCG, and 12 other PA-34 aircraft, advised the investigation that the connector is frequently disconnected in order to inspect the flying control cables that run under the console. During this maintenance activity they have, on a number of occasions on different aircraft, found loose and corroded pins, and evidence of overheating. The affective parts were replaced on all these occasions.

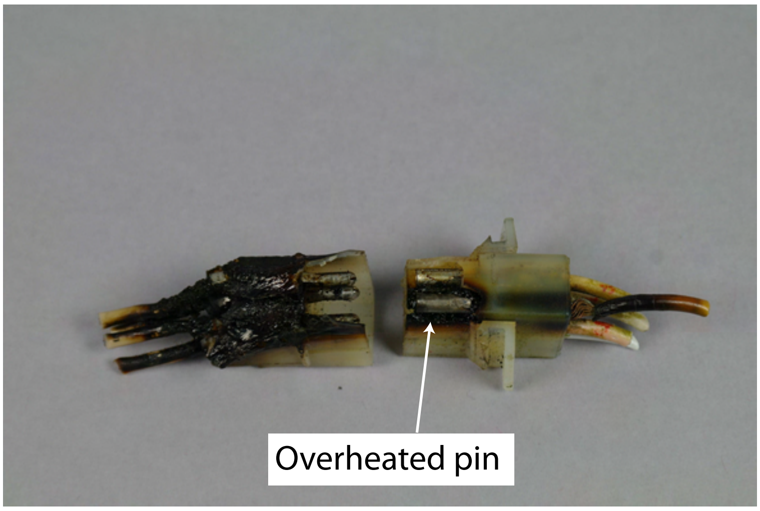


Figure 1

Electrical connector

Loose and corroded pins can result in an increase in electrical resistance, which might result in an increase in the voltage drop across the connector. This increase in voltage drop could cause the connector temperature to increase, which will further increase the electrical resistance and the temperature. This cycle of increased resistance and temperature increase is known as 'thermal runaway' and will continue until the power supply is disrupted.

The maintenance organisation confirmed that the 15 amp CB, that protected this circuit, did not operate during the incident and they subsequently found the CB to be serviceable.

Fire extinguisher

The cabin fire extinguisher utilised halon as the extinguishing agent, which is propelled out of the container by pressurised nitrogen. A label on the cabin fire extinguisher titled *'INSTRUCTIONS'* lists three steps in the operation of the extinguisher. The first steps states *'HOLD UPRIGHT. PULL OUT PIN'*. If the fire extinguisher is not held upright then the nitrogen will escape with the halon, thereby reducing the effectiveness of the fire extinguisher. The manufacture of the fire extinguisher advised the investigation that if the extinguisher is operated in the horizontal position, then only 50% of the halon will be discharged.

AAIB comment

The maintenance organisation had previously identified that the pins in the connector were susceptible to overheating as a result of corrosion or working loose. With the lack of any other obvious damage it is likely that these were the initiating factors which caused the thermal runaway that eventually resulted in the connector melting.

The fire extinguisher operated satisfactorily when held in the required vertical position, and the reported poor discharge rate was probably because it was operated when held at an angle. This demonstrates the importance of both crew and passengers being fully briefed on the use of any emergency equipment that they might need to use, or operate, in flight.

ACCIDENT

Aircraft Type and Registration:	Piper PA-38-112 Tomahawk, G-BRSJ
No & Type of Engines:	1 Lycoming O-235-L2C piston engine
Year of Manufacture:	1981
Date & Time (UTC):	3 March 2012 at 1102 hrs
Location:	Swansea Airport
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Extensive damage to aircraft
Commander's Licence:	Private Pilot's Licence
Commander's Age:	49 years
Commander's Flying Experience:	168 hours (of which 34 were on type) Last 90 days - 2 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot took off from Runway 22 with a reported wind of 220° at 15 to 20 kt. He stated that he was not comfortable controlling the aircraft in the gusty conditions and so he elected to land back onto the runway from approximately 30 to 40 ft agl. The landing resulted in the nosewheel collapsing and the aircraft slid to a halt on the runway. Both occupants were uninjured. The pilot attributed the accident to his misjudgement of the landing.

ACCIDENT

Aircraft Type and Registration:	Yak-52, G-LYFA
No & Type of Engines:	1 Ivchenko Vedeneyev M-14P piston engine
Year of Manufacture:	1982
Date & Time (UTC):	15 January 2012 at 1114 hrs
Location:	Manchester Barton Airfield
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers -N/A
Nature of Damage:	Propeller and engine cowling damaged, minor damage to airfield building
Commander's Licence:	Private Pilot's Licence
Commander's Age:	47 years
Commander's Flying Experience:	290 hours (of which 64 were on type) Last 90 days - 1 hour Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot and report by the aircraft maintenance organistaion

Synopsis

The pilot lost braking effect and directional control of the aircraft during taxi. The aircraft rolled into an airfield building at slow speed. Leaks in the aircraft's pneumatic system were found which accounted for the loss of braking.

Description of the event

The aircraft was parked on a grass area and had been prepared for flight following a period of about eight weeks during which it had not been used. The two occupants were both members of the same group and both qualified on the Yak-52.

Following a warm-up period after engine start, power was increased to start taxiing. Once on the hard taxiway surface, the aircraft rolled forward freely at idle power but, when the pilot applied left rudder and brake to initiate a turn, the aircraft did not respond. Further brake applications produced no braking effect and the aircraft rolled straight forward, towards an airfield building on the opposite side of the taxiway. The pilot switched off the magnetos to stop the engine while the rear-seat pilot, who had also tried his brakes to no effect, closed the fuel switch.

The aircraft rolled into the building at slow speed but with the propeller still turning. The two occupants vacated the aircraft after ensuring it was correctly shut down. The aircraft was pushed back to its parking position, having sustained damage to its engine cowling and propeller; the building, which was 14 m from the aircraft's parked position prior to taxi, suffered light scoring from the propeller and a broken window sill.

Subsequent inspection by the aircraft's maintenance organisation revealed the presence of four leaks in the undercarriage 'down' line of the pneumatic system. As this line also fed the pneumatically operated brake units, the leaks were established as the reason for the loss of braking.

ACCIDENT

Aircraft Type and Registration:	Robinson R22 Beta, G-BXUC
No & Type of Engines:	1 Lycoming O-320-B2C piston engine
Year of Manufacture:	1988 (Serial no: 908)
Date & Time (UTC):	22 September 2011 at 1500 hrs
Location:	Gloucestershire Airport
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Tailboom and supporting structure damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	26 years
Commander's Flying Experience:	n/k hours (of which n/k were on type) Last 90 days - n/k hours Last 28 days - n/k hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

After landing the pilot hover-taxied the helicopter to the apron close to the helicopter operator's facilities. He then attempted to throttle back but inadvertently increased the engine power this, combined with a left yaw pedal input which had been applied during the landing, caused the helicopter to rotate rapidly to the left. It completed approximately six horizontal rotations before the pilot was able to regain control. The helicopter came to rest upright with the rear of the landing skids embedded in grass at the side of the apron, see Figure 1. The skin of the helicopter's tailboom had buckled and its supporting structure had become distorted. The pilot was uninjured.

Figure 1

Ground marking produced by G-BXUC during the incident

ACCIDENT

Aircraft Type and Registration:	Robinson R44 II, Raven II, G-ROTG
No & Type of Engines:	1 Lycoming IO-540-AE1A5 piston engine
Year of Manufacture:	2006
Date & Time (UTC):	24 July 2011 at 1427 hrs
Location:	Marhamchurch, near Bude, Cornwall
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Fatal) Passengers - None
Nature of Damage:	Helicopter destroyed
Commander's Licence:	Private pilot's licence
Commander's Age:	45 years
Commander's Flying Experience:	285[1] hours (of which 221 were on type) Last 90 days - 6 hours Last 28 days - n/k hours
Information Source:	AAIB Field Investigation

Synopsis

While on a flight to visit friends near Padstow, Cornwall, the pilot unintentionally entered IMC, subsequently lost control of the helicopter and, after a very high rate of descent, crashed. There was a post-impact fire and the pilot was fatally injured.

As a result of the investigation some contaminants, that were not contributory to the accident, were found in the helicopter's fuel supply. One Safety Recommendation is made.

History of the flight

The pilot was planning to fly from Aldwick, near Blagdon, 2 nm south of Bristol Airport, where the helicopter was based, to Padstow, Cornwall, to visit friends. He took off at 1320 hrs and the flight progressed uneventfully via Taunton and Okehampton, Devon. En route he was in contact with Bristol Radar and Exeter Radar. At 1358 hrs, when the helicopter was north-east of Okehampton, the pilot was told to 'free call' Newquay Radar. At 1405 hrs he returned to Exeter Radar saying he was unable to contact Newquay. They advised him to contact London Information, which he did at 1407 hrs when 6 nm north-west of Okehampton, Devon.

Footnote

1 The pilot's experience was calculated using a combination of his logbook and the helicopter's logbook. The last entry made in his logbook was on 13 October 2010. The last entry in the helicopter's logbook was on 19 June 2011.

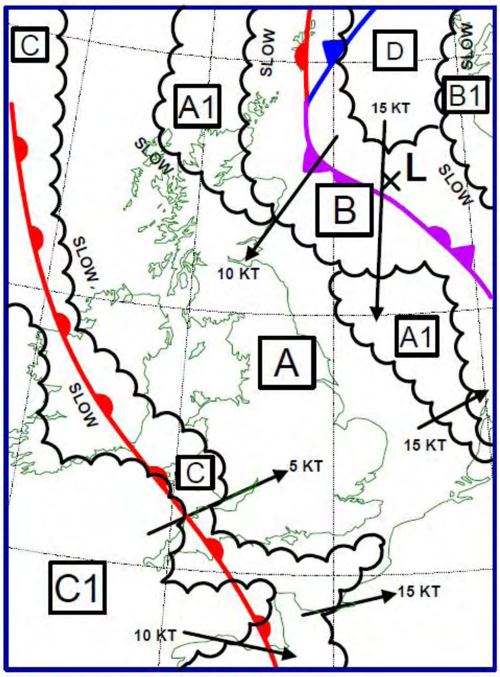
At 1418 hrs, when the helicopter was 24 nm north-west of Newquay Airport, London Information instructed the pilot to 'free call' Newquay Radar, which he acknowledged. Shortly thereafter the helicopter turned through approximately 180º, at about 1º/sec, on to a north-easterly track and started to climb. At 1426 hrs, after establishing contact with Newquay Radar, the pilot requested help from the controller, saying he was "LOST IN CLOUD". The pilot was assigned a transponder code which he read back correctly and selected. He then kept the transmit switch pressed resulting in his microphone remaining live. After about 18 seconds of silence, except for background noise, the pilot was heard talking to himself in an apparently distressed state before the transmission ended.

Radar information indicated that the helicopter then descended rapidly before crashing in a field 2 nm south-south-east of Marhamchurch, near Bude, Devon. The pilot was fatally injured in the impact. There was a post-impact fire.

Weather information

It was not possible to determine what weather forecasts the pilot viewed prior to the accident.

