CONTENTS

SPECIAL BULLETINS

None

COMMERCIAL AIR TRANSPORT

GENERAL AVIATION

CONTENTS (Continued)

SPORT AVIATION / BALLOONS

(ALL TIMES IN THIS BULLETIN ARE UTC)

ACCIDENT

Aircraft Type and Registration:	BAe.ATP, G-MANH
No & Type of Engines:	2 Pratt & Whitney Canada PW126 turboprop engines
Year of Manufacture:	1989
Date & Time (UTC):	9 April 2011 at 0147 hrs
Location:	Cardiff Airport
Type of Flight:	Commercial Air Transport (Cargo)
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Both right main landing gear tyres, gear leg components, hydraulic pipes and flap/nacelle fairings damaged
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	56
Commander's Flying Experience:	10,138 hours (of which 1,379 were on type) Last 90 days - 85 hours Last 28 days - 28 hours
Information Source:	AAIB Field Investigation

Synopsis

During an otherwise normal landing at Cardiff, a failure in the right landing gear freed the axle to oscillate about a vertical axis, leading to severe damage and deflation of both tyres. The original failure was the result of the corrosion induced weakening of a threaded attachment. Consequent overload fracture of another component appears to have taken place before the Cardiff landing. The landing gear manufacturer is introducing a new Service Bulletin to address the deterioration of the corroded and failed area in service and amending the build procedure to obviate the possibility of surface damage during component assembly creating an origin for a corrosion process. A further problem noted during the fleet inspection following the original event has been addressed in the final Service Bulletin.

History of the flight

The aircraft was on a night cargo flight from East Midlands Airport to Cardiff. The flight was routine with the co-pilot as the Pilot Flying (PF). The surface wind at Cardiff was from 060° at 9 kt and Runway 12 was in use. In accordance with the company standard operating procedures, shortly after touchdown the PF selected full reverse thrust with the commander intending to take control at 60 kt. As the aircraft decelerated through about 80 kt the crew noticed an abnormal, lateral vibration that appeared to be increasing. The commander took control and stopped the aircraft on the runway, suspecting a burst tyre. The crew informed ATC and shut down the engines using normal procedures. Inspection of the landing gear and runway by the crew and the Airport Fire and Rescue

Service (AFRS) revealed damage to and deflation of both tyres on the right main landing gear along with airframe damage. Two metal components were recovered from the runway. Approximately four hours later the aircraft was then unloaded and towed clear of the runway.

Subsequent examination

The aircraft was first viewed by the AAIB whilst parked on Taxiway D, adjacent to Runway 12. At the time of this first examination, it was noted that temporary installation of an apex pin in the torque link assembly of the right landing gear had taken place. This was reported to have been carried out after absence of the original pin was observed following the landing event.

Initial AAIB examination of the tyres revealed circular cutting of the sidewalls on the inner face of each, including tearing of the carcass structure through the sidewalls and across the treads. Some damage to the upper torque link was also visible.

Metallic items and considerable quantities of tyre debris were recovered from the runway during a series of inspections carried out shortly after the incident. The metallic items were identified as the apex pin and the castellated nut which secures the former component in position. The locations from which the pin and nut were reportedly recovered were in the region of the touch down zone. Subsequent runway examination in that area revealed unusual markings, to the right of the centreline. Although not definitely attributable to this aircraft, they were consistent with the likely effect of oscillating motion of a double wheeled axle in a horizontal plane. This appeared to have resulted in a mixed rotation and translational motion of the wheels with consequent tyre skidding. The unusual runway marks were in the region of the concentration of the normal linear rubber markings caused by typical landing tyre contact.

Main landing gear design

The main landing gear leg of the ATP has conventional torque links attaching the sliding tube (sometimes known as the sliding member) and axle assembly, together with the wheels and brakes, to the upper section (main fitting) of the leg. The link system constrains the axle against rotating in the horizontal plane.

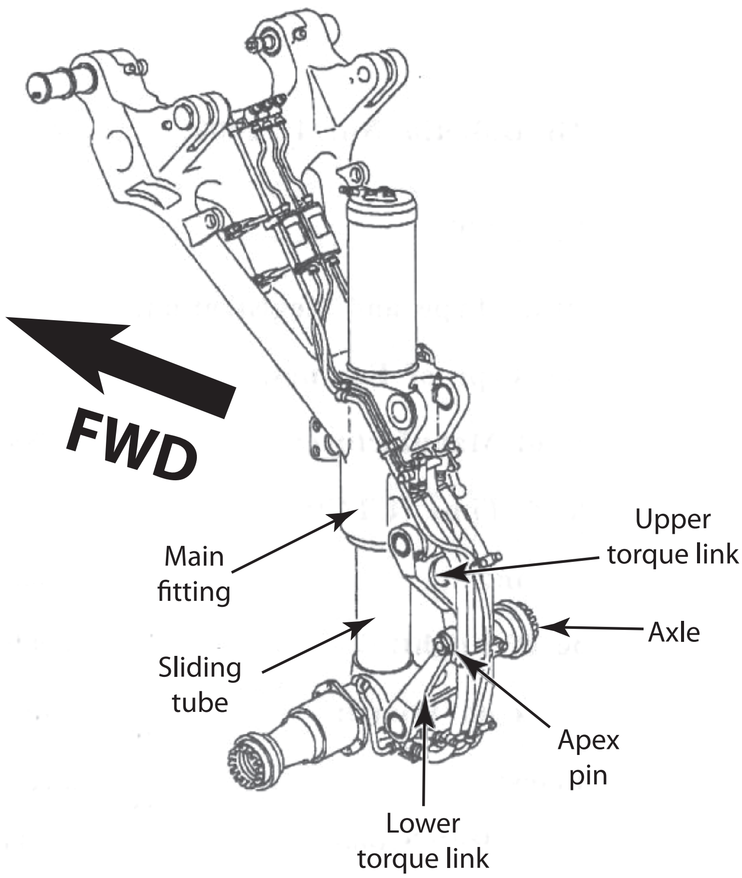

Figure 1
General view of leg with wheels and brakes removed

The upper torque link is pivoted on the aft face of the main fitting, whilst the lower link is similarly pivoted from the aft face of the axle/sliding tube assembly. The aft ends of each link incorporate an offset lug. The offsets enable an apex pin to pass horizontally through both lugs. Each link, when viewed from vertically above, is approximately triangular in profile and incorporates a pair of broadly spaced lugs at its forward end, with aligned horizontal axes and forming two apexes of each triangular component. The links are each pivoted via these lugs on corresponding fixed attachment lugs also having in-line horizontal axes. One pair of fixed lugs is mounted on the main fitting and carries the upper torque link whilst a further pair is on the sliding tube/axle assembly carrying the lower link. This pivot arrangement thus renders each link attachment rigid in a horizontal plane but permits angular movement in a vertical plane and hence controlled extension and compression of the sliding tube in the main fitting.

The lugs at the aft end of each link have bushed horizontal bores. The apex pin attaching the aft lugs together is secured in position by a large castellated nut screwed onto a threaded end portion of the pin. The pin also passes through a bracket and a washer fitted between the lugs and a shim positioned beyond the lug of the upper link directly secured by the castellated nut. (The bracket locates flexible hydraulic pipes routing to and from the brake units.) The castellated nut is prevented from rotating on the pin threads by a small diameter threaded locking bolt passing through the castellations and through one of two bores in the pin. These are orientated at 90º to the pin axis and 90º to one another. The shim thickness is varied to enable the backlash of the installed apex pin to be controlled on assembly, since the axial position of the castellated nut on the threads of the apex pin is dictated by the presence of the locking bolt and can only be varied in discrete steps corresponding to approximately $^{1}/_{12}$ of a

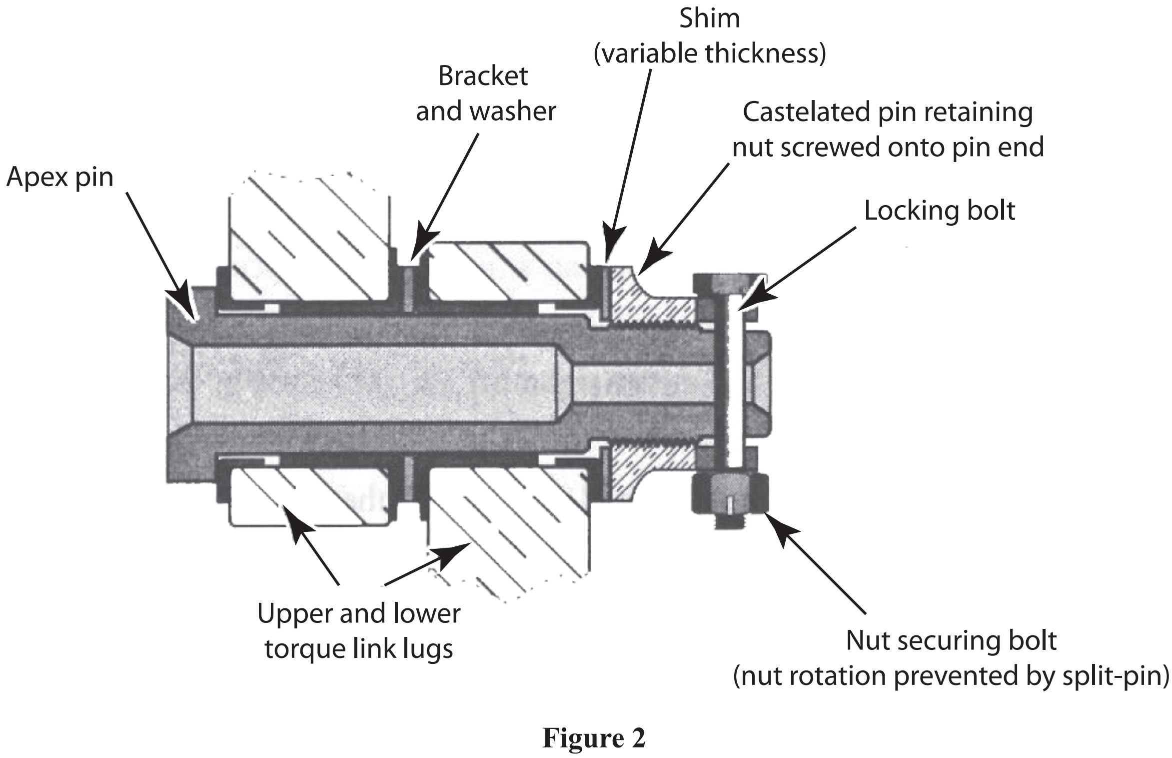

Figure 2

Section through apex pin, torque link lugs, castellated nut and locking bolt rotation. The locking bolt itself is secured by a small castellated nut screwed onto its threaded end having a split pin to prevent relative rotation.

The apex pin has a plain head termination at the opposite end to the threaded portion, enabling it to be secured, by a special tool, against rotation during assembly and maintenance operations. The mid portion is chromium plated and ground to enable a close fit to be achieved within corresponding bushes in the two torque link aft lugs. The aft lugs of the torque links incorporate grease nipples to lubricate the contact surfaces between the lug bushes and the apex pin. The pin and the nut are totally cadmium plated (with the exception of the chromium plated bearing sections of the pin).

Activity at accident site

Following AAIB examination, the aircraft was jacked and the wheels removed. It was then equipped with slave wheels and tyres before being towed to a hangar where the landing gear leg was replaced. The removed unit was forwarded to the leg manufacturer for detailed examination. The apex pin and nut were both retained by the AAIB for further investigation.

Initial examination showed that the chromium plated bearing surface of the shank of the apex pin was in good condition indicating correct fit and adequate lubrication. The locking bolt was largely destroyed, only the centre portion surviving, remaining within one of the bores in the apex pin. Neither the hexagonal head of the locking bolt nor the threaded portion at its opposite end, the small securing nut, and the split pin, were recovered during the runway inspections.

Detailed examination

The external threads on the pin and corresponding internal threads in the castellated nut were found to be extensively corroded. Those thread forms on the pin closest to the chromium plated bearing region still retained approximately the correct major diameters whilst those over most of the remaining length were significantly reduced in that diameter. The minor diameters of the thread forms within the nut had been altered to be of larger than standard diameters. Two deep internal axially orientated grooves through the threads were evident at diametrically opposite locations in the bore of the nut. The crests of the thread forms on the pin and within the nut showed evidence of relative axial movement. Examination of the fractured ends of the surviving mid portion of the locking bolt revealed that the fracture faces were of irregular conical /spherical shape.

History of the landing gear leg

The landing gear leg was last overhauled by Messier Services UK Repair and Overhaul Company in 2004. It was installed in the right-hand position on G-MANH on 12 May 2004 by an operator of the type during a post-lease check. This was carried out at that operator's Ronaldsway, Isle of Man (IOM) base. It appears that the aircraft remained parked at that location until 20 August 2004. It was then flown to Bucharest, Romania, for conversion from passenger to freight configuration. It was not flown again until 19 January 2006.

Previous experience

Broadly similar failures were reported on corresponding components of two ATP aircraft in 1999. In both cases repeat axial loadings appeared to have caused progressive damage to the flanks of the threads on both the pin and the nut until thread damage permitted loss of engagement and allowed the castellated nut to be driven axially along the pin.

In the previous two incidents, however, no thread corrosion was reported. Following those events a mandated Service Bulletin (SB) was drawn up by the aircraft manufacturer to instruct aircraft level activity and referred to a SB issued by the landing-gear manufacturer. This required dismantling of the torque link assembly for initial inspection after which periodic assessment of the end float of the nut/pin assembly is required and, where appropriate, dismantling of the joint and measurement of the threads. No similar failures have been reported in the eleven years since the imposition of the SB.

Other information

The present operator of the type in the UK reports that it rotates the fleet in such a way that utilisation is consistent and no aircraft has disproportionate downtimes or excessive calendar times between lubrication of the torque link bearings.

The pins are predominantly cadmium plated and the ground bearing surfaces are chromium plated, thus providing overall corrosion protection. The nuts are also cadmium plated. However, a number of dissimilar materials co-exist in close proximity once the torque links and pin are fully assembled. Under normal circumstances operation of the aircraft causes angular movement of the links and rotary relative movement of the pin within the links. This serves to spread lubricant and coat surfaces, supplying a degree of additional surface protection not present if any faces are not coated. Lubricant exiting from the bearing areas generally coats the exposed threads. There is no known history of significant corrosion of the pin and nut combination in normal operation.

Analysis

The condition of the internal thread forms in the castellated nut and the external threads on the pin were consistent with corrosion having removed material from the flanks of the thread forms in the nut and on the pin. This combination had apparently reduced the depth of mutual engagement to the point where the threaded joint was unable to carry its design axial load. The destruction of the locking bolt, the presence of internal axial grooves created within the nut (apparently by the fractured end faces of the locking bolt) and damage to the crests of the engaging thread forms, were all features consistent with axial separation of the castellated nut from the pin.

It was clear that axial loading had failed the corrosion weakened thread engagement. This had initially transferred the end load, applied via the lugs to the castellated nut, from their design support medium - the threaded joint between the pin and castellated nut - to the locking bolt (normally intended purely to prevent rotation of the castellated nut on the pin).

The nature of the visible damage to the ends of the surviving mid section of the locking bolt (being approximately conical / spherical in shape) was consistent with a sequence of discrete double shear loads being applied with different angular orientations by the castellated nut, after failure of its thread engagement, on the pin. This in turn was consistent with the bolt rotating in its bore in the pin between a series of shear load applications.

The failure of the weakened joint between the castellated nut and apex pin was thus the result of a sequence of loads applied to the nut through the torque links. These are presumed to have been caused by oscillating angular movement of the axle in a horizontal plane. Such repeat loading and failure was consistent with the effects of shimmy applied to a weakened nut/pin joint also having reduced angular restraint on motion of the axle in the horizontal plane. Once complete failure of the lock bolt had occurred, the nut was no longer effectively restrained axially on the apex pin. The deteriorated state of the two engaging thread forms enabled the apex pin to continue translating to the end of the apex pin under oscillating load from the torque link lugs. Once the nut separated from the pin, the latter was free to fall out of the lugs of the torque links, allowing complete freedom of the axle to oscillate in a horizontal plane.

The location at which the apex pin and castellated nut were found on the runway indicates that final failure occurred almost immediately after touchdown. This, coupled with the failure to find any of the separated parts of the locking bolt, its nut and the split pin anywhere on the Cardiff runway, suggests that initial failure of the pin and castellated nut thread engagement occurred during previous operations on the ground elsewhere.

Significance of service history

The component history record shows that a newly overhauled landing gear unit was fitted in the right position on G-MANH in May 2004, at Ronaldsway IOM. The aircraft remained parked there for over 3 months. The proximity of Ronaldsway to the sea causes a saline atmosphere to prevail. It is possible that the saline atmosphere, combined with some surface damage to engaging threads sustained on assembly and the proximity of dissimilar metals once assembled, allowed corrosion to initiate during the three months idleness at Ronaldsway. During this period without relative movement of the pin within the bushes, comprehensive distribution of lubricant would not have taken place. The pin would thus have been more vulnerable to initiation of corrosion if some damage to the plating had occurred when the threaded joint was assembled during overhaul.

The aircraft subsequently carried out a single flight to a conversion centre near Bucharest where it spent a total time of approximately 18 months idle whilst under conversion and in storage.

Summary of failure sequence

From the evidence it has been deduced that the sequence of failure was as follows:

(1) The initial parts of the failure process occurred during ground operation prior to arrival at Cardiff.

(2) Corrosion damage to engaging thread forms progressively reduced the strength of the joint between the castellated nut and the apex pin on the right landing gear.

(3) During ground operation, the castellated nut was loaded by horizontal forces in the torque link lugs which exceeded the strength of the weakened threaded joint such that the threads disengaged and the nut was forced to move axially along the threaded portion of the apex pin.

(4) Axial movement of the nut permitted the base radii of the castellations within the nut to come into contact with the shank of the locking bolt.

(5) Reduced angular restraint of the axle as a result of axial migration of the castellated nut along the apex pin allowed directional oscillation or 'shimmy' of the axle to occur. This produced 'hammer blows' on the shank of the locking bolt.

(6) Repeated impacts between the base radii of the castellations within the nut and the shank of the locking bolt resulted in progressive

distortion and double shear failure of the latter and continuing translation of the castellated nut along the apex pin. Axial grooving of the thread forms within the nut was created by the fractured ends of the mid portion of the locking bolt being drawn through the nut.

(7) Final separation of the castellated nut from the apex pin permitted the latter to migrate from the lugs and the sliding tube/axle assembly to rotate (or steer) about the tube axis, leading to high lateral loadings being applied to the tyre treads and the upper torque link cutting into the sidewalls of the tyres. The tyres sustained severe damage and deflated.

No previous instances of corrosion in the apex pin / nut combination have been reported to or recorded by the aircraft or landing gear manufacturers. The reason for the corrosion on this occasion, contrasting with its apparent absence on others, could not be determined. Unusual features of the operating life and storage location of the aircraft immediately after installation of the landing gear unit, however, may have contributed to an initial corrosion mechanism leading to long term deterioration.

Subsequent action

The landing gear manufacturer is replacing the existing SB with a new one to require regular removal of the nut from the pin to check for end float of the threads thereby avoiding the presence of corrosion from preventing float and thereby masking any deterioration of the thread form. It further requires an inspection of apex pin and nut threads for corrosion and replacement of both components if any is present. The likelihood that some surface damage was inflicted on the thread forms of the pin and/or the nut during assembly of the unit on G-MANH is to be addressed by introducing a jointing compound on the thread forms during future assembly operations. The unit assembly drawings are to be amended by the landing-gear manufacturer to reflect this modified procedure. The locking bolt, nut and split pin are to be discarded at each inspection and replaced with new items.

The landing gear manufacturers new SB is being reviewed by the aircraft manufacturer to enable its own SB to incorporate the controlling actions instructed by the landing gear manufacturer's SB. The aircraft manufacturer intends recommending to EASA that their revised SB be considered for Airworthiness Directive (AD) action.

Further event

During a fleet inspection carried out as a result of the failure, a fractured locking bolt was found on an apex pin on another aircraft. The castellated nut remained correctly screwed onto the apex pin. Examination of the fracture face of the bolt indicated a fatigue mechanism as the cause of the failure. A requirement to replace the locking bolt and nut with new items during re-assembly following implementation of the inspection action was therefore incorporated in the SB as described above.

ACCIDENT

Aircraft Type and Registration:	Beech 90, N46BM
No & Type of Engines:	2 Pratt &Whitney PT6A-28 turboprop engines
Year of Manufacture:	1978
Date & Time (UTC):	18 May 2011 at 1131 hrs
Location:	Kinson Manor Farm, Bournemouth
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Substantial damage to airframe and powerplants; landing gear collapsed
Commander's Licence:	FAA Commercial Pilot's Licence
Commander's Age:	47 years
Commander's Flying Experience:	800 hours (of which 660 hours were on type) Last 90 days - 13 hours Last 28 days - 6 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft's climb rate was lower than expected after takeoff and it was subsequently unable to maintain altitude. The pilot made a forced landing into a field. The cause of the apparent power loss was not determined.

History of the flight

The pilot had planned to fly from Bournemouth Airport to Manchester Airport operating the flight as a single pilot, with a passenger seated in the co-pilot's seat. He arrived at the airport approximately one hour before the planned departure time of 1130 hrs, completed his pre-flight activities and went to the aircraft at approximately 1110 hrs. The 1120 hrs ATIS gave the weather at the airport as: surface wind from 230° at 10 kt, visibility 10 km or greater, few clouds at 1,000 ft, broken cloud at 1,200 ft and at 2,000 ft, temperature 16°C, dew point 12°C and QNH 1015 hPa.

After starting the engines, the pilot was cleared to taxi to holding point 'N' for a departure from Runway 26 and he was given clearance to take off at 1127 hrs. At 1129:45 hrs, approximately 55 seconds after the aircraft became airborne, the aerodrome controller transmitted "FOUR SIX BRAVO MIKE DO YOU HAVE A PROBLEM?" because he believed the aircraft was not climbing normally. The pilot replied "NOVEMBER FOUR SIX BRAVO GOING AROUND" and, shortly afterwards, "FOUR SIX BRAVO REQUESTING IMMEDIATE RETURN". The controller cleared the pilot to use either runway to land back at the airport but received no reply.

The pilot carried out a forced landing into a field 1.7 nm west of the Runway 08 threshold at Bournemouth Airport and neither he nor his passenger was hurt.

Information from the pilot

The pilot reported that both engines started normally and the propeller checks that he carried out at the holding point before takeoff were satisfactory (see the section 'Propeller checks' below). He was given takeoff clearance while lining up on the runway and did not bring the aircraft to a halt before applying power.

The pilot believed that, if he selected the propeller levers fully forward (high rpm) and then moved the power levers forward to the torque limit[1], the propellers would exceed the 2,200 rpm limit during the takeoff run. Consequently, he normally took off with the propeller levers approximately half an inch aft of the fully forward position. He used this takeoff technique on the accident flight and recalled that the takeoff seemed normal with no tendency for the aircraft to drift either left or right. There was little crosswind and so he held the ailerons neutral during the takeoff roll and rotated the aircraft at an indicated airspeed of 104 kt. Immediately after leaving the ground, the pilot "dabbed" the brakes and selected the landing gear to UP. Shortly afterwards he noticed that the aircraft had drifted slightly to the left of the runway centreline, although he had not felt a marked swing that would have accompanied an engine failure. He also recalled that the aircraft's heading was still very close to the runway heading. After raising the landing gear, he put his hand back on to the power levers and noticed that the left lever was approximately "half an inch" behind the right lever. He rebalanced the left lever and thought that the imbalance might have caused the aircraft to drift left.

The pilot sensed that the aircraft's rate of climb was not normal although he did not recall the actual rate of climb. He checked the primary engine indications[2] and stated that they "seemed normal". No right rudder was required to keep the aircraft balanced and the pilot did not believe that the left engine had failed. He confirmed that the landing gear and flap were retracted (the takeoff had been made without flap), pushed the power levers forward to increase power and moved the propeller levers aft slightly, believing this would prevent the propellers from exceeding 2,200 rpm.

The aircraft was climbing "but not well" and the pilot asked the controller whether he could return to the airport. He began a right turn intending to fly a circuit to the right and land back on Runway 26. The engine instruments still seemed to the pilot to be indicating normally, and the master warning system generated no warnings or cautions, but he had to lower the nose to maintain the speed above 88 kt, which was the Minimum Single Engine Control speed, V_{MCA}. Shortly afterwards, the pilot realised that the aircraft was no longer climbing and decided to turn left to position for a return to Runway 08. As he began the turn, the EGPWS generated a SINK RATE warning indicating that the aircraft was descending. The pilot levelled the wings and, realising that the aircraft was still descending, decided to land in a field ahead.

The pilot selected the landing gear DOWN as the aircraft neared the field and moved the power levers to idle as the aircraft clipped some trees at the field boundary.

Footnote

[1] The torque limit the pilot used was marked by a solid red line on the torque gauge. See the later section on engine power.

[2] Torque, rpm, and Interstage Turbine Temperature (ITT).

After the aircraft came to a halt, he turned off the fuel and master switches and vacated the aircraft. Neither he nor the passenger was injured.

The pilot stressed that his operating technique on this takeoff was no different than on any other. He could not understand at the time, or subsequently, why the aircraft had performed so differently on this occasion.

Accident site details

The aircraft landed in a large field approximately two miles west of Bournemouth Airport, having flown through some young trees on the southern bank of the River Stour at a height of approximately 10 ft and on a track of around 207º(M). It touched down heavily on all three landing gears in a slightly nose-down attitude. The nose leg detached and was found approximately 50 m from the trees together with additional small items of debris, mainly from the underside of the engine nacelles. Between approximately 90 and 100 m from the trees, coincident with a shallow dip in the surface of the field, ground marks suggested that the aircraft became airborne momentarily. Subsequently, the main landing gear collapsed/retracted and the aircraft slid along on its belly, rotated to the left and came to a halt approximately 180 m from the trees on a heading of 112º(M).

The aircraft remained intact through the impact sequence although the main spar outboard of the left engine broke at some point. There was some creasing in the rear fuselage and there were numerous areas of damage on the leading edges of the wing and horizontal stabiliser caused by contact with the trees. The radome suffered significant damage and the radar antenna dish became detached. There was no fire.

Propeller ground marks

There was a short sequence of propeller blade 'chop marks' in the area of the initial touchdown point. The marks reflected the slight nose-down attitude at impact, which was probably accompanied by significant airframe and landing gear deflections. The distances between successive marks were approximately 60 cm and 56 cm for the left and right propellers respectively. When the memory module in the Honeywell EGPWS was downloaded subsequently (see 'Recorded information' below), the data indicated that the groundspeed at landing was approximately 88 kt. This, in conjunction with the blade mark spacing, gave values of 1,590 and 1,625 rpm respectively for the left and right propellers at impact.

On-site investigation

Examination of the cockpit showed that the pilot had returned the engine controls and switch selections to their normal shut-down positions, although the landing gear selector was found in the UP position. The pilot stated subsequently that he had not raised the lever during the accident sequence and suggested that the passenger might accidentally have knocked it to this position as he left his seat.

The left and right propeller blades displayed a symmetrical degree of damage and the pitch changing mechanism in both hubs failed during the accident sequence. The right propeller piston, mounted on the front of the hub, had broken off and was retained only by the feathering spring and Beta rods.

The aircraft was lifted off the ground in order to obtain fuel samples from the tank drains and from as close to the engines as possible. As it was raised, fuel was seen leaking from beneath both engines from fractured fuel delivery lines. The fuel had clearly been leaking for some time and, while some samples were collected, they were probably not representative of the fuel the engines were using at the time of the accident[3].

There were three fuel tanks in each wing: inner, outer and nacelle. The filler caps were examined for fit and seal condition and found to be satisfactory, which indicated that there was no scope for ingress of significant amounts of water as a result of being parked in heavy rain. A subsequent test revealed that seals on the inner tab mechanisms were in similarly good condition.

Following the on-site examination of the aircraft, the engines were removed for subsequent strip examination under AAIB supervision at an overhaul agent for the engine type.

Examination of the engines

The Pratt & Whitney PT6A-28 is a turbine engine driving a propeller shaft via a two-stage reduction gearbox. There are two major rotating assemblies; one of them being the compressor and its associated turbine, which together comprise the 'gas generator'. The final stage of the compressor is a centrifugal impeller, the outlet scroll of which delivers compressed air into the combustion chamber. The other rotating assembly is the 'free turbine', which consists of a single turbine stage located immediately downstream of, but not connected to, the compressor turbine and which drives the input shaft of the reduction gearbox.

Engine accessories include the primary propeller governor and a fuel control unit (FCU) that meters fuel in response to the power demand on the engine.

Left engine

The engine was fitted to N46BM in December 2007 following overhaul at which point it had achieved 15,243 hours and 10,637 cycles since new. The engine logbook did not record the hours and cycles since overhaul and did not record anything after November 2010. However, the evidence available indicated that, at the time of the accident, the hours and cycles since overhaul were in excess of 320 and 200 respectively.

The intake support struts around the intake annulus were broken, probably as a result of inertial loads experienced at the initial touchdown. This resulted in the gas generator module losing its location because the bearing at the impeller end of the compressor is located in this area. Disassembly of the engine showed that this lack of location had allowed the impeller to contact the shroud because all the blades exhibited significant burrs and the shroud surface had had much of its protective coating abraded away.

In this engine type, the gas flow downstream of the combustion chamber is turned through 180º in the 'large exit duct'. The surface of this duct exhibited some 'speckling', which had the appearance of solidified globules of the coating material from the impeller shroud. Such evidence is usually indicative of small pieces of material, in this case particles of the impeller shroud coating, being melted on passing through the combustion chamber and resolidifying on the exhaust or other engine components. It therefore provides an indication that the engine was alight at the moment of a severe impact.

Disassembly of the engine showed that the reduction gear system functioned smoothly and the gearbox magnetic chip detector was clean. Other components in the rotating assemblies, such as the compressor turbine

Footnote

3 During the subsequent site clearance it was found that fuel had penetrated approximately 1 m into the ground.

blades, were generally in a condition consistent with being part way through their overhaul lives. The tips of the power turbine blades had rubbed against the shrouds over part of the circumference as a result of distortion of the casing. After removal of the power turbine, some burnt fragments of grass were apparent in the casing near the combustion liner.

Elsewhere in the engine, the fuel nozzles were normal in appearance and the No 1 bearing, at the inlet end of the compressor, was in good condition.

In summary, no significant defects were found within the engine that might have been present before the accident.

Right engine

No significant maintenance had been carried out on the engine since an inspection and repair of the hot section in May 2005, at which point the engine had achieved 12,424 hours and 8,186 cycles since new. As with the left engine, the engine logbook recorded no flights after November 2010, although the evidence available indicated that in excess of 1,500 hours and 1,200 cycles had been achieved since the hot section repair. The hot section was reinstalled on the aircraft by a different maintenance organisation from the one which installed the left engine following overhaul.

A significant quantity of grass had adhered to the outside of the engine intake screen, indicating that the compressor was still rotating at speed when the aircraft was sliding across the field (the grass had entered through the air intake on the underside of the nacelle). The lack of grass on the left engine was probably indicative of the fact that the compressor on the latter spooled down rapidly following the failure of the intake struts.

Disassembly of the compressor revealed that the components were in good condition, with no evidence of rubbing. The combustion chamber liner was in a similar condition to that of the left engine, with areas covered with carbon deposits. However, there was no evidence of molten metal deposition in the large exit duct.

The reduction gears were smooth in operation and the associated magnetic plug was free from debris. There were fragments of scorched grass in the combustor outer casing, which were less burnt than those found in the left engine. This might indicate faster cooling of the casing due to the undamaged compressor taking longer to spool down.

Examination of all the remaining components, such as the fuel nozzles, revealed no significant defects and it was concluded that the engine was in a serviceable condition at the time of the accident.

Engine accessories

The engine accessories tested comprised the compressor bleed valves, FCUs, engine-driven pumps and the start flow valves.