The Met Office forecast form F215, period 1400 hrs to 2300 hrs, is shown in Figure 1 below. It predicted that the weather and visibility likely to be encountered in the area west of Okehampton (areas C and C1 in Figure 1) would be 20 km, occasionally 7 km in haze and light



Forecast Weather below 10000 FT

Valid 241400 to 242300 Z JUL 11. Fronts/zones valid at 241800 Z

AREA	SURFACE VIS AND WX	CLOUD	0 C
A	30 KM NIL ISOL HILL FG	OCNL SCT CU SC 025-040 / 050 BKN/OVC SC 015-025 / 030-050 **A1** ISOL SCT/BKN ST 010 / 015 **A1** N OF 59 N	080-XXX
B	15 KM NIL/-RA OCNL 7 KM RA ISOL 2000 M +RA/RADZ/(+TSRA **B1**) OCNL ISOL OCNL HILL FG	BKN/OVC CU SC AC AS 015-025 / XXX ISOL EMBD CB 015-025 / XXX **B1** ISOL (AREAS SEA COT) BKN ST 003-008 / 015	090-XXX
C	20 KM NIL OCNL (ISOL E) 7 KM HZ/-DZ ISOL 7 KM RA MAINLY W ISOL (AREAS **C1**) 2000 M BR/DZ OCNL 200 M FG **C1** OCNL HILL FG	AREAS SCT/BKN AC 080 / XXX BKN/OVC SC 015-030 / 050-080 OCNL (ISOL LAN) BKN ST 005-010 / 015 WDSPR BKN/OVC ST 002-005 / 010 ... ... **C1** (BASE 000 FG)	XXX
D	20 KM NIL ISOL 7 KM RA AREAS 2000 M BR ISOL 200 M FG	ISOL SCT/BKN AC 080 / XXX SCT/BKN CU SC 015-030 / 050-070 AREAS SCT/BKN ST 002-007 / 015 ... ... (BASE 000 FG)	XXX

All heights in 100's of feet above mean sea level
XXX means above chart upper limit
Cloud amount (Oktas) FEW: 1-2 SCT: 3-4 BKN: 5-7 OVC: 8
MOD / SEV ICE
MOD / SEV TURB
TS / CB implies GR
Speed of movement in KT
Temperatures in DEG C
Hill FG implies VIS <200 M

This forecast may be amended at any time.
Issued by Met Office Exeter at 240925 Z
Forecaster: Duty Forecaster
Contact telephone 0870 900 0100
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F215

Outlook Until: 250600 Z
ISOL BR OR FG PATCHES FORM OVERLAND IN AREA A, OTHERWISE SIMILAR.

Figure 1

Met Office Form 215 for 24 July 2011

drizzle with isolated visibility of 7 km in moderate rain to the west of the area. There would be isolated areas where visibility of 2,000 m in mist and drizzle could be expected with occasional 200 m visibility in fog in area C1 and occasional hill fog.

It forecast scattered[2] or broken[3] altocumulus with a base of 8,000 ft amsl. Additionally there was likely to be broken or overcast[4] stratocumulus cloud with a base of 1,500 to 3,000 ft amsl, with occasional (isolated over the land) broken stratus base of 500 to 1,000 ft amsl with widespread broken or overcast stratus base 200 to 500 ft amsl. In C1 there was expected to be extensive hill fog at sea level.

An aftercast for the entire route was obtained from the Met Office. It stated that at the time of takeoff the weather conditions were "good" at Aldwick, with neighbouring Bristol Airport reporting visibility in excess of 10 km, few clouds at 1,800 ft amsl and scattered clouds at 4,500 ft amsl.

There was no indication that, as the flight progressed south-west towards Bridgwater, there would have been any significant deterioration in the weather, with no more than small amounts of cloud at 1,500 to 2,000 ft amsl, beneath a more solid layer at 3,000 to 4,000 ft amsl. Exmoor would probably have given a degree of shelter from the moistening north-westerly flow up until the Tiverton area, about 10 nm north of Exeter, so the Met Office considered that there would not have been much deterioration in cloud base or visibility at this point.

As the pilot headed further west towards Okehampton, there was likely to have been an overcast layer at about 2,000 ft amsl. Locally, the terrain rises to a maximum of 823 ft amsl. Below cloud, the pilot would probably have experienced a visibility of between 3,500 m and 7 km at times as a result of occasional drizzle from thickening cloud layers aloft. Hill fog would also have been present.

For the rest of the route, weather conditions are likely to have deteriorated further with extensive low cloud and poor visibility (2,000 to 5,000 m). A lower cloud base of 300 to 500 ft amsl was more probable in the vicinity of the coast between Boscastle and Bude. Hill fog would also have been an increasing hazard.

The wind in the vicinity of the accident site was from a west to north-westerly direction at 10 to 13 kt at the surface and approximately 25 kt at FL040. Given the stable flow, both wind shear and significant gusts are unlikely to have occurred in the area.

The Air Navigation Order (ANO) states that in Class G airspace, a helicopter flying under VFR at or below 3,000 ft amsl shall remain clear of cloud in sight of the surface[5] and in a flight visibility of at least 1,500 m.

Witness information

The helicopter was heard by witnesses above the accident site approximately one minute before the accident. They then saw the helicopter appear out of the cloud in a "steep" nose down attitude at "high speed". After what was described as a possible attempt to recover from the dive the helicopter crashed into a field.

The witnesses described the weather at the time of the accident as "good visibility" below a cloud base of approximately 500 ft agl.

Footnote

2 Scattered cloud coverage is 3 to 4 oktas of cloud.
3 Broken cloud coverage is 5 to 7 oktas of cloud.
4 Overcast cloud coverage is 8 oktas of cloud.

Footnote

5 'In sight of the surface' means the pilot is able to see sufficient surface features or surface illumination to enable him to maintain the helicopter in a desired attitude without reference to any flight instrument.

Pilot's experience

The pilot conducted his helicopter training in the UK and South Africa (SA). He passed a PPL(H) Licence Skills Test (LST) in SA on 3 September 2007 and was issued an ICAO licence in SA. Training for this did not include any instrument appreciation flying[6].

The pilot undertook additional training in the UK, including 6 hours of instrument appreciation flying as required for the issue of a Joint Airworthiness Authorities (JAA) PPL(H). In the JAA LST the pilot is required to fly a Rate 1 (3º/sec) turn on instruments, through 180º. This is to demonstrate that he can safely turn the helicopter around to regain VMC in the event of encountering a Deteriorating Visual Environment (DVE). He passed the JAA LST on 4 September 2010 and applied to the UK CAA for a JAA PPL (H) on 10 September 2010. This was rejected because his SA LST had expired.

The pilot subsequently renewed his LST in SA on 13 September 2010 but had not informed the CAA at the time of the accident.

Medical information

The pilot held a valid JAA Class 2 medical certificate.

A post-mortem examination was conducted by a consultant aviation pathologist. He concluded that the pilot died of multiple injuries consistent with being involved in a high speed impact. Toxicology tests revealed no signs of drugs or alcohol.

Accident site

The helicopter was completely destroyed in the impact and much of the fuselage was consumed by a post-crash fire.

Footnote

6 During which flight under instruction is conducted by sole reference to flight instruments.

The helicopter wreckage was located in a field and on the adjacent road, in an area of gently sloping terrain at an elevation of approximately 180 ft.

A ground mark measuring 1.6 m x 2.6 m and 0.25 m deep identified the main impact point where the fuselage had struck the ground. Ground marks corresponding to the vertical stabiliser, tail rotor gearbox, tail rotor guard and rotating tail rotor blades were also evident in this location. Immediately to either side of the impact crater were two long narrow ground marks measuring 2.3 m and 1.3 m which corresponded to the position of the left and right landing skid respectively. The left landing skid ground mark was approximately 9 cm deep and the right, approximately 2 cm deep. Two distinctive curved ground marks 0.16 m and 0.21 m deep, forward and to the left of the main impact crater, were consistent with the rotating main rotor blades striking the ground during the impact sequence.

The landing gear skids and hoops separated at impact and were found broken into a number of sections at either side of the wreckage trail. The horizontal and vertical stabiliser assembly separated from the tail boom at impact and were found adjacent to the initial wreckage trail.

After initial impact the wreckage travelled along the ground in a direction of approximately 087º(M). The majority of the wreckage, including the fuselage, engine tail and boom, was found 23 m from the initial impact point.

The main rotor blades were located just inside the eastern boundary of the field, a distance of 78 m from the impact point. Both blades were still attached to the rotor hub, and damage to the blades was consistent with them having struck the ground while rotating with considerable energy. The main rotor gear box and mast had travelled through the boundary hedge and came to rest in the adjacent road, 88 m from the impact point. Fragments of the main rotor blades were found in various locations around the accident site, ahead and behind the initial impact point at distances up to 78 m.

Ground scorching indicated that a post-crash fire had commenced at the initial impact point, with the helicopter battery, found in the impact crater, a likely ignition source. Both the main and auxiliary fuel tanks were found ruptured and located close to the main wreckage. Much of the fuselage structure forward of the engine had been consumed by the fire. Several days after the accident, a number of areas of stained grass could be seen. Such staining typically occurs from aviation fuel, and the size of the stained areas, together with the extent of the ground scorching and evidence of a significant post-crash fire, are consistent with a substantial amount of fuel being in the fuel tanks at the time of the accident.

Power lines which ran through the field in a direction of 073º(M) and at height of 8 m and offset from the impact point by 21.4 m were undamaged.

From examination of the accident site and wreckage, it was determined that just prior to striking the ground the helicopter was travelling with a very high rate of descent and on an approximate heading of 048º(M) in an approximately nose-level attitude. It was banked slightly to the left, such that the left landing skid was low and possibly with a degree of side-slip to the right. There was no evidence of an in-flight break-up and the main rotor blades were rotating with considerable energy. It was concluded that the main rotor blades struck the ground coincident with the impact, causing the helicopter wreckage to pivot around to 087º(M) and the main rotor gearbox, mast and blades to separate from the helicopter.

Aircraft information

The Robinson R44 Raven II is a four-seat helicopter constructed primarily of metal, powered by a single fuel-injected six-cylinder piston engine and equipped with skid type landing gear. It is certified for VFR operations only. The flight controls are actuated by a conventional system of push-pull rods and bellcranks.

Power is transmitted from the engine to the main rotor gearbox by four rubber ‘vee-belts’, mounted on two sheaves (pulleys). The lower sheave is bolted directly to the engine output shaft. The ‘vee-belts’ transmit power from the lower sheave to the upper sheave, which in turn transmits power forward to the main rotor and aft to the tail rotor, via a main rotor and tail rotor gearbox. The transmission is engaged and disengaged by means of a clutch, which is operated by a two-position (ENG/DISENG) guarded switch on the instrument panel.

Two fuel tanks, a main tank (120 litres) and an auxiliary tank (70 litres), are located on either side of the fuselage above the engine.

The helicopter was manufactured in 2006 and the last entry in the technical log, dated 19 June 2011, indicated that at that time it had flown for a total of 581 hours. A review of the helicopter’s technical records indicated that it possessed a valid Certificate of Airworthiness and had been maintained in accordance with a CAA approved maintenance programme. The most recent maintenance action was an annual inspection carried out on 28 April, at 570 hours. This included, among other items, a mandatory 100-hour repeat inspection of the main rotor blades. The next maintenance inspection due was a 50-hour check on 27 October 2011, or at 620 hours, whichever occurred sooner.