The compressor bleed valve on each engine opens to spill excess compressor air overboard at low power and closes progressively as the power demand on the engine increases. The rolling diaphragms in both engine compressor valves were intact and the valve movements were smooth in operation. When bench tested, it was found that the control pressure for the unit from the left engine was slightly below the value specified in the component Maintenance Manual. The overhaul company commented that this would have resulted in the valve closing at a slightly higher engine rpm than normal, but that it would have had no noticeable effect on its operation.

The FCUs were bench tested, with the results being typical of units returned from the field; it was concluded that they would have operated satisfactorily. An inspection of some of the internal chambers revealed no evidence of microbiological compounds or any other debris.

The start flow valves, which should have no effect on engine operation after start, were found to operate satisfactorily apart from slightly stiff operating shafts, which were attributed to typical in-service wear. The engine-driven pumps, located upstream of the FCUs and designed to produce an rpm-dependent fuel pressure, were found to operate satisfactorily.

It was considered possible that identically mis-rigged propeller governors or badly calibrated tachometers may have caused the engines to operate at below normal rpm thereby resulting in a loss in performance on both powerplants. However, the technical records indicated that relevant engine maintenance activity, including rigging of the governors, was conducted by different organisations at different times; thus these potential causes of low rpm were thought to be highly improbable.

Fuel

It was not possible to obtain an airframe fuel sample that was representative of fuel being used by the engines at the time of the accident. The samples that were taken contained no visible water or evidence of microbiological compounds such as algae, and complied with the Jet A1 specification. Tests on fuel found in the fuel filter bowls of the FCUs of both engines produced similar results. The dissolved water content of all the samples was between 65 and 75 ppm (parts per million) and the fuel analysts commented that levels below 150 ppm do not generally give cause for concern. The left airframe fuel filter was found to be clean (the unit on the right side was damaged) and the FCU filters were also clear, as were the inlet screens of the engine driven pumps.

It seemed likely that, if water was present in the fuel in significant quantities, it would have resulted in abnormal engine operation before takeoff and asymmetric power fluctuations during takeoff. Although no such symptoms were reported by the pilot, the possibility that the fuel was contaminated by water was considered. Earlier in this report, it was concluded that water would not have entered the tanks as a result of the aircraft encountering rain, which left the bowser as the only potential source of contamination. As there were no reports of any other aircraft being affected, it was concluded that the fuel was not contaminated.

Recorded information

Recorded information was available from the Bournemouth Airport radar and the aircraft EGPWS computer[4]. The aircraft position and Mode C altitude was recorded approximately once every four seconds by the radar. The record commenced as the aircraft positioned for takeoff and ended approximately 10 seconds before the aircraft landed in the field. When the EGPWS computer generates a warning, it also records a 30 second snapshot[5] of parametric information, which includes GPS position, groundspeed and derived altitude. During the flight, two warnings were generated by the EGPWS. The first was a sink rate warning, which occurred shortly after takeoff, and the second was a terrain warning, which occurred shortly before the aircraft touched down. When the radar and EGPWS records were combined, a complete record of the accident flight was available (Figure 1 and Figure 2).

Footnote

4 Honeywell EGPWC, part number 965-1198-005.

5 The snapshot covers the time period from approximately 20 seconds prior to a warning having been generated, to 10 seconds after it has ceased. Each snapshot contains parameters recorded at a rate of once per second.

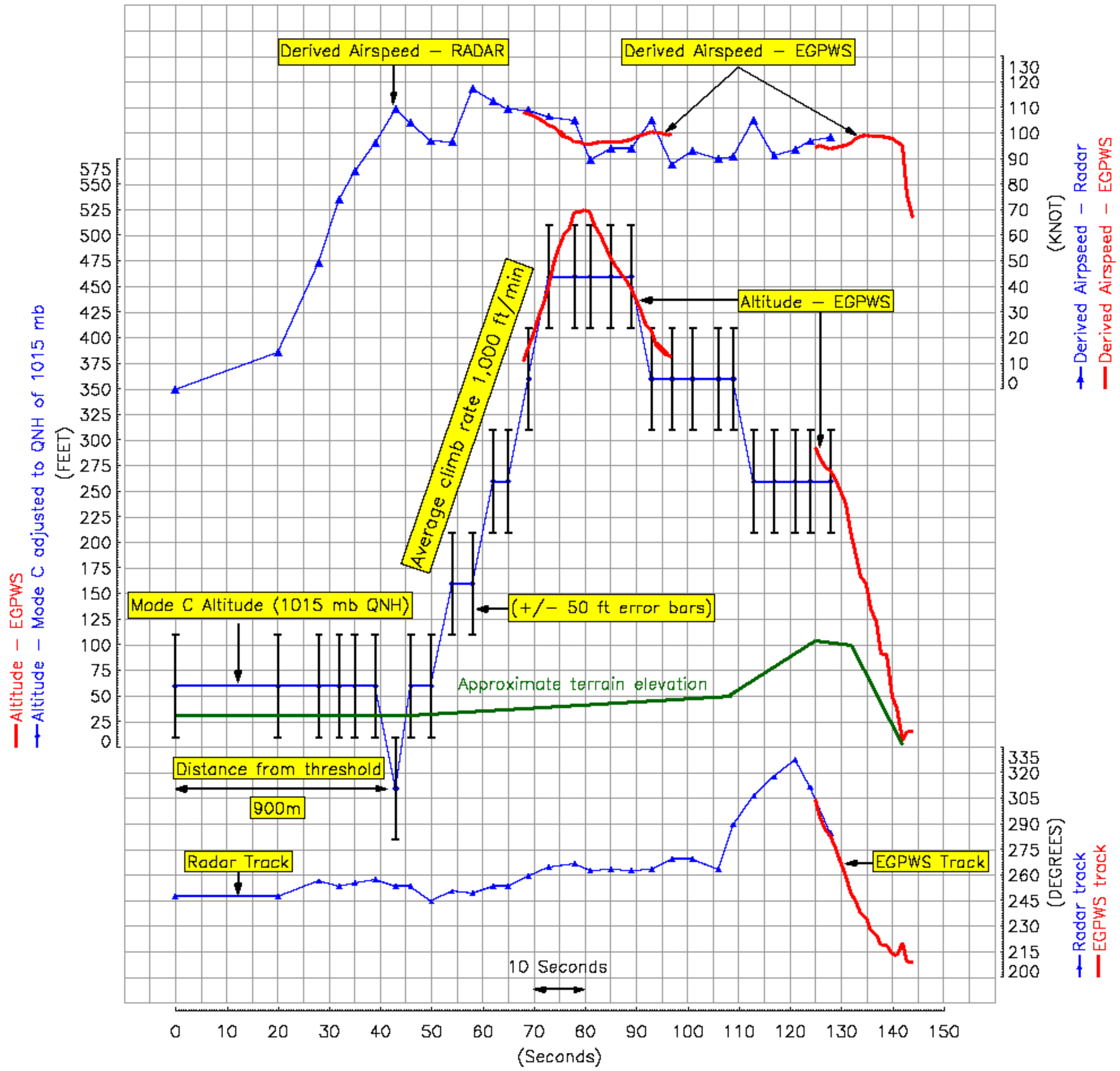

Figure 1

Recorded data for takeoff from Bournemouth Airport Runway 26 and descent into the field

Figure 2

Aircraft track (Radar in yellow and EGPWS in blue)

Interpretation of data

The Mode C altitude readout, which is based on a sea level pressure setting of 1013 hPa, was adjusted to a QNH value of 1015 hPa and an approximate airspeed was derived from the radar and EGPWS groundspeeds, based on a wind of 230° at 10 kt. At approximately 1128:08 hrs, the aircraft was positioned on the threshold of Runway 26. After 20 seconds, the first radar point was recorded as the aircraft commenced its takeoff run. Due to the +/- 50 ft quantisation of Mode C altitude, it was not practicable to determine the exact point on the runway that the aircraft left the ground. However, when the aircraft was approximately 900 m (2,953 ft) from the threshold, and at an airspeed of about 109 kt, there was a momentary decrease in the Mode C altitude from 60 ft to 10 ft, which is indicative of rotation for takeoff. Four seconds later, approximately 1,090 m (3,575 ft) from the threshold, the adjusted Mode C altitude returned to 60 ft (+/- 50 ft) (the runway elevation is approximately 30 ft at this point). After takeoff the aircraft drifted left of the runway[6], tracking approximately 255°(M), and was displaced to the south of the centreline by approximately 120 m when it passed the upwind threshold.

Footnote

[6] The runway is on a magnetic bearing of 257°.

During the 30 seconds after lift-off, the average climb rate (based on the Mode C altitude) was approximately 1,000 ft/min. As the aircraft climbed, its airspeed reduced progressively and, at an altitude of 525 ft, its airspeed was about 97 kt. The aircraft levelled off briefly before descending and an EGPWS Mode 1[7] SINK RATE warning was generated with the aircraft at an altitude of 460 ft and with a descent rate of about 540 ft/min. As the aircraft descended, its airspeed stabilised at about 100 kt. At 1.2 nm from the end of Runway 26, and at an altitude of about 350 ft, the aircraft made a right turn onto a track of 330°. This was shortly followed by a left descending turn from an altitude of 290 ft (170 ft agl) onto a track of about 215°. As the aircraft banked to the left, the airspeed was maintained between 96 kt and 100 kt, but the rate of descent increased progressively to about 1,000 ft/min. Shortly before impacting the line of trees, the descent rate was reduced; the airspeed was approximately 98 kt at the time. The estimated groundspeed at touchdown was 88 kt and the aircraft was airborne for approximately 95 seconds.

Propeller checks

The propeller control lever controls propeller rpm through the primary governor. Should the primary governor malfunction and command more than 2,200 rpm, an overspeed governor prevents the propeller speed from exceeding approximately 2,288 rpm. A PROP GOV TEST switch resets the overspeed governor threshold to between 1,960 and 2,140 rpm. During the before takeoff propeller check on each engine, the propeller lever is moved fully forward and, with propeller rpm set below 1,900 by the power lever, the PROP GOV TEST switch is held ON. The power lever is moved forward until the propeller rpm stabilises between 1,960 and 2,140 rpm to confirm correct operation of the overspeed governor.

Engine power

The power of a turboprop powerplant measured in shaft horsepower (shp) is proportional to the product of torque and rpm. The Airplane Flight Manual (AFM) gives two torque limits, corresponding to two rpm settings, each of which will produce a power output of 550 shp: 1,315 ft-lb of torque at 2,200 rpm and 1,520 ft-lb of torque at 1,900 rpm. The takeoff torque limit was shown as a solid red line on each engine's torque gauge on the instrument panel and the higher torque limit was shown as a dotted red line. The AFM technique for selecting takeoff rpm was for the propeller levers to be fully forward to allow the primary governor to maintain 2,200 rpm.

With the rpm levers fully forward, the primary governors will maintain the propellers at 2,200 rpm when the power levers are advanced for takeoff. With the rpm levers slightly aft of fully forward, propeller speed during takeoff will be less than 2,200 rpm and, if the power levers are used to set 1,315 ft-lb of torque, the power output of each engine will be less than 550 shp. Small movements of the rpm levers do not command large changes in rpm, and moving the rpm levers aft by half an inch, or even slightly more, is unlikely to reduce the power significantly, although the propeller efficiency may be reduced. When rpm is reduced there is a small increase in torque, and vice versa, but it is movement of the power levers that has the greatest effect on the power output.

Takeoff performance

The takeoff and climb performance figures in the AFM assume a power setting of 1,315 ft-lb of torque with

Footnote

7 An EGPWS Mode 1 (Excessive rate of descent) aural alert – "SINK RATE" – is generated after takeoff if a rate of descent develops that exceeds a threshold value. The threshold value increases with height above the ground.

2,200 rpm and a lift-off speed of 95 kt IAS. With an actual takeoff weight of 10,071 lb[8], the distance to lift-off should have been approximately 1,350 ft, the two engine climb rate should have been approximately 1,850 ft/min and the single engine climb rate should have been approximately 470 ft/min.

The pilot could not recall the exact point on the runway that he applied power but the aircraft was moving as he did so. From groundspeed information attached to the radar data, it was judged that the pilot began to accelerate approximately 400 ft from the threshold of Runway 26 and this was assumed to be the start of the takeoff run. Mode C and radar information suggested that the aircraft rotated approximately 2,500 ft from the start of the takeoff at approximately 109 kt. Radar data suggested that the aircraft was travelling at 95 kt IAS approximately 2,100 ft from the start of the takeoff run, and that the initial climb rate was approximately 1,000 ft/min.

Analysis

The takeoff performance calculation indicated that the aircraft should have lifted off at 95 kt after a ground run of 1,350 ft. Radar data suggested that it took approximately 2,100 ft to accelerate to 95 kt (although the pilot actually rotated at a reported 104 kt). This was considered to be a sufficiently reliable indication of the actual distance to 95 kt to confirm a lack of performance on the runway. The symptoms described by the pilot suggested a symmetrical power reduction rather than the failure of a single engine, and the drift to the left shortly after takeoff was considered to be the result of the aft movement of the left engine power lever while the pilot raised the landing gear. Symmetrical power loss is unusual and suggestive of fuel contamination but, as fuel contamination was discounted earlier in this report, the following section discusses the powerplants and engine handling.

Examination of the engines and testing of the accessories revealed nothing that could have had a bearing on the accident. The pilot reported that the engines ran normally before takeoff and that there were no warnings or cautions during or after takeoff. It was concluded that, in all probability, the accident was not caused by a fault in either engine.

The maximum power that the powerplants could have been producing during takeoff was probably slightly less than 550 shp because the rpm levers were not fully forward when the pilot set the torque. The pilot's recollection that the levers were approximately half an inch aft of fully forward was not accurate enough to give a reliable estimation of the rpm and, by inference, the power actually used. It seemed unlikely, however, that the reduction in rpm was sufficiently large to explain the reduction in performance.

The reduced power during takeoff would also have reduced the aircraft's climb performance after takeoff, although this might have been masked immediately after lift-off because the pilot rotated at approximately 104 kt, not 95 kt, which would have increased the initial climb rate. When he judged that the aircraft was not climbing as expected, the pilot pushed the power levers forward, which would have increased torque, and brought the rpm levers back, which would have reduced rpm and led to a slight increase in torque. The net effect of these actions on the overall power output was not determined but, if it was positive, it was evidently not sufficient to prevent the aircraft from descending.

Power levers are the major determinant of power output and the pilot was insistent that he set the torque

Footnote

[8] The maximum takeoff weight for the aircraft is 10,100 lb.

to the takeoff limit. Consequently, the investigation had insufficient evidence to determine the cause of the accident with any degree of certainty.

The pilot, faced with a lack of power and performance, made a positive decision to make a forced landing into a field. He did not allow himself to become distracted from the primary task of flying the aircraft and maintained a safe flying speed throughout, which ensured that the aircraft remained under control down to the ground. Had this not been the case, the outcome might have been less favourable.

Conclusions

The pilot experienced symptoms of symmetrical power loss sufficient to prevent the aircraft from sustaining level flight and made a forced landing into a field. The deficiency in the aircraft's takeoff performance suggested that its powerplants were not producing sufficient thrust. As fuel contamination was discounted and no fault was found in either engine, it was concluded that, in all probability, the poor performance was not caused by a failure in either powerplant. Maximum rpm was not selected for departure but it was unlikely that this explained the aircraft's poor performance on the runway or in the air. The pilot insisted that he had set torque to the takeoff limit. There was insufficient evidence to enable the cause of the apparent power loss to be determined.

ACCIDENT

Aircraft Type and Registration:	BN2T Islander, G-BSWR
No & Type of Engines:	2 Allison 250-B17C turboprop engines
Year of Manufacture:	1991
Date & Time (UTC):	13 July 2011 at 0148 hrs
Location:	Belfast International Airport, Northern Ireland
Type of Flight:	Commercial Air Transport (Non-Revenue)
Persons on Board:	Crew - 1 Passengers - 2
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to a propeller blade on the right engine, the nose cone and the fuselage
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	46 years
Commander's Flying Experience:	5,470 hours (of which 2,212 were on type) Last 90 days - 64 hours Last 28 days - 26 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft made a visual approach, at night, to Runway 07 at Belfast International Airport. The aircraft touched down short of the runway, making contact with the runway approach lighting system. Damage to the aircraft was discovered by the pilot when he inspected the aircraft after landing.

History of the flight

The aircraft had completed an operation in an area to the northwest of the airport and was returning to land on Runway 07 after a flight of 2 hours 30 minutes duration. It was the pilot's second flight of the night; after his first flight he landed on Runway 25 at 2115 hrs. The airfield weather conditions were CAVOK, with a surface wind from 090° at 5 kt and high level overcast cloud. A Special Visual Flight Rules clearance was issued by ATC and the aircraft was positioned for an approach to Runway 07. This runway is provided with a VOR non-precision approach, for which the inbound course is offset from the runway centreline by 16°. The approach lighting system consists of centreline lights with a single crossbar 439 m short of the runway threshold. The runway threshold is identified with high intensity green lights with wingbars. PAPIs, set at 3°, are located to the left of the runway.

The pilot acquired visual contact with the runway and estimated that he was lined up on the runway centreline at between 2 and 3 nm. He used the PAPIs to confirm that he was on the 3° glidepath and then descended below the 3° approach path, advising ATC that he was doing so. His aim was to land visually, touching down at the runway threshold.

The pilot's perception was that the approach was normal and that he flared and carried out an uneventful landing. However, after touchdown he and his two passengers heard a number of dull thuds. The aircraft decelerated normally and the pilot taxied to the parking area, where he shut down the engines. The pilot and passengers discussed the thuds they had heard and, initially, thought that they may have been caused by contact with a hare or other animal during the landing.

The pilot carried out an external inspection and noticed that there was grass on the underside of the aircraft and damage to the starboard side of the fuselage. He then made a telephone call to ATC to advise them that he may have made contact with the approach lights.

A runway inspection vehicle was detailed to inspect the lighting system and reported damage to the last three centreline approach lights. A further inspection showed tyre marks in the grass starting 80 m short of the paved surface, 125 m short of the displaced runway threshold.

The damage to the aircraft was significant. The starboard propeller was damaged, the engine required inspection for possible shock loading, there was impact damage to the nose cone and scratching, denting and a puncture hole in the starboard fuselage. There were also several other holes in the aircraft's skin.

The access taxiway to the normal parking area for the aircraft is close to the threshold of Runway 07.

Discussion

It was the pilot's perception that the approach and landing were normal. He had descended below the 3° glidepath with the intention of landing at the threshold. This may have been to minimise the taxi time but may also have been a habitual practice. He remained unaware that there had been anything unusual with the landing until after shutting the engines down.

The pilot subsequently considered that one explanation for the accident could be that, from his eye position, the single crossbar on the approach lights merged with the green threshold lights, thereby leading him to aim his touchdown at a point just beyond the crossbar. Other possible factors were that the night was very dark, with high overcast cloud, and that the final approach for Runway 07 is over an area with little cultural lighting. There was, therefore, a lack of visual cues, other than the PAPIs, on which to judge the position of the aircraft relative to the surface and the runway.

The operator has advised its pilots that the PAPIs must be used for approaches at night when they are available.

SERIOUS INCIDENT

Aircraft Type and Registration:	Boeing 737-8F2, TC-JKF
No & Type of Engines:	2 CFM 56-7B22 turbofan engines
Year of Manufacture:	2006
Date & Time (UTC):	13 March 2011 at 1412 hrs
Location:	London Stansted Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 2 Passengers - N/K
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	49
Commander's Flying Experience:	7,700 hours (of which 4,400 were on type) Last 90 days - 220 hours Last 28 days - 80 hours
Information Source:	AAIB Field Investigation

Synopsis

Shortly after takeoff from Stansted, the aircraft levelled at 800 ft aal (450 ft agl) and did not climb until the pilots received instructions from ATC. The pilots had misinterpreted altitude restrictions shown on the departure chart. One Safety Recommendation was made.

History of the flight

The aircraft was on a scheduled flight from London Stansted airport to Ankara, Turkey and was cleared to depart on a Clacton 8R standard instrument departure (CLN 8R SID) from Runway 22. After an uneventful start-up and taxi, the tower controller at Stansted issued a clearance for the aircraft to line up on Runway 22. The controller received a reply that sounded unclear and mumbled so he re-iterated the clearance. The controller observed the takeoff and initial climb, both of which appeared normal. He looked away for a short time and, when he looked back at the aircraft, saw it in a steep nose down attitude and descending before it levelled off. The local controller tried twice to establish communications with the aircraft but received no reply. He then contacted the departure controller at Swanwick who confirmed that the aircraft was on his frequency. The tower controller observed the aircraft flying a low-level left turn before commencing a climb.

The co-pilot, who was PF, had selected 800 ft on the Mode Control Panel (MCP) before takeoff. Shortly after takeoff he engaged the autopilot, the aircraft pitched nose down and, after reaching a maximum altitude of approximately 1,050 ft, it descended to 800 ft aal. The pilots contacted London Control and passed their callsign along with the SID designator of the procedure that they were cleared to fly. This frequency change took place before the pilots were instructed to do so by Stansted tower, which is contrary to the instructions on the SID which indicates that pilots will be instructed when to contact the departure frequency. The departure controller requested the passing and cleared altitude from the pilot and, when the pilots requested the controller to "SAY AGAIN PLEASE", this request was repeated. After the second request, the pilot transmitted that he was "NOW EIGHT THOUSAND EIGHT HUNDRED FEET". The altitude readout on the radar screen[1] showed an altitude of 800 ft and the controller asked the pilot to confirm that he was at 800 ft and reiterated his request for the aircraft's cleared altitude. The pilot replied "ALTITUDE EIGHT HUNDRED, SIX SIXTY NOW". The aircraft had entered a left hand turn and continued flying the lateral part of the CLN 8R SID which consisted of a turn through approximately 130° to roll out on a track of 088° towards the Clacton VOR. During this turn, the first part of which was flown level at a height of approximately 450 ft agl, the pilot reported that the autopilot disengaged and that he received "PULL UP" and "DON'T SINK" GPWS warnings. The controller asked the pilot to confirm that he was climbing to 4000 ft to which the pilot replied that he was 'NOW CLIMBING FOUR THOUSAND'. During this last dialogue the aircraft selected altitude, as displayed on the ATC radar screen, changed from 800 ft to 3,200 ft and, after the pilot confirmed that they were climbing to 4,000 ft, the aircraft selected altitude readout changed to reflect this. The aircraft entered a climb having turned through approximately 100°. The remainder of the departure proceeded without further incident.

The commander of the aircraft was on his third flight to a UK airport and on his second flight to Stansted. On the previous occasion that he had departed from Stansted he had flown a Dover SID without incident. The first officer was on his first flight into Stansted. The captain stated that he set 800 ft on the MCP because he interpreted the instructions printed in the general information section of the departure chart to mean that he was required to level the aircraft at 850 ft and not climb above this until instructed to do so by London Control. It was not possible for the co-pilot to select exactly 850 ft on the MCP as altitudes can only be selected in increments of 100 ft so he selected the nearest value that would not exceed the perceived 850 ft clearance limit.

Clacton 8R SID (CLN 8R)

The pilots were using Jeppesen charts and the relevant chart for the CLN 8R SID is shown in Figure 1. The SID chart contains a panel of general information at the top of the page. Items 3, 4 and 5 state:

> *'3. Initial climb straight ahead to 850'*
> **4.** *Cruising levels will be issued after take-off by LONDON Control*
> **5.** *Do not climb above SID levels until instructed by ATC'*

The information displayed on the Jeppesen chart reflects the information published in the UK AIP although the positioning of this information on the page is different and the UK AIP states 847 ft instead of 850 ft.

Footnote

[1] The Mode S transponder give the ATC controller an on-screen readout of the altitude that the pilot has selected on the MCP.

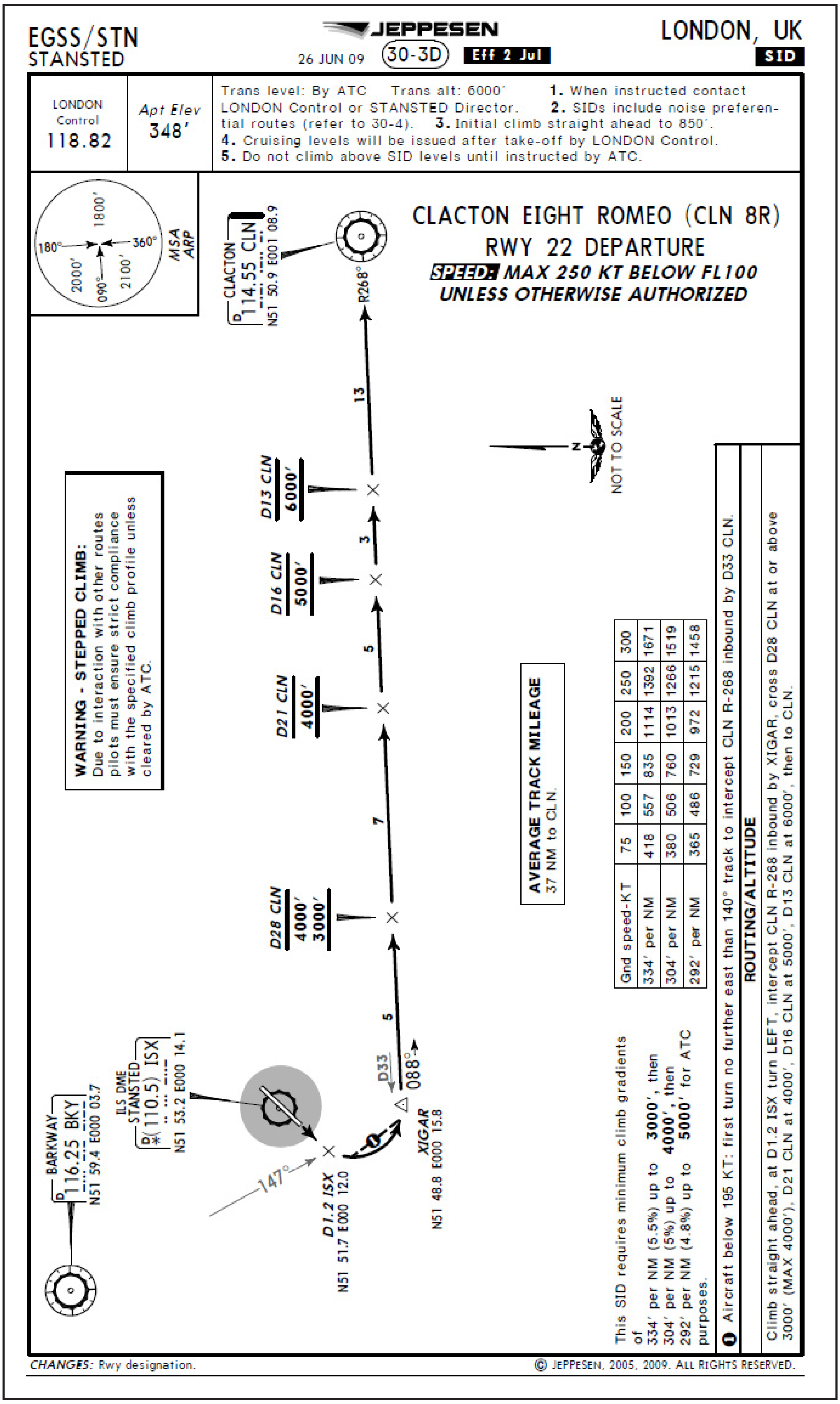

Figure 1

Clacton 8R SID

UK Standard Instrument Departures

The ICAO minimum height for commencing a turn on a SID is 120 m (394 ft). After the 1974 Trident (G-ARPI) Public Enquiry the CAA published a report entitled Safety Aspects of Terminal Area Procedures in which the UK opted to increase this height to 500 ft. This change is promulgated in UK AIP General Section GEN 1-7-48 where it states:

> *'…no turns are to be commenced below a height of 500 ft aal.'*

It is also stated in CAP 778 - Policy and Guidance for the Design and Operation of Departure Procedures in UK Airspace that states:

> *'The* ***earliest*** *point at which the first turn shall be specified is the point at which all aircraft will have achieved 500 ft aal.'*

Most of the SIDs published in the UK AIP contain a phrase reflecting this requirement with the majority using a phrase similar to that contained in the CLN 8R SID. However, the SIDs from Manchester airport, airports in the Channel Islands and the DVR and LAM SIDs from Stansted Airport show this information by using a phrase similar to:

> *'No turns below 850 ft QNH (500 ft QFE)*[2]*.'*

The reason for the adoption of this phrase at Manchester and the Channel islands is unknown. However, the DVR SIDs at Stansted were amended in 2006 in response to a similar incident involving a departure on the DVR 5S SID.

Footnote

2 The actual QNH altitude shown will vary depending on the geography of the airport. However, it will always reflect the minimum requirement of 500 ft aal.

Analysis

The commander of the aircraft was on only his second flight into Stansted and his third into any UK airport. The co-pilot had only operated into the UK once before and this was on his first flight into Stansted. The pilots misinterpreted the written instruction:

> *'Do not climb above SID levels until instructed by ATC'*

to mean that they had to await positive ATC clearance before climbing above any of the levels specified on the SID.

The previous time that the commander had departed out of Stansted, he flew a Dover SID and the general information wording of this procedure is different from the wording of the Clacton SID in that the Dover SIDs state

> *'No turns below 850 ft'*

where as the Clacton SIDs state:

> *'Initial climb straight ahead to 850 ft'.*

The phrase:

> *'Initial climb straight ahead to 850 ft'*

is grammatically similar to the phraseology specified in CAP 413 that ATC would use to instruct an aircraft to climb to and maintain a specified altitude (*'Climb to altitude 850 ft'*). The pilots interpreted 850 ft as the first SID level that they were required to maintain pending further instructions by ATC and they configured the aircraft accordingly.

It is possible for pilots, especially those whose first language is not English, to misinterpret the instruction:

'Initial climb straight ahead to 850 ft'

to mean that the aircraft is to level off at this altitude. Additionally, it is possible for pilots to misinterpret the instruction:

'Do not climb above SID levels until instructed by ATC'

to mean that they must obtain positive ATC clearance to climb above all of the levels specified on a SID.

The instruction not to commence a turn below 500 ft aal is shown in one of two different ways on SIDs published in the UK AIP. The commander's previous experience of a Stansted departure was on a Dover SID that presents this restriction using a different phrase to a Clacton SID. The pilot considered that this difference in phrasing was one of the factors that reinforced his misinterpretation of the information on the chart.

Safety action taken

As a result of this incident NATS has harmonised the general information section of published SIDs so that, where the phrase *'Initial climb straight ahead to...'* occurs, it is replaced by the phrase *'No turns below…'*. This action was only applied to airports within the London TMA.

The investigation revealed that vertical profile information given in the general information section of SIDs published in the UK AIP was misinterpreted. Therefore, the following Safety Recommendation is made:

Safety Recommendation 2011-089

It is recommended that the Civil Aviation Authority should ensure that the vertical profile information included within the general information section of all SIDs published in the UK AIP is unambiguous and that the wording used is consistent across all UK SIDs.

Conclusions

The pilots caused the aircraft to level incorrectly at 800 ft aal because they misinterpreted the information written in the general information section of the departure chart. This information originated from the UK AIP. The pilots' misinterpretation of the information was reinforced by the previous experience of the crew.

INCIDENT

Aircraft Type and Registration:	Boeing 737-8K5, G-FDZR
No & Type of Engines:	2 CFM56-7B27/3 turbofan engines
Year of Manufacture:	2009
Date & Time (UTC):	25 November 2010 at 2052 hrs
Location:	Newcastle Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 8 Passengers - 189
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	47 years
Commander's Flying Experience:	13,950 hours (of which 950 were on type) Last 90 days - 170 hours Last 28 days - 60 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft stopped on the paved surface but with the nosewheel 10 ft beyond the marked runway end at the end of its landing rollout. The runway was reported to have a covering of 2 mm of wet snow, having been swept and inspected shortly before the incident. Towards the end of the landing run, deceleration of the aircraft had reduced despite the application of full manual braking. Two Safety Recommendations have been made.