The technical log had not been updated for a month prior to the accident. Consequently, there was no information available relating to recent defects on the helicopter or maintenance items that were being carried forward or deferred at the time of the accident. The exact airframe hours could not be determined.

Detailed wreckage examination

General

Examination of the wreckage revealed that all damage to the airframe and systems had resulted from the impact with the ground, with no evidence to suggest that the helicopter had not been complete and structurally intact prior to the accident.

Control continuity

The continuity and integrity of the collective, cyclic, tail rotor and throttle control linkages were examined in detail. Whilst there was considerable disruption to these control runs, all appeared to have been intact prior to impact, and all damage was consistent with having been sustained during the impact.

Transmission

There was substantial disruption to the transmission system caused by the impact. The main rotor driveshaft was intact up to the forward flexible coupling, where the main rotor gearbox had detached. The tail rotor driveshaft was intact up to the tail rotor gearbox. The four vee-belts were intact and connected to the upper and lower sheaves. Two distinctive gouge marks measuring 6.5 cm and 8.0 cm on the upper sheave indicated that during the impact it had come into contact with the teeth of the starter ring gear, mounted on the aft end of the engine, just forward of the lower sheave. Metal debris corresponding to the material of the upper sheave was found in the teeth of the starter ring gear. The nature of this damage indicated that the starter ring gear was rotating (and that the engine was delivering power) when this damage occurred.

Rotor Blades

The damage to the main rotor blades was consistent with them having struck the ground while rotating with high energy.

Fuel

Both fuel tanks ruptured during the impact and were subject to significant fire damage so it was not possible to obtain a fuel sample from the fuel tanks. However, small samples of fuel were retrieved from the engine fuel injector and a fuel line which ran between the fuel injector and the fuel distribution spider.

Engine examination

The engine sustained damage as a result of the ground impact, most notably to the lower crank case and the accessories mounted at the forward end of the engine, which had also been subject to fire damage. The engine was removed from the wreckage and examined at the AAIB. There was no evidence of any pre-accident failure.

Light bulb analysis

The light bulbs were removed from both the upper and lower instrument consoles and their filaments analysed to determine whether any warning lights were illuminated at the time of impact[7].

Two of the bulbs had been damaged in the impact and it was not possible to analyse the filaments. Of the remaining

Footnote

[7] Light bulb filaments are made from tungsten which is brittle when cold and ductile when hot. If the bulb was off (or cold) then the filament will tend to shatter or break when subjected to substantial impact forces. If the bulb was on (or hot) the filament will stretch.

bulbs, a number of the filaments were found to be intact and the remainder were fractured. None of the filaments examined exhibited evidence of stretching or distortion, as would be expected in the case of a hot (illuminated) filament. It can be concluded that either impact loads were insufficient to cause any of the filaments to stretch, or none of the bulbs were illuminated at the time of the impact. Given the severe nature of the impact, it is more likely that none were illuminated.

Instrument Panel

The clutch switch was found in the DISENG position; however, the sprung guard over the switch was open and broken. It was therefore determined that the switch and the sprung guard were disrupted during the impact sequence.

Fuel

General

Three days prior to the accident the pilot had taken delivery of 3,000 litres of 100 LL Avgas, which is used in the Robinson R44. Witnesses reported that on the day before the accident, the pilot refuelled the helicopter and upon carrying out the fuel drain checks, drained a "significant" amount of water from the fuel tanks. Later that day the helicopter was flown on a local flight with no reported problems.

Condensation can form within aircraft fuel tanks, leading to the presence of water in the fuel. As water and particulate contaminants will sink to the bottom of the fuel tank, it is common practice for fuel samples to be taken from each fuel tank drain and the engine fuel drain prior to flight. The samples are visually inspected by the pilot for colour (100 LL Avgas has a blue tint), water content and the presence of any particulates.

The fuel company which supplied the fuel, takes a sample of the fuel loaded in their delivery trailers prior to dispatch. This is examined visually, for colour, brightness and the presence of sediment or water and a fuel density test is carried out. A Certificate of Quality and Conformity is then produced for the fuel and the sample is retained by the company. The company delivers mixed loads of fuel in the same trailers with aviation jet fuel in some compartments and Avgas in others. If a compartment has previously carried a different grade of fuel, before loading the new fuel it is fully drained and then flushed with some fuel of the type being loaded. Examination of fuel delivery records showed that the compartment from which the pilot's delivery of fuel was made had previously contained Avgas.

Fuel storage

The fuel supply for the helicopter was stored in a static bowser at the pilot's private site. The bowser was a rotationally moulded plastic tank, of the type commonly used for the storage of domestic heating fuel, and was equipped with a diesel dispenser pump. The precise history of the fuel bowser could not be determined and it was not clear whether the bowser had been bought new by the pilot for the specific purpose of storing Avgas, or whether it had previously been used for the storage of any other fuels. Neither the bowser nor the fuel hoses were specifically approved for use in an aviation fuel installation. Aviation fuel industry guidance[8] recommends that aviation fuels should be stored in bunded[9] tanks constructed of carbon steel or stainless steel. In addition, the guidance states that hoses used for dispensing aviation fuel should conform

Footnote

[8] Joint Inspection Group publication JIG 4, May 2007 – 'Guidelines for aviation fuel quality control and operating procedures for smaller airports'.

[9] A bunded tank is a tank within a tank; the liquid is stored in the inner tank and the outer tank serves to contain any leaks or spills from the inner tank.

to BS EN ISO 825:2011[10] which ensures that they are resistant to degradation by aviation fuels, thereby reducing the risk of contamination.

Fuel Analysis

The fuel samples from the fuel delivery vehicle and the pilot's fuel bowser were tested to determine whether they conformed to the industry standard fuel specification[11] for 100 LL Avgas. There was an insufficient quantity of fuel in the two engine samples taken to complete the full specification test, but all the samples were subject to gas chromatography[12] and infrared spectroscopy[13] techniques to evaluate the presence and extent of any contamination.

The bowser sample did not meet the specification requirements for distillation final boiling point and existent gum. Additionally a small amount of water was found in the bowser and fuel delivery vehicle samples. Both engine samples were wholly comprised of fuel with no evidence of water.

The bowser sample and the two engine samples contained contaminants. One of the contaminants was a phthalate ester, and its presence was consistent with the bowser sample failing the existent gum test. Phthalate esters are used as plasticisers[14] and can be extracted from polymeric materials that are in contact with fuel, such as fuel hoses and plastic storage containers.

Footnotes

[10] BS EN ISO 1825:2011 Rubber hoses and hose assemblies for aircraft ground fuelling and de-fuelling specification. Supersedes BS EN 1361.

[11] Defence Standard 91-90/3 for Aviation Gasoline, produced by the UK MOD Aviation Fuels Committee and endorsed by the CAA.

[12] The gas chromatograph identifies the individual components of a substance by separating them into approximate boiling range order.

[13] The infrared spectrometer analyses the chemical composition of substances by passing infrared energy through the substance.

[14] Substances added to plastics to increase their flexibility, transparency, durability, and longevity.

The other contaminant was consistent with a kerosene-type product, such as aviation jet fuel or domestic heating kerosene. As aviation jet fuel and domestic heating kerosene are very similar in composition, it was not possible to determine more specifically the exact nature of the contaminant. The presence of the kerosene based contamination in the bowser sample, estimated to be 2.8 % by volume, was consistent with the failure of the distillation final boiling point test.

A small quantity of kerosene contamination, approximately 0.2 % by volume, was also identified in the sample from the fuel delivery vehicle. It was not possible to determine whether this was as a naturally occurring component in the Avgas or whether it was due to jet fuel contamination, but the sample contained a higher quantity of kerosene material than two unconnected reference samples of Avgas, with which it was compared.

Regulatory guidance for the storage of aviation fuel in general aviation

The subjects of aircraft fuelling and the management of fuel installations at licensed aerodromes are covered under the provisions of Article 217 of the Air Navigation Order (ANO) 2010 and Civil Aviation Publication (CAP) 748 provides guidance on these subjects. In addition CAP 793 *'Safe Operations at unlicensed aerodromes'* contains the following guidance relating to the storage of aviation fuel.

> *'1 Operators of unlicensed aerodromes who also have the facilities to store and dispense AVGAS 100LL, Jet A1 or MOGAS should be aware of the requirements specified in Article 217 of the ANO 2009*[15]*.*

Footnote

[15] The 2009 version of the ANO was current at the time this edition of CAP 793 was published. The ANO has since been updated.

> 2 *The storage and dispensing of AVGAS 100LL and MOGAS from an aerodrome requires the operator or owner of the installation to hold the appropriate Petroleum Licence issued by their local Unitary Authority or branch of the Environment Agency. Fuelling procedures and guidance are contained in CAP 748 Aircraft Fuelling and Fuel Installation Management (available via www.caa.co.uk/cap748).*
>
> 3 *While primarily aimed at licensed aerodromes, this guidance is also relevant for fuelling arrangements at unlicensed aerodromes.'*

There is no equivalent published guidance for general aviation pilots regarding the storage of aviation fuel at private airstrips or helicopter sites. The technical aspects of fuel installation construction fall outside of the scope of the CAA guidance but are covered by codes of practice supported by the petroleum industry.

Recorded Information

Introduction

Recorded information was available from two radars located at Burrington, a GPS[16] recovered from the helicopter and ground based radio telephony (RTF) recorders.

The Burrington radar site is located approximately 22 nm to the north-east of the accident site. Each radar recorded information once every eight seconds, with a two second offset between the two radars. When the two radar recordings were combined, the helicopter's position and Mode C[17] pressure altitude were available at increments of two and six seconds respectively. The radar record commenced as the helicopter passed to the south of Bridgwater, Somerset, and ended shortly before the helicopter crashed. The GPS contained a track log of the flight, with GPS-derived position, track, altitude and groundspeed recorded at a nominal rate of once every thirty seconds. The GPS track log commenced as the helicopter departed the pilot's private site, and ended 26 seconds before the final radar point was recorded. There was a close correlation between the radar and GPS information, confirming the accuracy of the radar information. RTF records were available at various stages throughout the flight, including a radio transmission from the pilot shortly before the helicopter crashed.

Interpretation

All altitudes are above mean sea level (amsl) unless stated otherwise.

The first GPS data point was recorded at 1320:56 hrs as the helicopter took off from the pilot's private site (refer to Figure 2 and Figure 3).

Approaching Okehampton, the helicopter momentarily climbed from 1,300 ft to about 1,900 ft (Figure 3 – Point A), whilst also altering track by about 10°, from 253°(M) to 263° (deviating from a direct track to the town of Padstow), but as it passed to the north of Okehampton, it started to descend progressively. When the helicopter was at about 11 nm west of Okehampton it levelled off at about 950 ft (approximately 500 ft

Footnote

[16] Honeywell manufactured Skymap IIIC.

[17] When interrogated by ATC radar, the aircraft transponder transmits the aircrafts pressure altitude, quantised to the nearest 100 ft increment. This data is referred to as Mode C. The pressure altitude is based on the International Standard Atmosphere (ISA) that assumes a barometric pressure of 1013.25 hPa at sea level. The ATC radar system corrects the pressure altitude so that altitude is displayed on the controller's display.

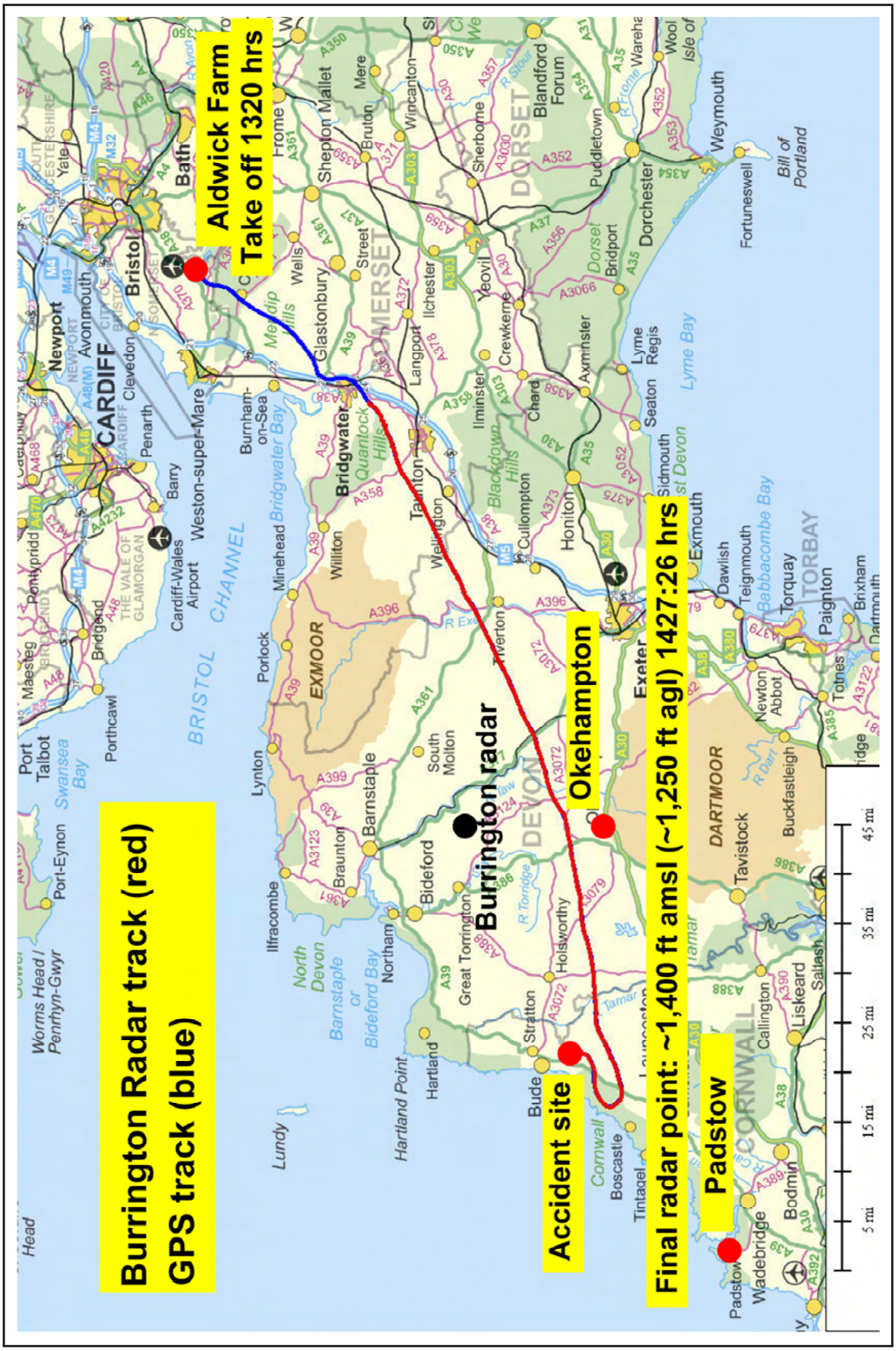

Figure 2

G-ROTG - GPS and Radar flight track

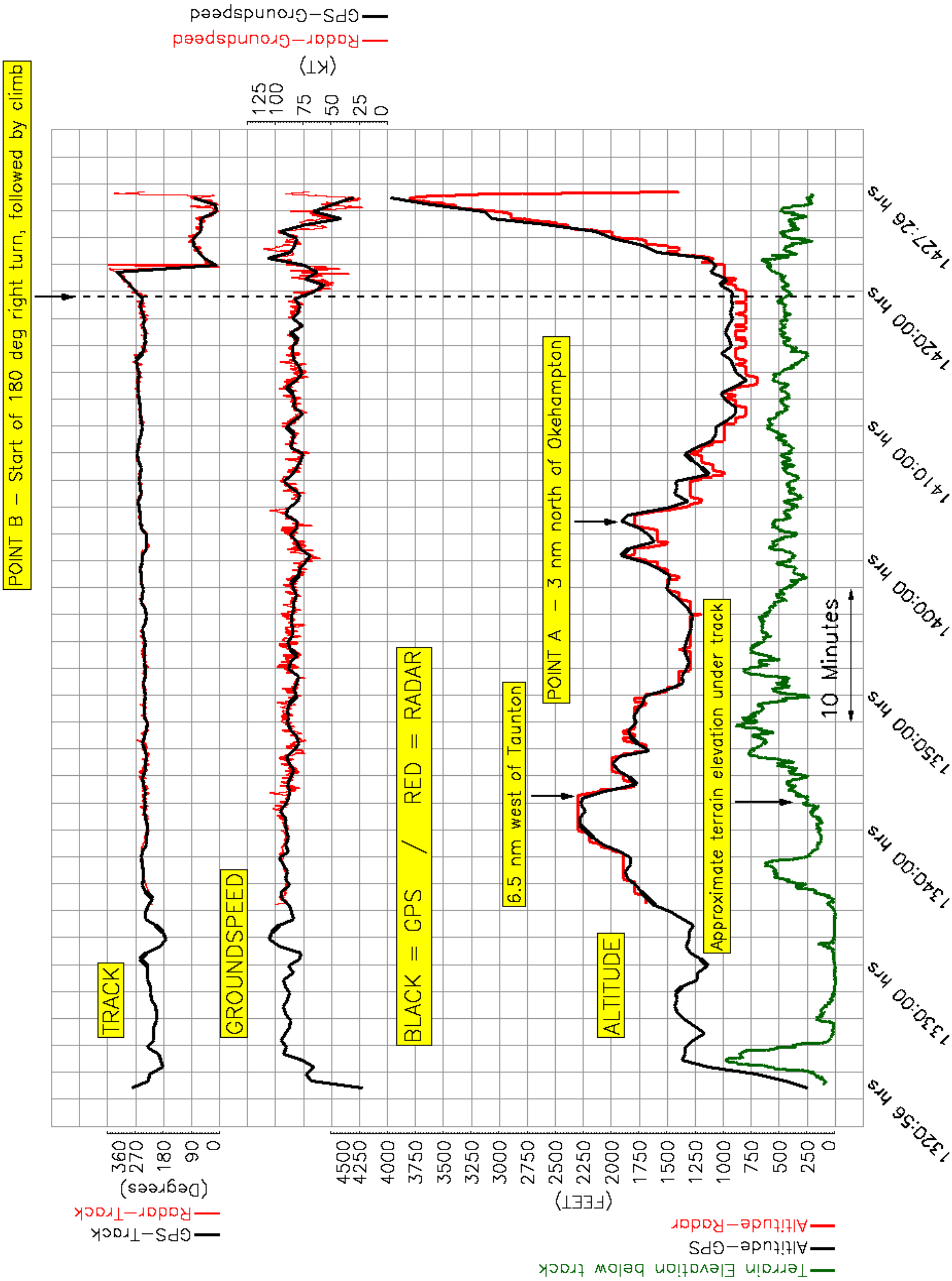

Figure 3

G-ROTG - GPS and Radar altitude profile

agl). At 1415 hrs, the helicopter made a left turn to track 245°, establishing a track towards the north of Padstow by about 9 nm.

At 1418 hrs, the pilot was instructed to 'free call' Newquay Approach, which he acknowledged. The helicopter was 24 nm to the north-east of Newquay, 18 nm to the north-east of Padstow and 6 nm to the south of Bude at the time. At about the same time, the helicopter altered track slightly to 253°. It then continued on track for about a further two minutes, at altitudes of between approximately 800 ft and 1,000 ft, and at heights as low as about 400 ft agl before making a gradual 180° right turn (Figure 3 – Point B) at about 1°/sec. During the turn, the helicopter maintained an altitude of about 1,000 ft (approximately 500 ft agl), but, as the turn was being completed, the helicopter started to climb at about 600 ft/min, although it was not in close proximity to terrain or obstacles that would have required it to climb.

At 1426:20 hrs, about four minutes after having turned back towards the north-east and eight minutes after having being advised to contact Newquay Approach, the pilot established communications with Newquay. Following his initial introductory call, which appeared normal, he advised the approach controller "GOT MYSELF INTO A BIT OF DIFFUCULTY HERE AND AT PRESENTLY THREE THOUSAND TWO HUNDRED FEET….. AND UH GOT LOST IN CLOUD, AM CLIMBING AND UH CAN YOU GIVE ME SOME HELP HERE PLEASE, TANGO GOLF". The controller acknowledged the pilot's request and advised him to select the transponder code (squawk) one seven five zero, to assist in identifying the helicopter on radar. The helicopter continued to climb and four seconds later, at 1426:48 hrs, the pilot acknowledged the squawk code. The helicopter was now at about 3,800 ft on a track of approximately 040º and its groundspeed had reduced to about 30 kt. Based on a westerly to north-westerly wind of 25 kt at FL040, the IAS of the helicopter would have been between approximately 7 kt to 15 kt at this time.

After confirming the squawk code the pilot continued to depress the radio transmit button for the next 36 seconds. During the later stages of the transmission, the pilot was heard to say "WHAT AM I DOING". Shortly afterwards, the helicopter started to descend rapidly. The final radar point was recorded at 1427:26 hrs, which coincided with the end of the pilot's radio transmission. The helicopter was then at about 1,400 ft (1,250 ft agl) and positioned laterally about 130 m south-west of where the initial ground impact occurred. In the following seconds the approach controller and another pilot on the same frequency attempted to provide advice to the pilot, but there was no further radio contact from G-ROTG.

During the final 14 seconds of radar information, the helicopter's altitude reduced from 3,500 ft to 1,400 ft, equating to a mean vertical speed of about 9,000 ft/min. Analysis of the four radar points recorded during this period indicated that the helicopter's vertical speed had been increasing as it descended, with incremental mean vertical speeds of 4,000 ft/min (40 kt), 9,000 ft/min (89 kt) and finally 14,000 ft/min (138 kt). The radar also indicated that the helicopter may have entered a left turn whilst it descended, and its groundspeed may have reached a maximum of about 90 kt, although due to the nominal accuracy of radar this cannot be confirmed.

RTF Analysis

The Robinson R44, Raven II is equipped with a low rotor speed warning system, which includes a warning light on the instrument panel and a horn. If the main rotor rpm drops to 97 % or below, and the collective is not in the fully down position, the horn emits a tone of between 800 Hz and 1,000 Hz and the light illuminates. The amplitude of the tone is such that it is intended to be audible above the normal operating noise of the helicopter when headsets are worn.