History of the flight

The aircraft was being operating on a scheduled service from Arrecife, Lanzarote to Newcastle Airport UK. The co-pilot was pilot flying. On the outbound sector, the pilots discussed the fuel requirements for the return leg. Snow showers were forecast for the estimated arrival time at Newcastle so they elected, as a precaution, to carry an additional 1,100 kg of fuel for a diversion to Edinburgh as well as Manchester, the nominated diversion airport. The pilots used the C-Land application[1] to check the expected landing performance at Newcastle and found that, at their expected landing weight, they would be able to accept a wet runway and a slight tailwind. They also decided that if the runway had more than 3 mm of contaminant, this would mean that it was contaminated, which was not acceptable for their operation.

During the uneventful cruise segment of the return flight the pilots monitored the Newcastle weather,

Footnote

[1] A laptop computerised landing performance calculator.

which was changing rapidly with 13 METARs issued during a one hour period. The final METAR before the incident, issued at 2050 hrs, indicated a surface wind from 310° at 13 kt, visibility 4,500 m, light snow showers, scattered cloud at 400 ft, broken cumulonimbus cloud at 900 ft, temperature and dewpoint both -1°C and QNH 1009 mb.

All METARs broadcast by the Newcastle ATIS system between 1950 hrs and 2050 hrs declared the state of Runway 07 as "WET WET WET". At 1948 hrs the pilots contacted their Operations department, who informed them that snow clearing was in progress at Newcastle but that the airport was expected to be clear for their arrival. Using the C-land application the pilots calculated that the landing distance required for a wet runway was approximately 300 m less than the landing distance available (LDA). Shortly afterwards the co-pilot briefed the approach, stating that the runway was wet and slushy, that Flap 40 would be used for the approach and landing, and that he intended to use full reverse and Autobrake 3 on landing. He also stated his intention to "DISCONNECT EVERYTHING WHEN VISUAL AND GO TO THE END". The crew briefly discussed the possibility of using Maximum Autobrake for the landing but decided this was unnecessary.

At 2031 hrs, when the aircraft was established on the ILS localiser, ATC informed the crew that another aircraft that had just landed had reported "MEDIUM TO GOOD" braking action. ATC then passed a runway inspection report which stated "100% CONTAMINATION AND 3 TO 4 MILLIMETRES OF SNOW". At this point the crew discontinued the approach and positioned the aircraft towards the 'NT' non-directional beacon, intending to hold there until either the runway had been cleared sufficiently for them to make a second approach or it became necessary to divert to Edinburgh.

At 2040 hrs ATC informed the pilots that one clearing run had been completed and that the runway now had a covering of 2 mm of wet snow. Judging that the runway was no longer contaminated, the pilots updated the landing data for a wet runway using the C-Land application and carried out a second approach. The pilots estimated that the aircraft touched down abeam Taxiway F that is approximately 150 m beyond the ideal touchdown point. The co-pilot recalled that after landing he selected full reverse thrust. At 97 kt groundspeed he deselected the autobrake using manual braking[2], and selected idle reverse which was achieved by 60 kt. Idle reverse remained selected for the remainder of the landing run. When manual braking, the co-pilot reported that he felt the anti-skid system operating. Recorded data showed that he applied variable pressure of between 2,000 and 3,000 psi to the right main landing gear (MLG) brakes and approximately 500 psi to the left MLG brakes. The co-pilot did not recall applying asymmetric braking. The commander initially assessed the deceleration as normal. However, after annunciating "60 KT" in accordance with normal procedures, he became concerned about the length of the landing run. He made a non-standard "50 KT" call, applied manual braking and took control of the aircraft. The co-pilot relinquished control of the aircraft but continued to apply manual braking. The aircraft remained close to the centre-line of the runway throughout the landing run and stopped with its wheels on the paved surface and the nose of the aircraft 10 ft beyond the red runway end lights. The aircraft was not damaged and there were no injuries.

The pilots judged that it would be impossible to taxi the aircraft from this position, so completed the shutdown

Footnote

[2] The manufacturer refers to operation of the brakes using the brake pedals as *'manual braking'*.

checks and disembarked the passengers when suitable steps and transport were made available to take them to the terminal. Both pilots independently walked on the runway back towards the Runway 25 displaced threshold and assessed the surface as very icy.

Airport information

Runway 07 at Newcastle has a LDA of 2,209 m and a width of 45 m. A copy of the aerodrome chart is shown in Figure 1.

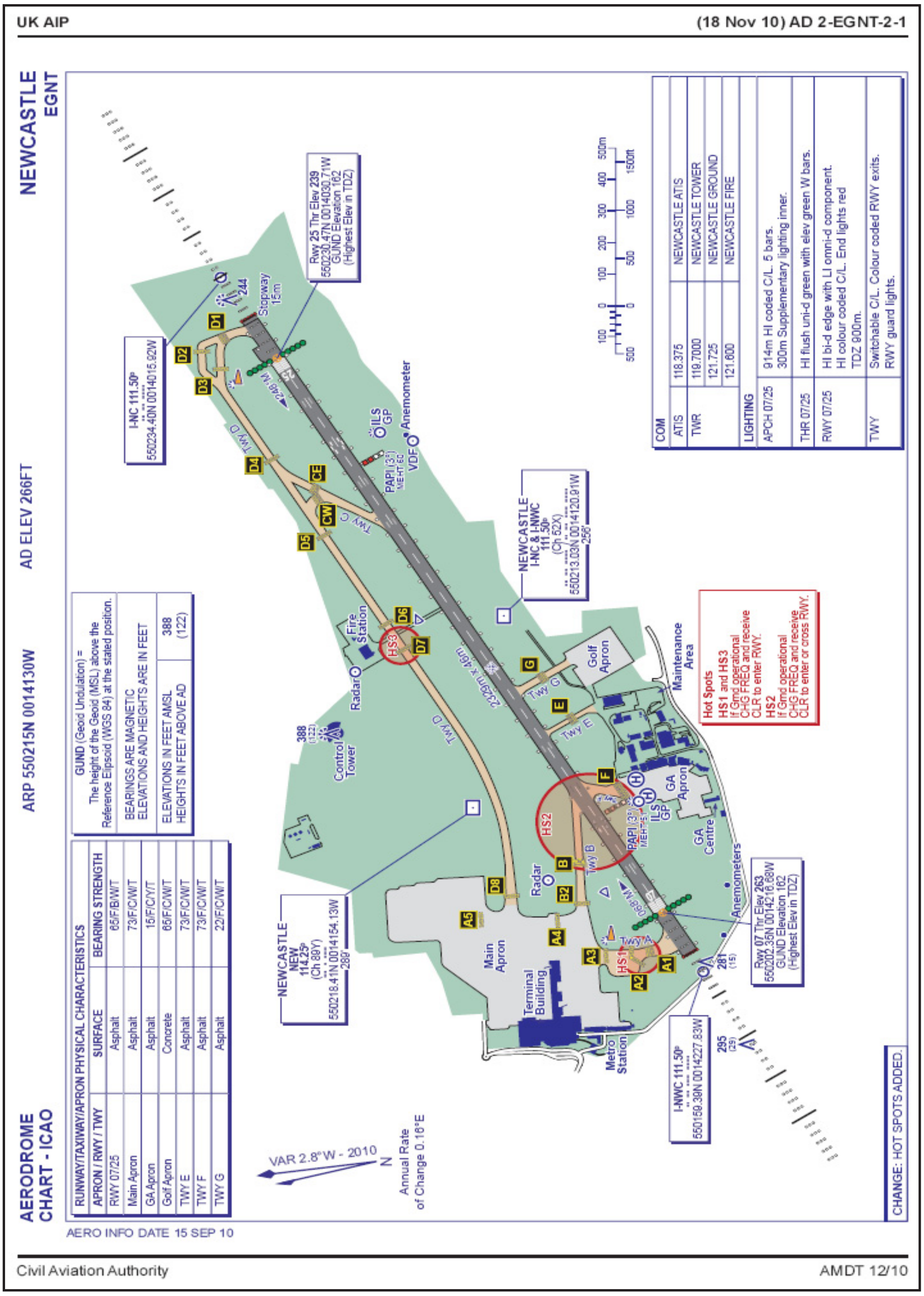

Figure 1

Newcastle Airport layout

After the aircraft had discontinued its approach the runway was swept by the airport sweeper vehicles, the Airport Operations Unit (AOU) operative following the runway sweepers to assess the runway surface visually. The AOU log shows:

> *'2025-2037 100% contamination, 1-2 mm wet snow. Snow all thirds'*

The ATCO log book shows:

> *'2040 Surface Inspection, contamination down to 1-2mm wet snow'*

The AOU operative recalls that he inspected the runway visually from his vehicle and estimated the contamination. He considered that the wet snow was in patches and commented that he had not experienced any problems with tyre grip while driving on the runway. The Airport Fire and Rescue Services watch manager, who attended the incident, reported that the runway condition was such that the black runway surface was clearly visible and that he had not had any tyre grip problems with his vehicle whilst driving the full length of the runway to attend the incident.

Appendix 3D of Civil Aviation Publication (CAP) 168, '*Licensing of Airfields*' details the method that should be used to assess and report the depth of snow or slush on a runway as follows:

> *'Depth of Snow or Slush*
>
> *A Standard Depth Gauge should be used to measure the depth of snow, slush or associated standing water on runways. Readings should be taken at approximately 300 m intervals between 5 and 10 m on each side of the centreline, avoiding the effects of rutting. Depth information shall be given in millimetres representing the mean of readings obtained for each third of the total runway length.'*

A Standard Depth Gauge is a mechanical device that consists of a tube that is stood vertically on the runway surface through the contaminant, and a coaxial disc that is lowered onto the top surface of the contaminant. The operator reads the depth of contaminant on a scale marked on the device. CAP 168 states that measurements should be taken every 300 m along a runway, between 5 and 10 m each side of its centreline. The operator of the device would need to disembark any vehicle 18 times to measure and fully assess the 2,329 m of Runway 07 at Newcastle.

Recorded information

The aircraft was fitted with a solid state flight data recorder (FDR) and cockpit voice recorder (CVR); both recorders captured the landing incident. Power to the CVR was removed promptly after the aircraft was shut down, preserving recordings relevant to the investigation.

The aircraft touched down at 2052:28 hrs at a recorded computed airspeed (CAS) of 140 kt and groundspeed of approximately 147 kt[3]. On touchdown, the ground spoilers deployed and both autobrake and reverse thrust were activated. Recorded brake pressure increased according to the autobrake command and aircraft longitudinal deceleration was between 0.26 and 0.21g. Fourteen seconds after touchdown, at a groundspeed of approximately 97 kt, the throttles were retarded to the idle reverse position and the autobrake disengaged.

Footnote

[3] Groundspeed was only recorded every four seconds.

Upon autobrake disengagement, manual braking was applied, initially significantly more on the right pedal than the left. At a recorded groundspeed of approximately 30 kt, maximum brake pressure was commanded to both sets of MLG brakes. Pressure applied to each brake could not be determined because commanded brake pressure was recorded upstream of antiskid regulation.

After the reduction in reverse thrust, there was a notable decrease in the aircraft deceleration to an average of 0.12g over the final 30 seconds of the landing. Application of full manual braking appeared not to change the deceleration except in the final two seconds, when deceleration peaked at 0.34g.

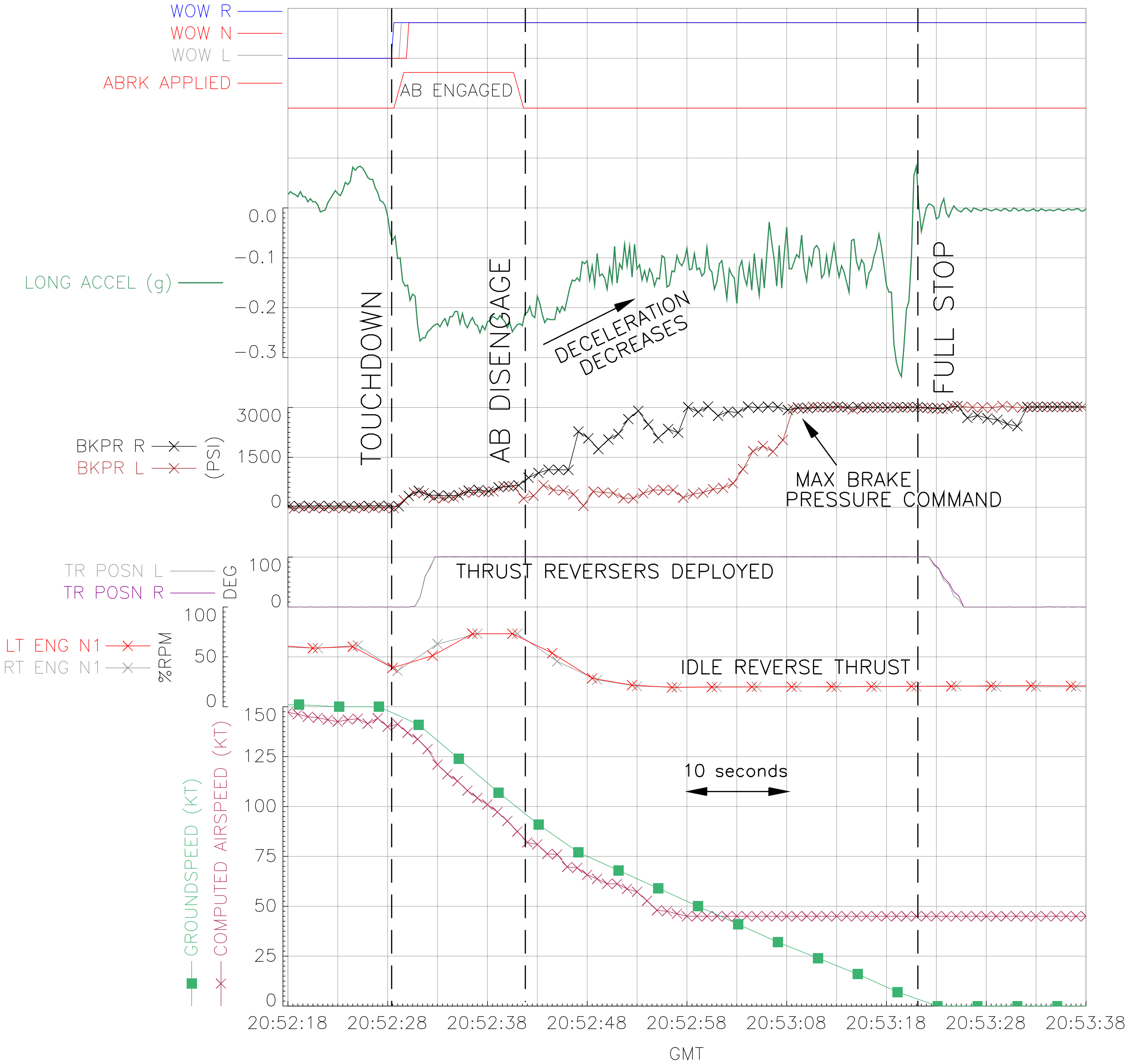

Figure 2

G-FDZR FDR parameters

Pilot in-flight assessment of landing distance

The crew used the C-Land application to calculate the landing distance required (LDR). The C-Land application requires an input of type and depth of contaminant in order to perform the calculation.

In the absence of the C-Land, the pilots can use the landing distance advisory information in the Quick Reference Handbook (QRH) to calculate the landing distance required. To do this the pilot must know the expected braking action on the runway. This information can come from three potential main sources; pilot reports, runway friction reports and runway surface description.

Braking action reports from pilots on previous landing aircraft can be used to assess braking action but these will be subjective and, if the previous landing aircraft is of a different type or weight, not directly applicable to the next aircraft to land.

Continuous Friction Measuring Equipment (CFME) should not be used to measure braking action when snow or slush are present on the runway.

The CAA NOTAL 2010/09 states:

> *'CAA policy is that Continuous Friction Measuring Equipment (CFME) should not be used when snow/slush conditions are present, as readings on wet snow and slush are unreliable from existing equipment; there is no correlation between CFME readings and aircraft braking performance.'*

In 2007 Boeing issued a Flight Operations Technical Bulletin (FOTB) 07-2 entitled *'Landing on Slippery Runways*' to all operators which advises:

> *'Runway mu values* ***can vary significantly*** *for the same contaminant condition due to measuring techniques, equipment calibration, the effects of contamination on the friction measuring device and the time passage since the measurement.* ***Do not*** *base landing distance assessments solely on runway mu friction reports. If mu is the only information provided, attempt to ascertain the depth and type of runway contaminants to make a better assessment of actual conditions.'*

Runway surface description can be used to assess braking action by using a Braking Action Correlation Table, published by the manufacturer, which provides estimated correlations between type and depth of contaminant and expected braking action. The QRH available to the crew contained this table.

Research

During winter 2010-11, the CAA led a limited trial aimed at providing accurate and timely runway contamination information at four UK aerodromes. A wider trial is planned for 2011-12. The methodology/system to develop landing distance from this is not part of the trial. However, EASA is commissioning research into systems/equipment that could seek to link the two elements. Similarly, the FAA, through their Take-off And Landing Performance Assessment Rulemaking Committee (TALPA-ARC) trials, has been working to develop a system which does enable runway contamination information to be used to help to determine landing distance required. Both trials are ongoing.

Use of reverse thrust

FOTB 07-2 states that pilots should:

> *'Maintain reverse thrust as required, up to maximum, until the airspeed approaches 60 kt. At this point start reducing the reverse thrust so that the reverse thrust levers are moving down at a rate commensurate with the deceleration rate of the airplane. The thrust levers should be positioned to reverse idle by taxi speed, then to full down after the engines have decelerated to idle.*
>
> *'Note: If the stop is in question, maximum reverse thrust should be used until the stop is ensured.'*

In normal operation, pilots might not be accustomed to applying increased reverse thrust as the landing ground roll proceeds because during most landings it is applied and then reduced.

Contaminated runway definitions

EU-OPS-1.480 contains the following definition of a contaminated runway:

> *'A runway is considered to be contaminated when more than 25 % of the runway surface area (whether in isolated areas or not) within the required length and width being used is covered by the following:*
>
> *(i) surface water more than 3 mm (0,125 in) deep, or by slush, or loose snow, equivalent to more than 3 mm (0,125 in) of water;'*

UK AIP AD 1-1-4 para 15.2 contains a table in which the following statement is made:

> *'For JAR-OPS performance purposes, runways reported as DRY, DAMP or WET should be considered as NOT CONTAMINATED.'*

UK AIP AD 1-1 para 5.5.2 states:

> *'Aqua planing conditions should be assumed to exist whenever depths of water or slush exceeding approximately 3mm effect a significant portion of the available runway.'*

CAP 683 '*The Assessment of Runway Surface Friction Characteristics*' contains the following definition:

> *'A runway is termed contaminated when water deeper than 3 mm, or wet snow or slush is present over 25% or more of the assessed area.'*

CAP 168, Appendix 3D, - *'National Snow Plan including Procedures for Dealing with Winter Contamination of Aerodrome Surfaces*', refers to contaminated surfaces but without definition.

AIC 86/2007 (Pink 126) - 'Risks and factors associated with operations on runways affected by snow, slush or water', refers to contaminated runways but does not define them. It states, at paragraph 2.3:

> *'Depths greater than 3 mm of water, slush or wet snow, or 10 mm of dry snow, are likely to have a significant effect on the performance of aeroplanes.'*

AIC 14/2006 (Pink 91) '*Landing Performance of Large Transport Aeroplanes*' contains the following statement:

> *'5.1 JAR-OPS 1 defines a contaminated runway as one which is covered with ice, snow, slush, or more than 3 mm of standing water.'*

ICAO Annex 14, '*Aerodromes*', does not define contaminated runways.

Analysis

The aircraft touched down abeam Taxiway F, approximately 450 m from the Runway 07 threshold which is approximately 150 m beyond the optimum touchdown point. Landing beyond the optimum touchdown point adds to the calculated landing distance required.

The initial deceleration of the aircraft was similar to that expected with Autobrake 3 selected but deceleration of the aircraft reduced when idle reverse thrust was selected.

The pilot was aware that he was to use the full length of the runway and exit at the end. He reduced the reverse thrust to idle by 60 kt and it remained at idle until the aircraft came to a halt. The FOTB allows for full reverse to be maintained down to 60 kt and then for reverse thrust to be gradually reduced until reverse idle is achieved no later than taxi speed. It is likely that the earlier reduction of reverse thrust to idle contributed to the increased landing distance. The pilot could have reselected full reverse later in the landing run when a successful stop became in doubt but this might have been an unaccustomed pilot action because, in normal operation, pilots are used to applying reverse thrust and then reducing it as the landing ground roll proceeds.

When braking manually, the brake pressure applied by the pilot on the right MLG brakes varied between 2,000 and 3,000 psi and on the left MLG brakes between 0 and 600 psi. The co-pilot recalls feeling the antiskid system operating when he took over manual braking until the aircraft came to a halt. Later in the landing run, after idle reverse thrust was selected, residual reverse thrust and aerodynamic drag would have contributed little to deceleration of the aircraft. Recorded deceleration during that period was not consistent with the 'GOOD' braking action anticipated by the crew, suggesting that the runway surface was slippery. Runway conditions had been assessed visually immediately before the incident from a vehicle which was following the sweeping vehicles. The resulting report of surface conditions may not have been accurate.

The definition of contaminated runways in CAP 683 differs from the statement contained in AIC 86/2007. The former considers a runway as contaminated when any depth of slush or wet snow is present over the defined area, whereas the latter document requires a depth of 3 mm of wet snow or slush for there to be a significant effect on the performance of aircraft. The CAA stated that material contained across CAA documentation relating to contaminated runway operations is targeted at different audiences and therefore there are necessary differences in style and content. However, in the case of CAP 683 and AIC 86/2007, the difference in wording results in a contradiction. The inconsistencies concerning the definition of a contaminated runway surface, or the effects of contaminant when wet snow or slush is present, could cause pilots to assess incorrectly the contamination state of a runway. This incorrect assessment would lead to an incorrect calculation of LDR. Therefore, the following Safety Recommendation is made:

Safety Recommendation 2011-087

It is recommended that the CAA publishes a single definition of Contaminated Runways.

The CAA stated that currently there is no common taxonomy regarding runway contamination, and the requirements published by ICAO and EASA (in

EU-OPS) differ. The ICAO Friction Task Force (FTF) is working to produce a taxonomy and the CAA is an active member of the task force.

CAP 168 states that the depth of snow or slush on a runway should be measured using a Standard Depth Gauge at predetermined intervals along the runway. It appears that this method was not used in this case. To complete a full and accurate assessment of Runway 07 would have required the operator to take 18 measurements along the runway, disembarking from any vehicle used on each occasion. This would have been a time-consuming process during which time the runway would be unavailable for aircraft movements and the condition of the contaminant might change sufficiently to render the results invalid, especially in the rapidly changing weather conditions.

Although the definitions of contaminated runways are not consistent, the majority of definitions imply that 3 mm of contaminant is the depth above which aircraft stopping performance may be significantly affected. When assessing contaminant depth of this magnitude using a Standard Depth Gauge, a measurement error of only 1 mm represents a 33% error.

In order to calculate landing performance the pilots normally use the C-Land application with the QRH providing an alternative method. In the absence of reliable direct reports of braking action, the pilots could use with the Braking Action Correlation Table in the QRH to complete their calculations. Both methods require type and depth of contaminant and, for either method to correctly calculate landing distance the pilots must accurately know the type and depth of contaminant.

Existing methods of contaminant depth measurement, as defined in CAP 168, may provide an inaccurate depth assessment of the contaminant because of the length of time required to complete it and because the depth measured is sensitive to small gauge reading errors. These combine to provide pilots with inaccurate information which may affect the accuracy of the LDR calculation. Therefore, the following recommendation is made:

Safety Recommendation 2011-088

It is recommended that the CAA develops a system of contaminant depth measurement that provides accurate and timely runway contamination information to enable pilots to determine the landing distance required.

Safety action

The aircraft operator has made internal recommendations to:

1. Review the guidance to pilots in company manuals regarding the use of auto and manual braking especially in relation to the possibility of inadvertent asymmetric manual braking in a crosswind.

2. Review the guidance to pilots in company manuals regarding landing in conditions where the braking action is not given but may be in doubt.

3. Review the guidance to pilots in company manuals regarding the "60 KNOT" call made by the non-handling pilot during the landing roll especially to clarify whether airspeed or groundspeed should be used for this call.

4, Initiate a survey to establish if a pattern of early disengagement of auto brake exists.

Conclusion

The aircraft entered the stopway of Runway 07 at Newcastle Airport because the braking action on the runway was less than the pilots had anticipated. It is possible that there was a significant difference between the actual and reported conditions because the depth and type of contaminant on the runway was assessed visually. Touchdown of the aircraft beyond the normal touchdown zone, and selection of idle reverse thrust before the aircraft was at taxi speed, may have contributed to an increased landing distance.

ACCIDENT

Aircraft Type and Registration:	Britten Norman Islander BN-2A-27, VP-MNI
No & Type of Engines:	2 Lycoming O540 piston engines
Year of Manufacture:	1971
Date & Time (UTC):	17 April 2011 at 1915 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:	Damage to nose structure, nose landing gear, left wing tip and left propeller
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	37 years
Commander's Flying Experience:	2,332 hours (of which 839 were on type) Last 90 days - 135 hours Last 28 days - 51 hours
Information Source:	AAIB Field Investigation

Synopsis

After a normal landing the right brake failed. The pilot used the left brake to steer the aircraft into the grass to the left side of the runway to avoid the steep drop at its end. After departing the side of the runway the aircraft hit a raised embankment. 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). The investigation also revealed that the aircraft manufacturer and some engineering organisations used a different brake bleeding procedure from that published in the AMM. One Safety Recommendation has been made.

History of the flight

Following an uneventful flight from VC Bird Airport, Antigua, the aircraft made an approach to Runway 10 at John A Osborne Airport, Montserrat. After a normal touchdown the pilot applied the brakes and noticed that there was no resistance from the right brake pedal. While maintaining directional control with the rudder pedals 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 applied left brake and allowed the aircraft to veer left onto the grass just beyond the taxiway exit. The aircraft struck an embankment located 20 m north of the runway edge, about 150 m from the end of the runway (see Figures 1 and 2). The impact, which was estimated by the pilot to be at about 10 kt, resulted

Figure 1

Accident site

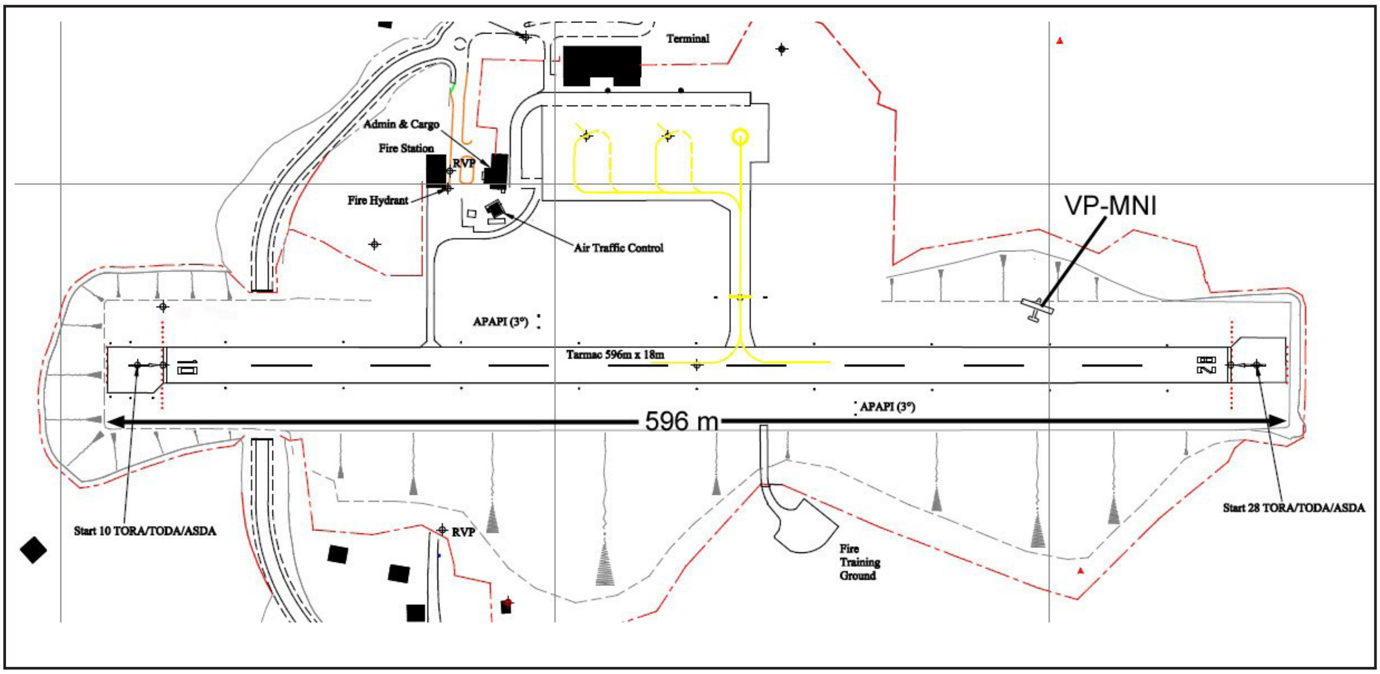

Figure 2

Accident site location relative to the runway in damage to the nose structure and caused the nose landing gear leg to collapse. The left wing tip leading edge was also damaged when it struck the embankment. After the aircraft came to rest the passengers were able to exit the aircraft via the main door.

Aircraft examination

The aircraft was examined by the aircraft owner's engineering representative. He reported that there were no visible brake fluid leaks and that the left brake operated normally, although the pedal was slightly 'spongy'. However, when the right brake pedal was operated it deflected fully with no resistance and remained depressed. When the right brake pedal was tapped it returned to its normal position. Then, when the pedal was pumped slowly, the brake pressure increased and the right brake began to operate. When the parking brake was applied the right brake remained solidly engaged for a 10-minute test period with no evidence of leakage. When the parking brake selector was released the brake remained on until a greater pressure was applied at the brake pedal – this was consistent with normal operation of the brakes.

The rudder cables and nosewheel steering cables were confirmed to be connected and properly routed. The engineer concluded that the right brake had failed to operate during the landing due to trapped air in the hydraulic lines.

Description of the brake system

The Islander is equipped with four conventional hydraulic fluid operated brake units, one fitted at each main landing gear wheel. The brake system includes four hydraulic master cylinder reservoirs, one fitted at each toe-operated brake pedal which form part of the rudder pedals (see Figure 3). When a brake pedal is actuated, fluid under pressure is routed via a combination of flexible hoses and rigid pipelines to the brake units at the wheels. Bleed screws are located at the top of each main gear leg and at each wheel brake unit. These bleed screws are used to bleed any air within the system. Trapped air in the system can cause the brakes to feel 'spongy' and can prevent brake actuation.

Maintenance history

The same pilot had flown the aircraft into VC Bird Airport, Antigua prior to the accident flight, and noticed on landing that the right brake pedal had to be depressed "almost to the floor" to get pressure. She reported this to the local engineer who inspected the aircraft and found a leak at the right outer brake assembly. He determined that the piston O-ring seal on the right outer brake assembly needed to be replaced. During the replacement of the O-ring a small amount of fluid was lost. He therefore replenished the right master cylinder reservoirs and carried out a brake bleeding procedure with the assistance of the pilot.

The engineer reported that he bled the right brake system by opening the bleed screws on both the right inner and right outer brake assemblies, while calling for the pilot to pump the right brake pedal. When the air was bled from the system he topped up the right master cylinder reservoirs with hydraulic fluid. The brakes were then tested and functioned normally. About 45 minutes to 1 hour after this work was completed the pilot taxied the aircraft for departure and confirmed that both brakes were operating normally.