The warning horn from G-ROTG was tested and found to operate correctly, generating a tone of just greater than 800 Hz. Frequency spectral analysis of the final RTF transmission did not identify the presence of the warning horn having been activated.

To establish that the sound generated by the low rotor speed warning horn could be recorded as part of a radio transmission, a series of audio tests were conducted using a helicopter of the same type as G-ROTG. The pilot's headset microphone was positioned normally throughout the tests and both verbal and open microphone (non-verbal) radio transmissions were made, simulating the characteristics of the final radio transmission from G-ROTG. Analysis of the ground based RTF recordings established that the sound generated by the low rotor speed warning horn was present during all the tests, which included a simulated loss of engine power during flight.

When a pilot speaks into the headset microphone, background sounds such as those generated by the engine are attenuated due to the noise cancelling design of the microphone. However, during an open microphone transmission, background sounds may be readily recorded. The initial 18 seconds of the final radio transmission consisted of an open microphone transmission. Frequency spectral analysis identified that during this period, sounds were present that corresponded mathematically to the operation of the engine, main rotor gearbox and main rotor. It indicated that the engine was operating at about 2,760 rpm (103 %), with the speed of the main gearbox (which is driven by the engine) and speed of the main rotor being consistent with that of the engine rpm. During the final 18 seconds of the radio transmission, background sounds were masked by the voice of the pilot talking, apparently to himself. During the radio transmission the pilot did not mention a problem with the helicopter's controls or engine.

Evaluation flight

During the investigation a helicopter similar to G-ROTG was flown to assess rates of descent resulting from various combinations of power and indicated airspeed. The results are shown below.

IAS (kt)	Power setting	Average Rate of descent from altimeter (feet/min)
70	IDLE	1,500
130	FULL power	3,000
130	Descent power	4,000

Helicopter accident data analysis 2000-2010

From 2000 to 2010 there were 276 reportable accidents involving small helicopters[18] in the UK and UK registered helicopters in Ireland, of which 27 were fatal. Of these, 16, nearly 60%, were attributed to the pilots encountering DVE.

While helicopters have the ability to slow down, turn around or 'land out', there seems to be reluctance for pilots to make the decision in a timely manner to do either of these. A pilot's ability to make a suitable decision to avoid DVE may decrease as the situation deteriorates and result in the helicopter unintentionally entering IMC.

Footnote

[18] Small helicopters are those of 3,175 kg All Up Mass or less, irrespective of the number or type of engine, or number of seats.

The CAA intends to publish a new AIC to be read in conjunction with AIC 100/2007 (Pink 129), *'Helicopter flight in degraded visual conditions'*, advising helicopter pilots that a precautionary landing in a helicopter is a legitimate exercise and well suited to its capabilities. It will also emphasise that making a precautionary landing should always be considered a viable option, preferable to continuing on into DVE.

Analysis

Engineering

Examination of the accident site and wreckage indicated that the helicopter was structurally intact and functioning normally prior to the accident. The ground marks and presence of undamaged power lines in close proximity to the initial impact point, indicate that the flight trajectory was predominantly vertical at the point of impact. Evidence from the examination of the engine and the transmission components, and in particular the main rotor blade strikes, indicated that the engine was delivering significant power at the time of the accident. Spectral analysis of RTF did not reveal abnormalities.

Fuel

An aircraft engine is designed to operate most efficiently on a specific type of fuel conforming to pre-determined specifications. The use of fuel that deviates from these specifications can reduce operating efficiency and, under some conditions, can cause complete engine failure. Although the investigation determined the presence of contamination in the fuel supply for G-ROTG, there was no evidence that engine operation had been significantly compromised. The investigation concluded that the plasticiser contamination was probably a result of the conditions in which the fuel was stored and dispensed. Neither the bowser nor the dispensing hoses at the pilot's private site were approved for use with aviation fuel.

The investigation was not able to determine the source of the kerosene-based contaminant in the Avgas supply.

Published guidance exists relating to ensuring fuel quality and the provision of adequate fuel storage facilities at licensed and unlicensed aerodromes, but this guidance is aimed at aerodrome operators and fuel suppliers. While the contamination identified in G-ROTG's fuel supply did not influence the outcome of this accident, the investigation identified issues relating to fuel quality and storage. There is no relevant guidance specifically aimed at general aviation pilots operating from private airstrips or helicopter sites. Therefore the following Safety Recommendation is made:

Safety Recommendation 2012-009

It is recommended that the Civil Aviation Authority publish guidance to General Aviation pilots regarding the quality and storage of fuel for use in aircraft.

Conduct of the flight

The forecast and aftercast for the route flown by the helicopter indicated that the weather was likely to have been marginal for flight under VFR west of Okehampton, due to the low cloud and hill fog.

The helicopter's altitude gradually reduced as it progressed west of Okehampton. This is consistent with the pilot trying to stay clear of cloud as cloud base and in-flight visibility reduced.

The helicopter turned through approximately 180º and then started climbing. This was probably an attempt by the pilot to turn around to find better weather conditions, a manoeuvre he would have been required to demonstrated on the JAA PPL(H) LST. This turn was flown at about 1º/sec rather than the 3º/sec required for the LST. This indicated that, while the pilot was doing as he was taught, he was doing so very cautiously. This could be another indication of the poor flight conditions. Initially, the climb may have been inadvertent. Having climbed into a low cloud base during the turn, or if encountering very poor visibility upon rolling out, the pilot may then have decided to continue climbing.

As the helicopter climbed its ground speed decreased from about 105 kt to approximately 55 kt. At about 3,800 ft amsl, immediately before the helicopter started its final high rate of descent, its groundspeed was approximately 30 kt. As the wind at FL040 was predicted to have been from the west to north-west at about 25 kt, the IAS of the helicopter was likely to have been less than 15 kt, which would have made it very difficult to control in VMC or IMC.

Such a situation is likely to require much of a pilot's effort to control the helicopter, leaving insufficient capacity to plan for a safe outcome.

The maximum rate of descent achieved during the descents in the evaluation flight was approximately 4,000 ft/min. The maximum rate of descent recorded by the radar and GPS during the final seconds of the accident flight was approximately 14,000 ft/min. This, together with the pilot's transmission "WHAT AM I DOING", suggests that he had become spatially disorientated and had lost control of the helicopter.

Ground marks at the accident site indicated that the helicopter impacted the ground in an approximately level attitude. This, in addition to witnesses' testimonies, suggests that the pilot may have attempted to regain control of the helicopter upon regaining visual references. However, given the high rate of descent and the small amount of height available below the cloud, it is unlikely that any control inputs at this stage would have arrested the high rate of descent in time to avoid impacting the ground.

Conclusion

The pilot of G-ROTG encountered DVE and subsequently climbed in cloud to nearly 4,000 ft amsl. It is likely that he become spatially disorientated before losing control of the helicopter, which entered a very high rate of descent from which it did not recover. No mechanical fault was found with the helicopter.

ACCIDENT

Aircraft Type and Registration:	BFC Challenger II Challenger, G-MYOZ
No & Type of Engines:	1 Rotax 503 piston engine
Year of Manufacture:	1996
Date & Time (UTC):	1 November 2011 at 1200hrs
Location:	Longside Airfield, Peterhead, Aberdeenshire
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Right wing tip, landing gear leg, nosewheel, nose cone and propeller tip
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	74 years
Commander's Flying Experience:	180 hours (of which 180 were on type) Last 90 days - 1 hour Last 28 days - None
Information Source:	Aircraft Accident Report Form submitted by the pilot

Whilst at about 650 ft in a left-hand circuit, a few minutes after taking off from Runway 28, the pilot reported that the engine lost power. After deciding that it was not possible to return to Runway 28, the pilot elected to land on Runway 10. The surface wind was stated to be 180° at 12 kt. At approximately 20ft aal, the pilot reported that the "into-wind wing was suddenly forced downwards which could not be corrected". The right wingtip contacted the runway and the aircraft tipped onto its nose.

The pilot assessed that a possible cause of the loss of engine power was carburettor icing. The reported local weather conditions, when referenced against the Civil Aviation Authority's Carburettor Icing Prediction Chart, published in Safety Sense Leaflet No 14, indicated that serious carburettor icing could occur at any power setting.

ACCIDENT

Aircraft Type and Registration:	Falcon (3) 195 Hang Glider, No Registration
No & Type of Engines:	None
Year of Manufacture:	2010
Date & Time (UTC):	28 October 2011 at 1249 hrs
Location:	Darley Moor Airfield, Derbyshire
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Fatal) Passengers - N/A
Nature of Damage:	Substantial
Commander's Licence:	None
Commander's Age:	16 years
Commander's Flying Experience:	13 dual aerotow launches
Information Source:	AAIB Field Investigation

Synopsis

The student hang glider pilot was carrying out her first solo aerotow launches, having previously completed a number of tandem training flights. Shortly after lift off, the hang glider rolled to the left and, although an initial weight shift correction was made, continued deviating to the left of the tow direction. The towing pilot and the student hang glider pilot both released from the tow line and the hang glider entered a steep nose down, descending spiral into the ground. The student hang glider pilot received fatal injuries.

No defects were found, with either the tug aircraft or the hang glider, that could have contributed to the accident. However, a number of factors were identified that could have made it more difficult for the student pilot to control the hang glider.

The British Hang Gliding & Paragliding Association (BHPA) has initiated an in-depth review of aerotowing procedures and is also reviewing its audit and inspection processes.

History of the flight

Background

The student hang glider pilot had carried out a number of tandem flights and was now considered to be ready for her first solo flight. The tandem flights had been carried out using a Falcon (3) Tandem hang glider. For the solo flight a Falcon (3) 195 hang glider was used. This was considered by the training school to give as similar a set up and 'feel' to the tandem hang glider as possible.

The aerotow launch system used a Pegasus Quantum 15-912 as the towing aircraft. The hang glider was attached to the tow line by means of a two-point bridle and there were separate quick-release systems for the towing pilot and the hang glider pilot.

The weather conditions were good, with a surface wind directly down the runway at around 5 kt. Runway 20 was in use.

First flight

The solo hang glider was set up and the student pilot prepared for the launch. The intention was to tow the hang glider to a height of 1,500 ft aal, before release. A briefing was given which included information about the significant differences between a tandem and a solo flight. When all was ready, the signal was given for the tow to start[1]. The instructor was in a position under the wing, assisting with the launch. He was equipped with a handheld radio transmitter with which he could transmit instructions to the student pilot, if needed, and there was a radio receiver for the student pilot on the hang glider. The towing aircraft was fitted with a rear-view mirror in which the towing pilot could watch the progress of the tow.

The tow commenced, the hang glider lifted off and the student pilot controlled the pitch. The hang glider started to oscillate a little from side to side and then banked left and deviated to the left of the towing aircraft. The student pilot released from the tow and recovered into a level attitude, turned into wind and made a safe landing.

The student pilot and the instructor discussed why the flight had not been able to continue successfully and what corrections to make next time. The student pilot noted the comments and advised that the same mistake would not recur. She was also asked if she wanted to carry out a further tandem flight but decided to attempt another solo flight.

Accident flight

The student pilot was re-briefed before the tow commenced. The hang glider lifted off and started deviating to the left, taking up a left banked attitude. The instructor on the ground, now positioned behind the hang glider, made a radio call to tell the student pilot to "shift right" but, as he did so, saw that a weight shift correction had already been made. However, he noted that the correction was not sufficient to level the wing of the hang glider and that the left turn continued and increased. He radioed to the student pilot to release. The towing pilot and then the student pilot released the tow line; the hang glider then went into a steep nose down, descending left spiral and struck the ground. The instructor later commented that he had been startled by the speed with which the accident had happened and his impression was that the situation was not recoverable.

The area of impact was on a disused concrete/asphalt runway surface. Several people ran over to give assistance and an air ambulance was called. The student pilot was transferred to hospital but had suffered fatal injuries in the accident.

Other information

Witnesses

Using the rear-view mirror, the pilot of the towing aircraft saw the hang glider deviate to the left after it lifted off. She considered that, at the point the hang glider was released from the tow, the situation should have been recoverable. It appeared to her that the

Footnote

[1] This signal was passed from the hang glider pilot to the towing pilot via the instructor and two Signallers (see Figure 1).

student pilot did not make any further control inputs once the hang glider had released.

One witness was watching the aerotow launch from the other end of the runway, some 400 m to 500 m away. He had with him a handheld radio and could hear the transmissions made by the instructor. He saw the hang glider turn to the left, after takeoff, and heard the instructor say to weight shift right. He did not see any sign of a correction but noted that the hang glider turned further left and that the nose up pitch attitude increased. As this happened, he heard the instructor call "release". He could tell that the tow had been released because the pitch attitude of the hang glider changed again. He saw the hang glider continue to turn left and adopt a nose down pitch attitude. The left turn then continued until the hang glider struck the ground.

Meteorological information

The weather conditions were fine and reported by the training school to have been good for aerotowing operations. The wind was not recorded at Darley Moor Airfield but the 1350 hrs METAR for East Midlands Airport, 17 nm to the south-east, reported a surface wind from 210° at 7 kt.

Examination of the accident site

The hang glider was lying on a disused section of a concrete/asphalt runway, located approximately 35 m to the side of the runway from which it had taken off and approximately 100 m from the launch point (see Figure 1). The tow rope was found a little further along the runway in use and was lying at an angle of approximately 30° to the direction of the runway. The

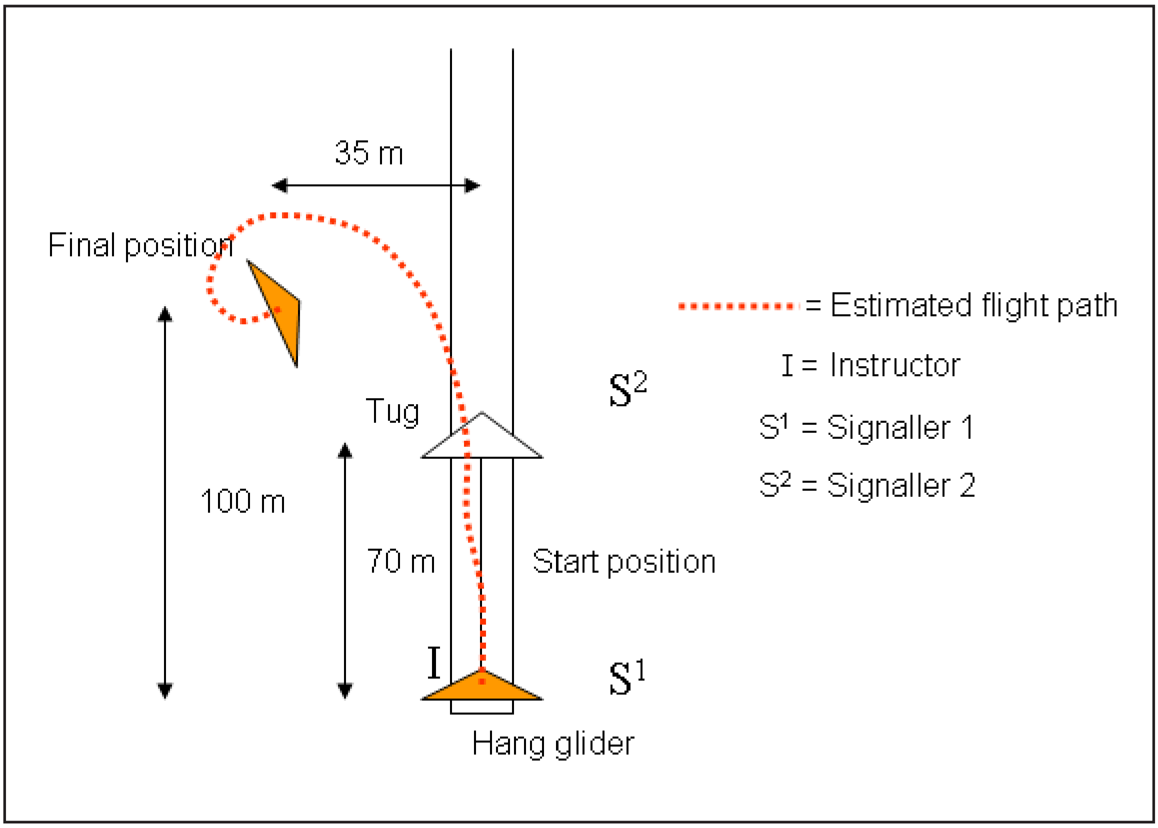

Figure 1

Diagram of the accident site

hang glider was complete and intact, apart from the control frame which had suffered impact damage. The leading edge on the left side of the wing appeared to have struck the ground first, as the sail cloth along its length was torn. Some dismantling of bracing wires had taken place as part of the efforts to rescue the pilot.

Pilot information

The student pilot had been flying paragliders for two years and had attained a Club Pilot rating. In April 2011 she started hang glider training. The training was carried out in accordance with the BHPA Hang Gliding Aerotow Training Programme and started with tandem aerotows, of which she completed 13. The training programme included recovery from unusual attitudes, stalling and lockout[2], as well as exercises in recovery techniques for issues that may occur on-tow, such as pilot-induced oscillation and regaining the correct towed position after lateral and vertical displacements. All these exercises were to be carried out at a safe altitude. During training, because of the need to maintain the correct body position, student pilots are first taught to control pitch and roll separately. Later, these are combined into a co-ordinated manoeuvre.

The towing pilot was also a hang gliding instructor and was experienced in aerotow operations, both in flying the towing aircraft and in being aerotowed in solo and tandem hang gliders.

The towing pilot had flown several tandem flights with the student pilot earlier in the day. During them, the student had demonstrated her ability to correct oscillations competently following four simulated oscillation exercises. The towing pilot, in her capacity as an instructor, had considered the student to be very capable and ready for solo flight. Although on the first solo flight the tow was released at a height of about 50 ft, it was competently handled and a safe landing was made, further demonstrating the student's readiness to fly solo.

Towing aircraft

General description

The Pegasus Quantum 15-912 (see Figure 2) is an advanced weight-shift controlled aircraft, operating on a Permit to Fly. It had been modified to include factory modification PG134, which installs a towing hook mechanism, automatic and manual release mechanisms and a rear-view mirror. The procedures and limitations for towing operations using this equipment are set out in the Glider Tug manual, which is a supplement to the Operator's manual. The aircraft had also been modified to include an optional rear hang point for the wing. This provided a slower range of trim speeds, 37 to 55 mph, and is intended for use in this type of towing operation. The wing was rigged to this rear hang point. Towing operations were conducted at a speed of 40 to 41 mph, although, due to the characteristics of the towing aircraft, the speed would reach a higher speed at lift off.

Documentation

The Glider Tug manual includes detailed limitations, instructions and guidance for all aspects of towing with this aircraft. For aerotowing hang gliders, it stipulates that:

> *'Aerotowing must be carried out according to the BHPA aerotowing operations manual.'*

Footnote

[2] Lockout - This is when a hang glider turns away from the direction of the force applied by the tow line, to such an extent that the tension in the tow line causes the hang glider to deviate rapidly, at an increasing rate, and the pilot no longer has sufficient control authority to correct it. Once developed, the only way to recover is to release the tow line.

Figure 2

Towing aircraft, G-WHEE
(courtesy Derbyshire Constabulary)

Among the specified limitations, the following were relevant:

> *'The towline must be at least 70 m long….*
> *A maximum weak link strength of 100 kg must be observed according to the BHPA aerotow manual….*
> *Hang gliders to be towed must be capable of a sustainable maximum speed of at least 55 mph.'*

Maintenance

The aircraft, G-WHEE, was found to be in satisfactory condition and the towing equipment operated normally. The Certificate of Validity of the Permit to Fly was in date and the aircraft had the required placards displayed. No defects were identified that could affect the towing operation.

The towline being used was 68.3 m long and of the correct material. It had weak links fitted to each end. The weak link at the towing aircraft end had a break value of 150 kgf and the one at the hang glider end had a break value of 125 kgf.

Hang glider

General Description

The Falcon (3) 195 is a conventional hang glider constructed of aluminium alloy tubing frame, with a polyester sail cloth covering. Although not subject to any regulation, the hang glider had been tested and found to comply with an industry-developed design code, the 2006 HGMA (Hang Glider Manufacturers Association) standard. It was considered suitable for novice pilots. The basic weight of the hang glider is 53 lb.

Additional wheels had been fitted to allow ground launching with the pilot in a prone position. A castoring main wheel was attached to each end of the control bar and incorporated rubber bungees to allow a degree of suspension. An extension to the keel allowed the fitment of a tailwheel. (A similar arrangement is showing in Figure 3.) The additional landing gear weighed approximately 28.5 lb.

The hang glider manufacturer was asked to assess the effect on its handling characteristics. Their experience indicated that the control response would generally be slower and the control authority somewhat diminished, due to the percentage reduction in pilot weight compared to the overall weight of the hang glider and the increase in rotational inertia away from the centre of gravity. The manufacturer concluded that it is likely these changes would be noticeable to an experienced pilot but would not compromise a pilot's ability to control the hang glider.

A towing bridle was attached to a point on the keel forward of the control frame and incorporated a quick release fitting which was operated by a lever, similar to a bicycle brake lever, on the right hand side of the control bar. The other end of the towing bridle was attached to the pilot's chest with another independent quick release fitting which could be operated by the pilot. The end of the towline was fitted with a ring, through which the towing bridle passed (see Figure 3). Operating either release allowed the towing bridle to pass through the ring on the towline, releasing the tow.

Documentation

The manufacturer provides an Owner/Service manual which contains detailed limitations, instructions and

Figure 3

Similar hang glider showing pilot position and bridle arrangement guidance for rigging and operating the Falcon range of hang gliders. The January 2007, second edition notes:

> *'They have not been designed to be motorised, tethered or towed. They can be towed successfully using proper towing procedures. Pilots wishing to tow should be USHGA (United States Hang Glider Association) skill rated for towing.'*

The manual also quoted a recommended 'hook in' pilot weight range of 175 to 275 lb for the Falcon (3) 195 model, based on the compliance testing, but suggested the optimum range is 200 to 240 lb. It notes:

> *'Be advised that pilots with hook in weights within 20 lbs of the minimum recommended will find the Falcon somewhat more demanding of pilot skill to fly.'*

The student pilot involved in this accident weighed 134.5 lb. It was estimated that her 'hook in' weight was not more than 150 lb.