Brake bleeding maintenance procedures

The aircraft maintenance manual (AMM) for the Islander, chapter 2.9, contains a procedure for bleeding the brake system. The procedure involves gaining access to the bleed screws on top of each main landing gear leg by

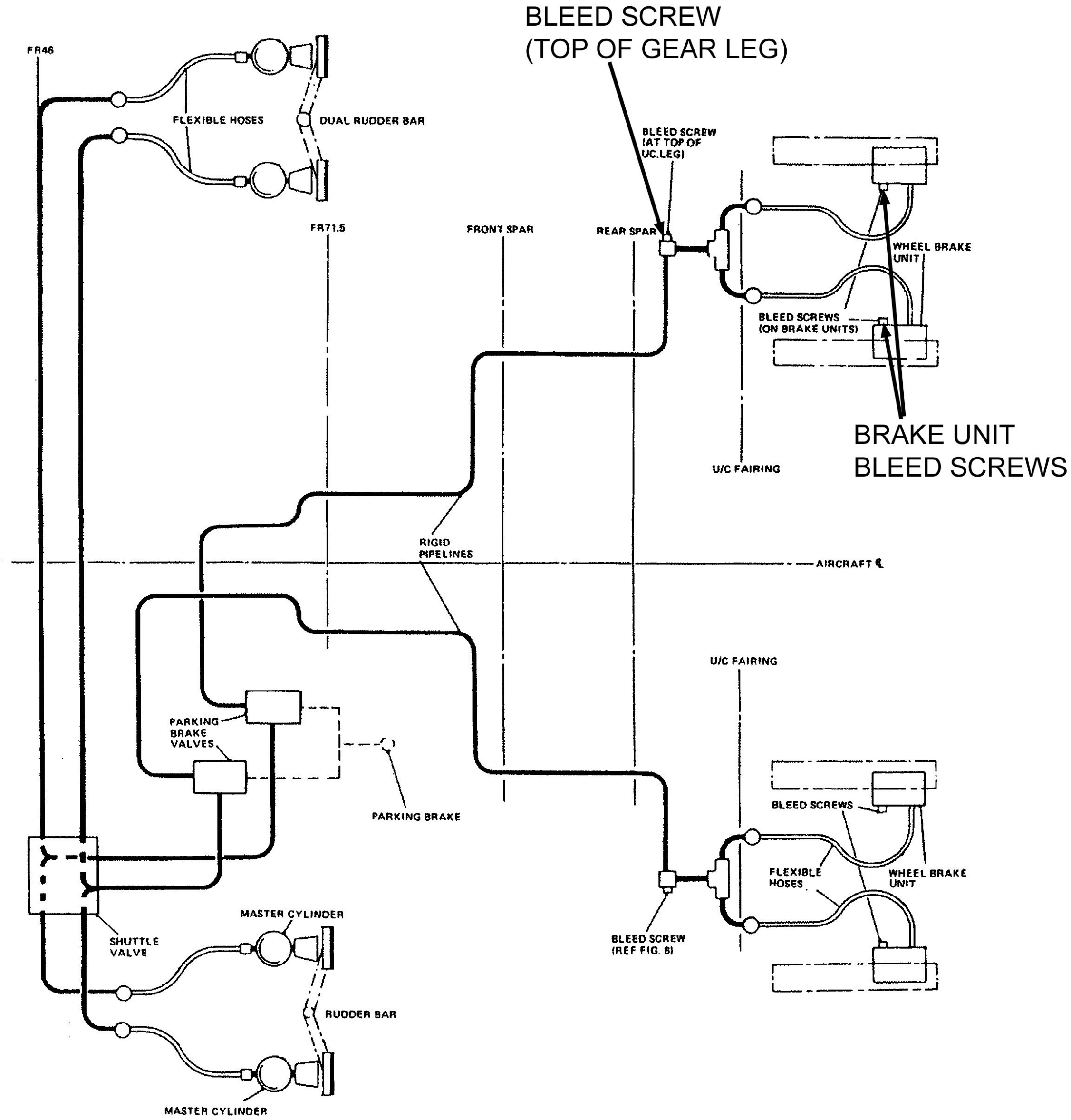

Figure 3

Diagram of the brake system

removing access panels on the upper surfaces of each wing. To bleed the right brake system a polythene tube is attached to the bleed screw at the top of the right main gear leg and tubes are attached to both right brake unit bleed screws. The polythene tubes from each brake unit bleed screw are then placed in a clean container. With the upper bleed screw closed and both brake unit bleed screws open, the right brake pedals are then pumped (at both the pilot and co-pilot positions) until air-free fluid emerges into the container. When clear fluid is seen to be flowing, both bleed screws are tightened. Then the upper bleed screw at the top of the landing gear leg is opened and the same brake pedal pumping procedure is followed. The master cylinder reservoirs are then topped up.

The aircraft manufacturer publishes a different brake bleeding procedure for the Trislander aircraft, even though the brake system on the Trislander is the same as that on the Islander. The brake bleeding procedure in the Trislander AMM calls for the bleeding procedure to be carried out at the upper bleed screw on top of the landing gear leg first. Afterwards, bleeding is carried out at the brake unit bleed screws, but in turn, rather than both at the same time as in the Islander procedure. The Trislander procedure also calls for the polythene tubes to be placed in a container partially filled with hydraulic fluid, rather than in an empty container as in the Islander procedure.

At the time of writing the aircraft manufacturer had not provided an explanation for the difference in procedures. However, they did supply a copy of their production brake bleeding procedure used following assembly of Islander aircraft. This procedure is similar to the Trislander AMM procedure, but instead of calling for the brake pedal to be pumped with a bleed screw open, the production procedure calls for the following repeated sequence for the left brake:

> *'Open bleed valve; push pilot's left hand pedal down and hold; close bleed valve; release pilot's left hand pedal; open bleed valve; push co-pilot's left hand pedal down and hold; close bleed valve; release co-pilot's left hand pedal.'*

and repeat until air-free fluid flow is achieved. This procedure is then repeated at the individual brake units.

The engineering representative for the owner of VP-MNI reported that he had found that the procedure in the Islander AMM did not always result in all trapped air being expelled. He advocated a fourth procedure which involved opening the bleed screw at the top of the landing gear leg and attaching a tube submerged in a container of fluid. A hand-operated oil pump is then attached to a brake unit bleed screw. This pump is then operated until air-free fluid flows from the bleed screw at the top of the landing gear leg. The process is repeated at each brake unit bleed screw. After refilling the reservoirs the brake pedals are then pumped until clear fluid flows from the bleed screws on top of the wing. The procedure also calls for the aircraft to be left to stand for an hour before checking for 'spongy' brakes.

Two UK operators of Islanders and Trislanders were contacted to find out their brake bleeding procedure. One stated that they followed the first part of the Trislander AMM procedure and bled from the upper bleed screw while pumping the brakes, but then used a hand-operated oil can to pump clean fluid into each brake unit bleed screw similar to the procedure used by the engineering representative for the owner of VP-MNI. They stated that if there is any air trapped between the upper bleed screw and the brake units it is more effective to clear this air by pumping it up towards the upper bleed screw than by trying to pump it down towards the brake units. The second UK operator agreed that it was not always possible to eliminate all the air by following the AMM procedure and they also sometimes employed a hand pump.

Pilot licensing

Aviation activities in Montserrat are regulated by Air Safety Support International (ASSI[1]) and are carried out in accordance with the *Air Navigation (Overseas Territories) Order 2007 as amended* (AN(OT)O)

Footnote

[1] Air Safety Support International (ASSI) is a subsidiary company of the UK Civil Aviation Authority and has been designated by the Governor of Montserrat to perform the civil aviation regulatory tasks on behalf of the Governor.

and the *Overseas Territories Aviation Requirements* (OTARs). At the time of writing ASSI did not issue pilot's licences. The pilot of VP-MNI held a JAA (Joint Aviation Authorities) Commercial Pilot's licence issued by the UK CAA (Civil Aviation Authority) with a Montserrat Certificate of Validation issued by ASSI. The pilot also held a JAA Class 1 Medical Certificate issued by the UK CAA. The Montserrat Certificate of Validation enables operations using Montserrat-registered aircraft but ceases to be valid if the UK licence or medical becomes invalid.

The pilot of VP-MNI was about two months pregnant at the time of the accident and she believed that her licence remained valid because she had consulted a JAA aviation medical examiner who had approved her for further flight duties in accordance with the OTARs. The section on '*Pregnancy*' in OTAR 67.209 states that a pregnant pilot can continue exercising the privileges of their licence up to the 30th week of gestation[2]. The section on '*Medical Requirements*' in the AN(OT)O states that a medical certificate shall be suspended on the confirmation of pregnancy, but this suspension may be lifted by the Governor:

> *'for such period and subject to such conditions as he thinks fit.'*

According to ASSI this suspension would normally be lifted until the 30th week of pregnancy in accordance with the OTARs. However, ASSI stated that the pilot should have notified the UK CAA about her pregnancy and would have been subject to CAA rules in addition to the OTARs due to her holding a UK licence. The UK Air Navigation Order states that a UK pilot must notify the UK CAA as soon as pregnancy is confirmed and that this will result in the medical certificate being suspended. The suspension can then be lifted by the CAA following a medical examination. If the examination indicates a normal pregnancy then the CAA will lift the suspension until the 26th week of gestation, but with a multi-pilot limitation in the case of Class 1 certificate holders (in accordance with JAR-FCL 3.195). The pilot of VP-MNI ceased flying after the 24th week of her pregnancy but she was unaware of the UK rules and had been operating single-pilot in the Islander up until that point. The airline operator was aware of the pilot's pregnancy but was unaware that the pilot needed to comply with UK rules.

The International Civil Aviation Organisation (ICAO) has published the following standards relating to pregnancy in Annex 1 on *Personnel Licensing*:

> *'6.3.2.21 Applicants who are pregnant shall be assessed as unfit unless obstetrical evaluation and continued medical supervision indicate a low-risk uncomplicated pregnancy.'*
>
> *6.3.2.21.1 Recommendation. – For applicants with a low-risk uncomplicated pregnancy, evaluated and supervised in accordance with 6.3.2.21, the fit assessment should be limited to the period from the end of the 12th week until the end of the 26th week of gestation.'*

Aerodrome information

The runway at John A Osborne Airport is 596 m long – a distance which includes the two 28 m displaced thresholds at both ends. The declared landing distance available (LDA) for Runway 10 is 540 m. There is a

Footnote

2 OTAR Part 67 was based on the original Bermuda Rule Part 67 which included the 30th week gestation limit. During the drafting of OTAR Part 67 ASSI requested the UK CAA's Medical Division for comments on Bermuda Rule Part 67 and since no comments on the pregnancy requirements were made they were adopted without change in OTAR Part 67.

near vertical drop in excess of 200 feet at the end of this runway. On 31 May 2011 another Islander aircraft, registration VP-MON, almost departed the end of Runway 28. This incident was the subject of an AAIB Special Bulletin S2/2011 published on 21 July 2011. Issues relating to the aerodrome will be discussed in the final report on the VP-MON incident.

Analysis

On landing, the aircraft suffered a loss of right braking and, in order to avoid the steep drop at the end of the runway, the pilot elected to use the left brake to steer the aircraft into the grass to the left side of the runway where it hit a raised embankment. The probable cause for the loss of right braking was trapped air in the right brake hydraulic lines. This air may have been present prior to the O-ring seal removal but was more likely to have been introduced during the seal removal and replacement. The engineer had carried out a brake bleeding procedure but he had not completed the full procedure as described in the AMM. He had not opened the bleed screw at the top of the right landing gear leg, and therefore air may have remained trapped in these lines. The investigation revealed the existence of several different brake bleeding procedures. The aircraft manufacturer had three different brake bleeding procedures, namely the Islander AMM procedure, the Trislander AMM procedure and their own production procedure. Three engineers from three different maintenance organisations had suggested that sometimes the manufacturer's procedures were inadequate for completely bleeding all the air out and that a hand pump attached to the brake bleed screws was sometimes required. Therefore the following Safety Recommendation is made:

Safety Recommendation 2011-093

Britten-Norman Aircraft Limited should review the different brake bleeding procedures for the Islander and Trislander aircraft including those used by engineering organisations, determine the most effective procedure and publish it in the aircraft maintenance manuals.

The pilot's pregnancy had no bearing on the cause of the accident, but the investigation revealed differences in the rules relating to pregnancy. The OTAR rule permitting flight up to the 30th week of gestation is different from the CAA rule of 26 weeks and the ICAO recommendation of 26 weeks. This difference resulted from OTAR 67 being based upon Bermuda Rule Part 67. The OTARs and ICAO Annex 1 allow for single-pilot operations while pregnant, whereas the CAA rules only permit multi-pilot operations by pregnant pilots holding a Class 1 medical.

Safety action by ASSI

In light of these findings ASSI have stated:

'As part of the ASSI ICAO Corrective Action Plan, OTAR 67 will be subject to a thorough overview and revision in association with the UK CAA Medical department'.

Safety action by the aircraft manufacturer

The aircraft manufacturer responded to Safety Recommendation 2011-93 with the following statement:

'Britten-Norman Aircraft Ltd are aware of detail differences in the brake bleeding procedures published in the aircraft maintenance manuals for different marks of aircraft with similar brake

systems. All of the procedures are considered to be effective providing they are followed correctly. Notwithstanding this, it is accepted that variations to the procedures may result in improved efficiency of the brake bleeding process with or without the use of additional equipment. Additionally, there would be merit in having a common procedure which takes advantage of best practice developed by the aircraft operators over years of in-service experience. Britten-Norman has, therefore, instigated a review of the different known bleeding procedures with a view to developing a common procedure which can be tested and approved prior to being published in the aircraft maintenance manuals.'

ACCIDENT

Aircraft Type and Registration:	Cessna 441 Conquest, G-USAR
No & Type of Engines:	2 Garrett Airesearch TPE 331-10N-513S turboprop engines
Year of Manufacture:	1985
Date & Time (UTC):	25 July 2011 at 0708 hrs
Location:	Doncaster Airport, South Yorkshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 2
Injuries:	Crew - None Passengers - None
Nature of Damage:	Right landing gear, wing, flaps damaged and engine shock-loaded
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	37 years
Commander's Flying Experience:	4,830 hours (of which 425 were on type) Last 90 days - 120 hours Last 28 days - 35 hours
Information Source:	AAIB Field Investigation

Synopsis

During the landing roll, the right main landing gear trailing arm failed causing the right wing to contact the ground. The aircraft veered to the right and came to rest on the grass on the right side of the runway. The pilot was uninjured. The reason for the failure of the trailing arm could not be identified due to damage of the fracture surfaces caused by contact with the runway.

History of the flight

After a normal landing, the pilot selected reverse pitch on the propellers to slow the aircraft. As the aircraft decelerated a vibration from the right main landing gear became apparent. The pilot initially believed that it was caused by wheel shimmy, but after a few seconds the pilot heard a loud bang and the right wing dropped. As the aircraft subsequently rotated to the right, the pilot shut down both engines. After the aircraft came to a halt, the pilot left the aircraft through the normal exit. He was uninjured.

Investigation

Examination of the aircraft revealed that the right main landing gear trailing arm had failed between the lower shock absorber bracket and the hinge point. After recovery of the aircraft, the trailing arm assembly was removed for detailed examination. The section of the trailing arm, which had remained attached to the landing gear leg, had been damaged by contact with the runway surface after the failure. This had destroyed any features which may have been present on the fracture surface.

The section of the trailing arm which had remained attached to the wheel was examined. No corrosion was identified on the external surface of the arm or on the inner bore. The fracture surface on this section had two distinct features. The first was a large area which showed the characteristics of a fracture due to overload in bending. The second was a flat face, perpendicular to the axis of the trailing arm. Both optical and Scanning Electron Microscope (SEM) examination of this area failed to identify any features which could be associated with the initiation of the failure, but did confirm that it had been abraded by contact with the runway surface, which removed any features that may have indicated the initial failure mode of the trailing arm.

Maintenance history

The maintenance records confirmed that the aircraft had been maintained in accordance with the manufacturer's approved maintenance programme and that the aircraft satisfied all the regulatory requirements. The records confirmed that the aircraft had undergone a scheduled maintenance input in May 2011 which included inspections of the main landing gear for defects and condition. No defects were identified with the trailing arms of the main landing gear during this input.