In the flying section of the manual it notes:

> *'At speeds faster than trim, you will be holding the bar in pitch against substantial force, and if you let go to move your hand the glider will pitch up and roll towards your remaining hand.'*

The manual advises that the normal operating speed range is 20 mph to 30 mph and the maximum steady speed in free flight a pilot can achieve is approximately 42 mph. The V_{NE} is stated as 48 mph. The trim speed can be set by ground adjustment of the hang point position on the keel; the trim speed would typically be set to be within the normal operating speed range.

The BHPA Technical Manual, Section 2, Chapter 7, subpart 4C details the requirements for a hang glider being aerotowed and includes the following requirement for its speed range:

> *'The mid-point of the glider's placarded max All Up Weight (AUW) speed range must lie within the tug's placarded tow speed range. (This is to ensure that the glider is capable of flying at the tug's safe operating speeds).'*

The placard on this type of hang glider states that the stall speed at maximum pilot weight is 25 mph and that V_{NE} is 48 mph, giving a mid-range speed of 36.5 mph.

Maintenance

There are no formal airworthiness requirements for hang gliders but this one was reportedly inspected regularly, including daily and pre-flight inspections, in line with the requirements of the manufacturer's maintenance schedule. When not in use, it was stored in a hangar in the rigged condition. No maintenance records were available, nor were they required to be kept. The hang glider was reported as being less than a year old and appeared to be in satisfactory condition. No pre-existing defects were found that could affect its airworthiness.

Controlling a hang glider

Control of a hang glider is achieved by the pilot moving their weight relative to the hang glider wing. The shift of weight provides an out of balance force to which the hang glider responds. The weight of the pilot affects controllability, as control is achieved through the movement of the pilot's weight; lower pilot weight results in less control force.

Pitch control

Pitch control is achieved by the pilot shifting their weight forward and aft. Each hang glider has a natural trim or 'hands-off' speed and this is the speed it will fly at without pilot input. The hang glider is stable around this speed and will naturally react to any deviation from this speed and return to its trim speed. For example, if its speed is increased, the hang glider will naturally pitch up and this will cause its speed to reduce. The pilot can fly the glider faster than the trim speed by shifting and maintaining their weight forward. This counters the natural tendency of the hang glider to pitch up as speed increases and, as a result, it will stabilise at a higher speed for as long as the pilot holds their weight forward.

As towing speeds are generally above trim speed, it is common practice to attach one end of the towing bridle to a position on the keel forward of the control bar. This applies a nose down force to the hang glider to assist the pilot in maintaining the correct pitch attitude during the tow.

Roll control

Roll control is achieved by the pilot shifting their weight laterally, from side to side. The roll will commence as soon as the pilot moves sideways due to the, now, uneven weight distribution generating an uneven load across the wing. The wing is designed to flex and help the roll develop. Sideslip towards the lower wing will also develop, as a secondary effect of roll, and this will cause the wing to roll further into the turn and the nose to drop. Due to the natural characteristics of this type of wing, as speed increases it becomes more directionally unstable. The design is, by necessity, a compromise between sufficient low speed control authority and satisfactory high speed directional stability.

Personal safety equipment

The pilot was wearing a helmet approved to European Standard EN966 - *Helmets for Airborne Sports*. It appeared that it had been subject to considerable force during the accident but had otherwise been in good condition.

Pathological information

An aviation pathologist carried out a post-mortem examination on the pilot. He observed that there was a severe head injury but, apart from fractures of the jaw and a rib, there was no other significant injury. He considered that the force with which the pilot's head struck the ground would have exceeded the helmet's design limits.

Organisational information

The sport of hang gliding is not regulated in the UK but is conducted under the supervision of the BHPA. The BHPA oversees pilot and instructor training standards, provides technical support such as airworthiness standards, runs coaching courses for pilots and supports a country-wide network of recreational clubs and registered schools. The BHPA provides a Technical Manual covering all activities under their supervision.

Aerotowing with a microlight aircraft is a regulated activity and was first approved in the UK by the Civil Aviation Authority in 1994.

The sport of hang gliding has developed around the world during the last 50 years. Hang gliders were initially foot launched from a hill. This method has some limitations; notably that a hilly area is required, the equipment has to be carried to the top of the hill and the weather and wind conditions have to be suitable. This means that the learning process is often lengthy and is usually carried out as a solo pilot, although some tandem flights are available.

Launch systems were developed, using winches or static lines, and some of these are suitable for tandem hang gliders. Aerotowing is a more recent activity, which allows a tandem hang glider, with an instructor and student, to be towed to a greater height, typically around 3,000 ft aal, thereby allowing more airborne and training time. Training can take place over a generally flat area, giving smoother air conditions and a possible landing back at the launch point. Thus, more training flights are possible in a shorter space of time.

Aerotowing is widely considered to be the most demanding of the hang gliding launch procedures. Some pilots progress through foot launching and winch launching before attempting aerotows. Ab initio aerotow training is carried out at a number of locations. The BHPA advises that a typical number of tandem launches before solo flight is between 15 and 20. Recognising the demanding nature of aerotowing, this school introduced an assessment system, such that students were evaluated on their ability during the early tandem flights. Only the more able were allowed to progress towards an aerotowed first solo; other students progressed using a winch launch system.

Aerotow operation on the accident flight

The hang glider was fitted with integral wheels for the launch; this was a similar configuration to the tandem hang glider used for training. More commonly, for a solo launch, a trolley is used which remains on the ground after the hang glider lifts off. The BHPA considered a trolley launch to be a progression and that early solo flights should be kept as similar in configuration to the tandem flights as possible.

A number of people were involved with this aerotow launch procedure. As well as the towing pilot and the student pilot, there was the instructor, with a radio, who was on the ground, alongside the student pilot at the start of the launch. There was an observer (Signaller 1) by the hang glider, equipped with a bat to signal when all was ready for the tow to start, and an observer (Signaller 2) ahead of the towing aircraft to receive and relay these signals to the towing pilot (see Figure 1).

Several instructors, who were familiar with aerotow operations, noted that it was fairly common for students to enter an oscillation after takeoff during the early stages of their training.

Analysis

Training

The student pilot had completed a structured training programme at a BHPA approved school. Although the number of dual aerotows completed was less than the typical number reported by the BHPA, the instructor considered that the student had demonstrated that she was more than capable of progressing to solo flight and additional dual training was not necessary.

The training programme was comprehensive and included recovery from unusual attitudes, stalls, lockout and oscillations. However, such training is, by necessity, carried out at a safe altitude with an instructor.

During the first solo flight, initially a lateral oscillation developed, followed by a deviation to the left. The student pilot released herself from the tow and made a controlled landing into wind. The recovery manoeuvre was carried out well and gave the instructor additional assurance that the student pilot was ready for solo flight.

The second solo flight started with a roll and deviation to the left at an early stage. Although there was an attempted correction, it was not sufficient and the deviation increased. This time, the towing pilot released first. The student pilot released soon afterwards but the hang glider would have been exposed to different release forces from those experienced during the first solo flight. It is possible that the student pilot delayed making corrections as a result of her experience during the first solo flight.

Although the training is designed to expose a student to many possible scenarios, when an unusual attitude or event is experienced close to the ground the pilot's view is different because of the changed perspective. Furthermore, the time available to make a recovery is short and requires quick, accurate corrective action.

Towing aircraft and hang glider

No defects were found with either the towing aircraft or the hang glider that could have contributed to the accident.

The pilot's hook-in weight was below the minimum recommended for the hang glider. Although the additional landing gear increased the overall weight, it did not form part of the moveable weight used to control the hang glider. The low pilot weight would have, according to the manufacturer's literature, made the hang glider

> *'somewhat more demanding of pilot skill to fly'.*

The speed range of the towing aircraft should match the speed range of the hang glider, to enable both to remain within their design limitations during the tow. The towing aircraft has a tow speed range of 37 to 55 mph. Towing operations were conducted at a speed of 40 to 41 mph, although, due to the characteristics of the towing aircraft, the speed would be higher at lift off. Whilst this was within the recommended hang glider speed range, the operating limitations for the towing aircraft required the towed hang glider to have a sustainable maximum speed of 55 mph. This hang glider has a V_{NE} of 48 mph and in free flight the maximum sustainable speed a pilot can achieve is around 42 mph. Also, the BHPA Technical Manual requires the mid-point of the hang glider's speed range to be within the placarded tow speed range of the towing aircraft. In this case, it was just below that.

General takeoff characteristics for this aircraft combination

During the launch, the speed of the hang glider increases to near its recommended maximum in the period from just after lift off until the towing aircraft has taken off. The speed then reduces to the normal tow speed in the climb out. This means that the hang glider is above its trim speed and, therefore, requires a nose down input to prevent it from climbing out of position. This force is provided, in part, by the pilot but mainly by the end of the towing bridle attached to the keel.

The directional stability of the hang glider becomes increasingly unstable as its speed increases. In the period just after lift off, a student pilot is taught to control pitch to avoid climbing too high and, separately, to control any roll deviation that may develop. At this time, the towing aircraft's speed peaks and the hang glider is close to its maximum recommended speed and is, therefore, more directionally unstable. Instructors commented that inexperienced pilots often develop lateral oscillations just after takeoff, which is an indication of this inherent instability. More experienced pilots have the skill to correct and manage this instability before it develops into an oscillation. If a lateral deviation develops, the speed of the hang glider will increase further (much like a water skier traversing behind a boat) and this increase in speed makes it more unstable and, therefore, more difficult to control.

Accident flight

The student pilot appears to have controlled pitch and maintained the correct vertical position during the takeoff but, from shortly after lift off, the hang glider did not maintain the correct lateral position behind the towing aircraft. The length of the tow line being used was just below the minimum length specified by the Tug Manual and that recommended by the BHPA Technical Manual. This reduced the pilot's margin for error and meant any angular deviations would develop more quickly. A longer tow line effectively allows more time for a pilot to recognise and react to any deviations.

The hang glider rolled to the left soon after lift off. Once it started to deviate from the proper towing position, its speed and, therefore, the nose up pitch force would have increased rapidly. The towing bridle attached to the keel would have helped the pilot to counter this force, up to the limit of the tow line weak link. Although the weak link fitted to the tow line was above the value specified by the Tug Manual and recommended by the BHPA Technical Manual, it was not possible to determine whether or not a weak link of the specified value would have broken and released the tow before the tow line was manually released by the towing pilot.

As the deviation to the left developed, it would have rapidly reached a point where the pilot no longer had sufficient roll control authority and the only course of action was to release the tow. The towing pilot saw the deviation developing and released the tow line. This was closely followed by the student pilot releasing the tow line, using the hand lever on the control bar. At the point of release, the tow line tension was likely to have been high and the release would have caused the hang glider to pitch up rapidly as a natural response to the removal of the nose down force on the keel.

Because the hang glider was banked to the left, the pitch up would have been into the turn. The action of the pilot in moving her right hand to release the tow could have caused the glider to pitch up and roll left even more. By this stage, the situation may not have been recoverable, especially for a student pilot with the limited height available.

Safety actions

The BHPA has initiated an in-depth review of aerotowing procedures and will be paying particular attention to the equipment being used and any special requirements for initial solo flights.

The BHPA is also reviewing its audit and inspection processes for aerotowing operations, to ensure that all the elements identified in the above review are regularly and thoroughly checked.

Further relevant actions

Following this accident, the manufacturer of the towing aircraft reviewed the Glider Tug manual and has applied to the BMAA to remove the hang glider sustainable maximum speed requirement. This is to ensure there is no conflict between operating criteria in this manual and that contained in the BHPA Technical Manual, Section 2, Chapter 7 which covers aerotowing procedures for hang gliders. A statement requiring all aerotow operations to be in accordance with the BHPA aerotowing procedures will remain.

Conclusions

From shortly after takeoff, the hang glider did not maintain the correct position behind the towing aircraft and entered an increasing roll to the left. It rapidly deviated from the desired flight path and, despite the tow line being released, resulted in a loss of control from which the student pilot did not recover.

A number of factors were identified that could have made it more difficult for the student pilot to maintain the correct towed position.

The BHPA has initiated an in-depth review of aerotowing procedures and is also reviewing its audit and inspection processes.

ACCIDENT

Aircraft Type and Registration:	Magni M24C gyroplane, G-ORDW
No & Type of Engines:	1 Rotax 914-UL
Year of Manufacture:	2011
Date & Time (UTC):	2 March 2012 at 1500 hrs
Location:	Cark Airfield, Cumbria
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - 1 (Minor)
Nature of Damage:	Rotor blades, propeller, cabin and tail
Commander's Licence:	Private Pilot's Licence
Commander's Age:	62 years
Commander's Flying Experience:	238 hours (of which 91 were on type) Last 90 days - 13 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The pilot attempted to execute a go-around from just above the runway. The gyroplane rolled to the right on application of right rudder and full power, and the right main wheel contacted the ground. The aircraft rolled over, coming to rest on the runway on its right side. The pilot and his passenger escaped serious injury.

History of the flight

The pilot had purchased the gyroplane new in 2011 and had been flying it since November 2011, having converted to gyroplanes from fixed wing types. He based G-ORDW at Cark Airfield on the north shore of Morecambe Bay. The airfield has a hard runway, orientated 06/24 and 500 m in length by 15 m width. To either side of the runway was 100 m of open and unobstructed grassland, with 12 m strips of compacted earth along each side the runway, suitable for gyroplane operations. The pilot had flown about 30 hrs P1 on the type before the accident flight, including about 15 hrs in G-ORDW. The flight was to be his first in the aircraft with a passenger.

The pilot gave his passenger a thorough safety briefing, including operation of the doors and four-point safety harness. The weather was suitable, with scattered cloud at about 2,500 ft and a surface wind from about 200° at 5 to 8 kt. The aircraft departed from Runway 24 and completed an uneventful flight of about an hour before the pilot returned to the airfield for landing. The weather was as before, and as the wind was blowing at approximately 40° to the runway centreline, the pilot planned to land directly into wind, across the runway and compacted ground strips.

The first approach was normal, except that the pilot realised it would result in landing slightly long so he flew a go-around. On the second approach, the expected touchdown was at the correct place, at the beginning of the hard runway and the pilot reduced engine power to idle for landing. He immediately became aware that the aircraft was drifting to the right. As the aircraft crossed the runway edge and just a few feet above it, the pilot applied left rudder to correct the drift, and the aircraft yawed left, placing it almost sideways on to its direction of travel.

The pilot immediately applied right rudder and full power with the intention of going around, but as well as yawing right, the aircraft also rolled right and the right main wheel struck the runway surface, causing the aircraft to roll over onto its right side. The rotor blades and propeller struck the grass, while the nose and nosewheel made contact with the runway. The aircraft then rotated under the influence of the turning rotor head and came to rest on the runway, pointing 90° to the left of runway heading.

After confirming that his passenger was not seriously injured, the pilot secured the aircraft by operating the fuel cut-off control and isolating electrical power. Personnel on the airfield quickly arrived to assist, and an ambulance was called (although this was later stood down when it became clear there were no serious injuries). The pilot was uninjured, while his passenger suffered a small cut to her shin and bruising consistent with the forcible restraint provided by her harness.

Pilot's analysis

In a very detailed and candid report, the pilot offered an analysis of the event. He was comfortable that the decision to land at an angle to the runway centreline was sound, given the suitability of the surface and the gyroplane's ability to stop very quickly after touchdown. While the wind was well within his ability and experience to deal with, he thought that it had either changed in direction between approaches, or that his second approach had not been directly into wind, causing the right drift over the runway.

Application of left rudder to correct the drift had been incorrect, and the pilot was aware that he should have applied left cyclic control instead. The decision to go-around had been taken just a little too late. On application of go-around power, the aircraft would yaw left and roll to the right, requiring right rudder and left cyclic to correct. The pilot recalled already having right rudder applied to correct the drift, but thought that he had not applied left cyclic to correct the expected right roll.

ACCIDENT

Aircraft Type and Registration:	Rans S6-ES Coyote II, G-CCJN
No & Type of Engines:	1 Rotax 582-48 piston engine
Year of Manufacture:	2005
Date & Time (UTC):	5 February 2012 at 1300 hrs
Location:	Eshott Airfield, Northumberland
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Nose leg, cockpit floor and right main leg damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	64 years
Commander's Flying Experience:	781 hours (of which 127 were on type) Last 90 days - 3 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft engine stopped at low height, shortly after takeoff. The pilot turned back to the airfield and attempted a landing on a secondary runway, but the aircraft landed heavily, causing damage to the landing gear and forward fuselage. Neither occupant was injured.

History of the flight

Following normal pre-flight inspection and checks, the pilot taxied the aircraft for Runway 26. The pilot was accompanied by a co-owner of the aircraft as his passenger. The weather was fine, with a light westerly surface wind. Pre-takeoff checks were carried out, which included running the engine at full power: all indications appeared normal.

Takeoff and initial climb proceeded normally until the aircraft was at about 200 ft, at which point the engine suddenly stopped. The pilot lowered the nose and, as there was no runway remaining ahead, started a right turn back towards the airfield whilst attempting to re-start the engine. He determined that his best option was to continue the right turn to land on the cross Runway 19, a tarmac runway with a grass strip beside it.

The aircraft reached the grass strip but, with little height and speed in hand, the pilot was unable to carry out a normal flare. The aircraft hit the ground heavily in a nose low attitude, causing the nose leg to collapse and fold up under the forward fuselage. The right main leg was also damaged.

Both the pilot and his passenger were wearing lap strap seatbelts with diagonal shoulder straps. Neither was injured and both were able to exit the aircraft unaided. The cause of the engine failure had not been established at the time of reporting, but fuel starvation was considered by the pilot to be a probable cause.

AAIB comment

The engine failure occurred at a critical stage of flight. The success of the manoeuvre was probably due to the pilot's experience and familiarity with the aircraft and airfield, together with relatively benign weather conditions and favourable airfield layout. However, the aircraft sustained significant damage and was probably close to the stall when the pilot attempted to flare. Previous experience has shown that a number of attempted turn-backs have resulted in loss of control, normally due to decayed airspeed, with sometimes fatal outcomes. In all but exceptional circumstances, the safest course of action following an engine failure immediately after takeoff is to land straight ahead, maintaining airspeed and turning only as much as may be required to avoid obstacles.

ACCIDENT

Aircraft Type and Registration:	Savannah Jabiru(4), G-CDAT
No & Type of Engines:	1 Jabiru Aircraft PTY 2200 piston engine
Year of Manufacture:	2004
Date & Time (UTC):	17 February 2012 at 1642 hrs
Location:	Eshott Airfield, Northumberland
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Nose leg collpased and propeller damaged
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	66 years
Commander's Flying Experience:	97 hours (of which 60 were on type) Last 90 days - 9 hours Last 28 days - 9 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Description of the event

The pilot reported that he was making a powered approach to Runway 26 at Eshott, with a surface wind from 240° at about 18 to 25 kt. At about 6 ft above the runway the pilot encountered what he described as wind shear, causing the aircraft to descend suddenly, contact the runway firmly and bounce. It then stalled and landed again in a nose low attitude, causing damage to the propeller and the nose leg structure. The aircraft came to a halt on the runway. The pilot shut down and secured the aircraft before vacating with his passenger. Both were unharmed.

ACCIDENT

Aircraft Type and Registration:	VPM M16 Tandem Trainer gyroplane, G-CVPM
No & Type of Engines:	1 Rotax 912ULS piston engine
Year of Manufacture:	1998
Date & Time (UTC):	14 February 2012 at 1529 hrs
Location:	Halfpenny Green (Wolverhampton) Airport
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Upper part of rudder and propeller tips
Commander's Licence:	Private Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	75 hours (of which 58 were on type) Last 90 days - 1 hour Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot had stopped at Halfpenny Green to refuel on a trip from Yorkshire to the pilot's home base near Exeter. After refuelling, he taxied the aircraft to Runway 34 for departure. The pilot began pre-rotation of the rotor, but was unable to hold the aircraft stationary on the brakes. At about 110 rotor rpm the pilot moved the cyclic control aft. The rpm was less than desired, but the pilot thought it would be safe to do so and it would assist rotor rpm build up. With the rotor at less than normal flying speed, the gyroplane pitched nose-up and there was severe vibration through the cyclic control. The pilot pushed it forwards again and reduced power before taxiing back to the apron. Upon inspection, a section of the top of the gyroplane's rudder was found to be missing, along with tips of the propeller blades. Photographs supplied by the pilot also showed damage to a rotor blade, consistent with the disc having flapped back into contact with the rudder and propeller.

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1/2010 Boeing 777-236ER, G-YMMM
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at 1 nm south-east of North Caicos
Airport, Turks and Caicos Islands,
British West Indies
on 6 February 2007.

Published May 2010.

3/2010 Cessna Citation 500, VP-BGE
2 nm NNE of Biggin Hill Airport
on 30 March 2008.

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4/2010 Boeing 777-236, G-VIIR
at Robert L Bradshaw Int Airport
St Kitts, West Indies
on 26 September 2009.

Published September 2010.

5/2010 Grob G115E (Tutor), G-BYXR
and Standard Cirrus Glider, G-CKHT
Drayton, Oxfordshire
on 14 June 2009.

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6/2010 Grob G115E Tutor, G-BYUT
and Grob G115E Tutor, G-BYVN
near Porthcawl, South Wales
on 11 February 2009.

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7/2010 Aerospatiale (Eurocopter) AS 332L
Super Puma, G-PUMI
at Aberdeen Airport, Scotland
on 13 October 2006.

Published November 2010.

8/2010 Cessna 402C, G-EYES and
Rand KR-2, G-BOLZ
near Coventry Airport
on 17 August 2008.

Published December 2010.

2011

1/2011 Eurocopter EC225 LP Super Puma,
G-REDU
near the Eastern Trough Area Project
Central Production Facility Platform in
the North Sea
on 18 February 2009.

Published September 2011.

2/2011 Aerospatiale (Eurocopter) AS332 L2
Super Puma, G-REDL
11 nm NE of Peterhead, Scotland
on 1 April 2009.

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