ACCIDENT

Aircraft Type and Registration:	1) P-51D Mustang (Commonwealth CA-18 Mk 22 NA), D-FBBD 2) Douglas AD-4N Skyraider, F-AZDP
No & Type of Engines:	1) 1 Packard Motor Car Co Merlin V1650-7 piston engine 2) 1 Wright R3350-268 piston engine
Year of Manufacture:	1) 1951 2) 1960
Date & Time (UTC):	10 July 2011 at 1616 hrs
Location:	Near Duxford Aerodrome, Cambridgeshire
Type of Flight:	1) Private 2) Private
Persons on Board:	1) Crew - 1 Passengers - None 2) Crew - 1 Passengers - None
Injuries:	1) Crew - 1 (Minor) Passengers - N/A 2) Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	1) Aircraft destroyed 2) Outboard section of right wing detached
Commander's Licence:	1) Private Pilot's Licence 2) Airline Transport Pilot's Licence
Commander's Age:	1) 64 years 2) 64 years
Commander's Flying Experience:	1) 3,894 hours (of which 1,035 were on type) Last 90 days - 26 hours Last 28 days - 16 hours 2) 25,920 hours (of which 15 were on type) Last 90 days - 76 hours Last 28 days - 30 hours
Information Source:	AAIB Field Investigation

Synopsis

The pilot of a P-51 Mustang was leading a 'Vic' (Vee) formation of three aircraft participating in an airshow at Duxford. On his left was a Douglas Skyraider and on his right was another P-51 Mustang. On a signal from the leader, the formation carried out a 'break' manoeuvre [1] to the left. During the left turn the Skyraider and the leading Mustang collided. The

Footnote

[1] The 'break' manoeuvre is when each aircraft in the formation pulls up and turns, in this case, to the left in a set sequence at three second intervals. Each aircraft then positions behind the aircraft ahead at sufficient distance to perform the landing.

Mustang pilot was forced to abandon his aircraft and descended by parachute to a safe landing; the Skyraider pilot was able to land his aircraft at Duxford.

The accident occurred after the Skyraider pilot had lost sight of his leader and continued to make a tighter turn than his leader's aircraft, which had slowed down. This caused their respective flight paths to converge, resulting in the collision.

Background information

The Skyraider pilot was a French national who had not previously taken part in the weekend Duxford air display of historic aircraft, which is known as the 'Flying Legends'. For this reason he had to demonstrate his competence in meeting the UK display flying requirements and underwent a Display Authorisation (DA) evaluation which was conducted by a DA Examiner (DAE). This involved flying an aerobatic sequence, both as an individual aircraft and in close formation with another aircraft. He successfully completed the test and his DA was issued by the UK CAA.

The accident occurred on the second day of the two-day, weekend event, during the finale of the display. This comprised a long formation of 27 aircraft in elements of two, three and four aircraft. This formation is known as the 'Balbo'[2]. In order to land such a large number of aircraft, the formation makes three passes along the display line in front of the crowd and at the end of each pass, a specified number of elements break away from the crowd, in this case to the left, in a predetermined sequence. The aircraft involved in the accident were in the third element of the leading section. The order in which they were to carry out the Break manoeuvre is illustrated at Figure 1.

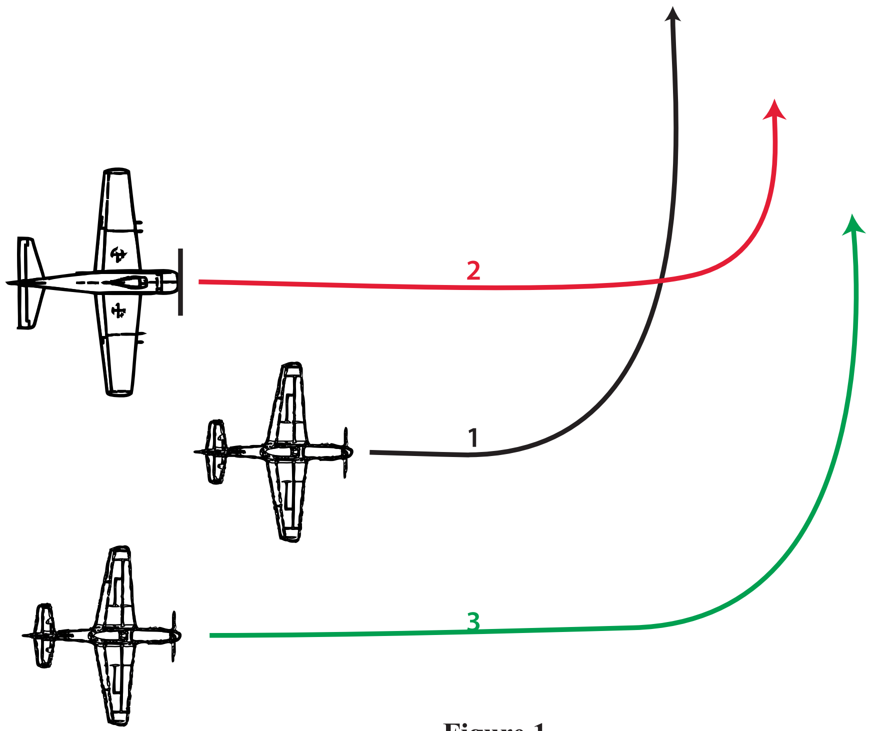

Figure 1

The sequence of the aircraft in the accident element carrying out their respective break manoeuvres

Footnote

[2] A term used to describe a large formation of aircraft named after the Marshal of the Italian Air Force, Italo Balbo.

The break sequence allows a manageable number of aircraft to position, in a specific order, suitably spaced, on the downwind leg of the circuit for landing. Both the accident aircraft had flown earlier in the display as part of other formations which had been briefed separately. These had also culminated in a break to land manoeuvre.

On the Saturday, the first day of the airshow, the break manoeuvre was uneventful and although the Skyraider pilot had lost sight of his leader as he climbed and turned his aircraft, which he considered normal, he quickly regained visual contact during the initial part of his break. At the post-flight debrief held between the three pilots in the element, there were no issues or concerns expressed and no changes to the break manoeuvre were made.

On the Sunday, the earlier formation flights involving the accident pilots were carried out without difficulty, and again no debrief points were raised.

History of the flight

After takeoff from Runway 24, the Balbo formation aircraft assembled into the pre-arranged elements. The weather conditions for the display were good and the weather was not a factor in the accident. At the end of the first pass in front of the crowd, the two aircraft at the rear of the Balbo carried out their break for landing. At the end of the second pass, the 12 aircraft in the second section carried out their break to land and on the third pass, the four elements of the leading section performed their respective breaks. On the next pass, following his hand signal to initiate the break, the lead Mustang aircraft broke upwards and turned to the left with an angle of bank of about 40°, turning towards the south as briefed. Three seconds later the Skyraider climbed and commenced a turn to the left, initially at an angle of bank of 60° but this increased to 90° as the turn progressed. The Mustang pilot reduced power to reduce his airspeed to 170 mph and lowered the first stage of flap. The Skyraider pilot maintained the same engine power setting and looked to his left to try and regain visual contact with his leader, but despite scanning the area ahead, was unable to locate him. The lead Mustang suddenly appeared in his two o'clock high position and the Skyraider pilot attempted to initiate an avoiding manoeuvre but the two aircraft collided.

The Mustang pilot, who was wearing a parachute, considered making a forced landing in the open areas ahead of his aircraft, but faced with an abnormally aft control column position and severe airframe buffeting, he elected instead to abandon the aircraft and, after deploying his parachute, landed safely.

Immediately after the collision, the Skyraider aircraft made a 360° roll to the right, due to the loss of the outboard section of the right wing. Following the roll, the pilot was able to bring his aircraft under control. There was no airspeed indication due to the loss of the pitot tube which was located on the missing section of the right wing. The aircraft was landed using the normal landing flap setting.

Accident site details

The Mustang had crashed into a cereal crop approximately 2 km southwest of the airfield. The ground marks indicated that the aircraft struck the ground on a track of 185º (M), banked at almost 90º to the left and pitched steeply nose-down, with the nose leaving a shallow impact crater. This had resulted in a compact wreckage site, with the main wreckage lying some 16 to 18 m from the scar in the ground made by the left wingtip. The furthest flung item of debris was found approximately 50 m from the point of initial impact.

The engine had broken away from the airframe and was found a short distance from the impact crater. The propeller assembly had become detached from the engine; the individual blades displayed evidence of chordwise scoring but otherwise had not suffered major damage, suggesting a low power setting at impact.

The largest piece of wreckage consisted of the fuselage aft of the nose, together with much of the wing structure. The impact forces had resulted in the tail section being folded over on top of the fuselage centre section. Some light scrape marks were observed on the unpainted underside of the rear fuselage; the absence of earth adhering to this area of the wreckage suggested that these marks may have been associated with the airborne collision. In general however, it was considered that the severe airframe disruption that occurred at impact would have tended to obliterate much of the airborne contact marks. Despite the damage it was possible to confirm that the rudder and elevator operating cables had remained attached to their surfaces.

The fuel tanks, located in the wings, had been torn open during the impact, dissipating the fuel. There was no fire, although the Fire Service had blanketed the wreckage with foam after the accident.

The Mustang's canopy was found approximately 980 m due north of the impact site. The outboard portion of the Skyraider's right wing was found some 280 m north-east of the canopy and about 1 km south-east of the airfield. The section of wing was approximately 1.7 m in length, and bore evidence of a deep impact crease on the upper leading edge at the inboard end. The radius of the crease was sharp, which, following subsequent analysis of photographs taken of the event, suggested that the wing may have contacted the radiator cowling of the Mustang, which is located on the fuselage underside.

Photographic evidence

There was considerable video footage and still photography taken of the aircraft immediately before, during and after the collision. Figure 2 shows the aircraft virtually at the moment of impact, together with an enlarged portion that shows more detail.

Photo: Huw Hopkins

Figure 2

The moment of the collision, with enlargement showing damage to the Mustang's right tailplane

The enlarged image indicates that the Skyraider wing had passed beneath the Mustang's fuselage such that it contacted the leading edge of the right tailplane. This had resulted in a flap of tailplane skin protruding upwards into the airflow. It was not possible to determine the full extent of the damage due to the serious disruption to the tailplane structure during the subsequent ground impact. However, it is likely that the damage caused significant disturbance to the airflow over the tail, with an associated effect on the elevator controls. It can also be seen that the Skyraider's right aileron remained attached, despite the outboard portion being structurally unsupported.

Figure 3 shows a photograph of the Mustang immediately after abandonment by the pilot. It can be seen that the underside of the fuselage has sustained a significant amount of damage in the area that contained the engine coolant radiator. It is considered that this generated the crease in the leading edge of the Skyraider's wing, as noted earlier, and which resulted in its structural failure.

Photo: Huw Hopkins

Figure 3

View of Mustang showing damage to fuselage underside

Examination of the video footage indicated that the Mustang's canopy was jettisoned approximately 3.5 to 4 seconds after the collision, with the aircraft then adopting a level attitude on a gently descending flight path. The pilot was seen to exit the aircraft around 10 seconds later, following which the aircraft entered a steepening dive. It struck the ground approximately 3.5 seconds after the pilot baled out. The parachute deployment sequence could be seen in the video and, although the actual landing area was obscured by trees, it was estimated that 7 to 8 seconds elapsed between the canopy starting to inflate and the subsequent landing.

Display briefings

A flying display briefing was held at 0945 hrs daily and was given by the Flying Display Director. It was a comprehensive briefing for all the participating pilots and covered the day's activities and procedures to be adopted. A kneepad-sized aide-memoir was provided for each pilot and contained all the relevant information needed to take part in the display.

The Balbo formation was briefed by the Balbo leader after the main display briefing. A written 'Balbo Brief' was also provided for each pilot and contained all the information presented during the briefing.

The leader of each element in the Balbo briefed the pilots in their element on the formation and the break manoeuvre. Following the briefing, the pilots in the accident element walked through their display sequence, adopting the formation shape, and their individual positions within the formation. The leader was to run in at about 200 mph, signal the break with his left hand and then pull up rolling to the left using some 50° to 60° angle of bank, turning onto a southerly heading. The wingmen would then delay for three seconds before commencing their break in order to ensure separation.

Following the display any issues were discussed and any necessary changes made.

On the Saturday, the sequence of briefings was followed and no changes were required to be made to the display. On Sunday the three pilots in the accident element did not hold their briefing as the day before but the leader confirmed with his two wingmen that they were happy with the display.

Flight crew information

The Mustang pilot

The Mustang pilot started flying in 1967 and obtained a PPL 1988. He commenced flying historic aircraft in 1993 using a Harvard and acquired the accident aircraft in 1997. He had also flown other Mustangs. He had taken part in the Flying Legends and Balbo on 12 occasions. He had sold the aircraft in March 2011 but was asked by the new owner to display it during the Flying Legends weekend.

The Skyraider pilot

The Skyraider pilot had served initially as a fast jet pilot and instructor in the French Air Force and, as a fast jet pilot and instructor, he had taken part in and taught break manoeuvres which tended to be more dynamic than those briefed at Duxford. After leaving the Air Force he followed a career in commercial aviation as a pilot with his national airline and commenced historic aircraft flying in 2006. He had displayed historic aircraft throughout Europe since 1998 and had been a member of an aerobatic team since 2005.

Safety and survival

The Skyraider pilot, despite his difficulties in controlling his aircraft, was able to perform a successful landing. The Mustang pilot was forced to abandon his aircraft. He was wearing a set of flying overalls, boots, gloves and a leather flying helmet[3] with integral headphones. He also wore a Strong Para-Cushion Seat 304 parachute and was secured in the aircraft seat by a four point harness. He had frequently rehearsed the sequence of actions needed to be completed when abandoning the aircraft.

Following the collision the Mustang yawed to the right, the left wing dropped and the nose pitched down. The pilot heard the impact, and although he did not see the other aircraft, realised he had been in a mid-air collision. He regained control of his aircraft and confirmed the engine was still producing power. He then reduced power. He realised from the control column being aft of the normal position that the aircraft was damaged and jettisoned the canopy with his right hand. He attempted to trim the aircraft for the best glide speed in preparation for a belly landing in the farmland ahead. When he relaxed the back pressure on the control column, the aircraft nose pitched down and he could feel a buffeting through the control column and airframe. He decided to abandon the aircraft and released his seat restraint harness with his left hand and then placed that hand on the left side of the cockpit. He put both feet on the floor and moved his right hand to the right side of the cockpit at the same time pushing up to stand up in the cockpit. As he released the control column, the aircraft pitched nose down and the combined effect was that he exited the cockpit at a height of about 500 ft. He struck the tailplane, hitting his head, both arms and a shin. He immediately pulled the parachute deployment handle and saw the canopy deploy. He was surprised at the high rate of descent but landed in a cornfield, executing a parachute roll to absorb the impact. He was able to stand up, remove his parachute and awaited the arrival of the emergency services.

Footnote

3 The helmet was a modern, Kevlar, hard flying helmet, covered in leather to simulate a vintage leather flying helmet.

Discussion

The collision occurred due to the Skyraider continuing the turn without the pilot having sight of the lead aircraft. His turn was tighter and his speed greater than that of his leader, causing the flight paths of the aircraft to converge. The approximate relative tracks of the aircraft in the accident element are illustrated at Figure 4 below.

Whilst abandoning his aircraft, the Mustang pilot impacted the tail section. He was fortunate that his injuries did not prevent him from operating his parachute deployment mechanism. Had he been incapacitated, there was no automatic means, such as a static line, for deploying the parachute. The low height also meant that the parachute had to be deployed as soon as the pilot had cleared the aircraft structure. As a result, the following Safety Recommendation is made:

Safety Recommendation 2011-083

It is recommended that the Civil Aviation Authority considers, where a parachute is worn as safety equipment, whether the provision of an automatic means of operating the parachute would provide a safety benefit.

The Mustang pilot had frequently rehearsed the sequence of actions needed to be completed when abandoning the aircraft and was able to exit the aircraft very quickly; a factor which was significant in the successful outcome. Other pilots who wear parachutes may benefit from regular practice and rehearsal of aircraft abandonment drills.

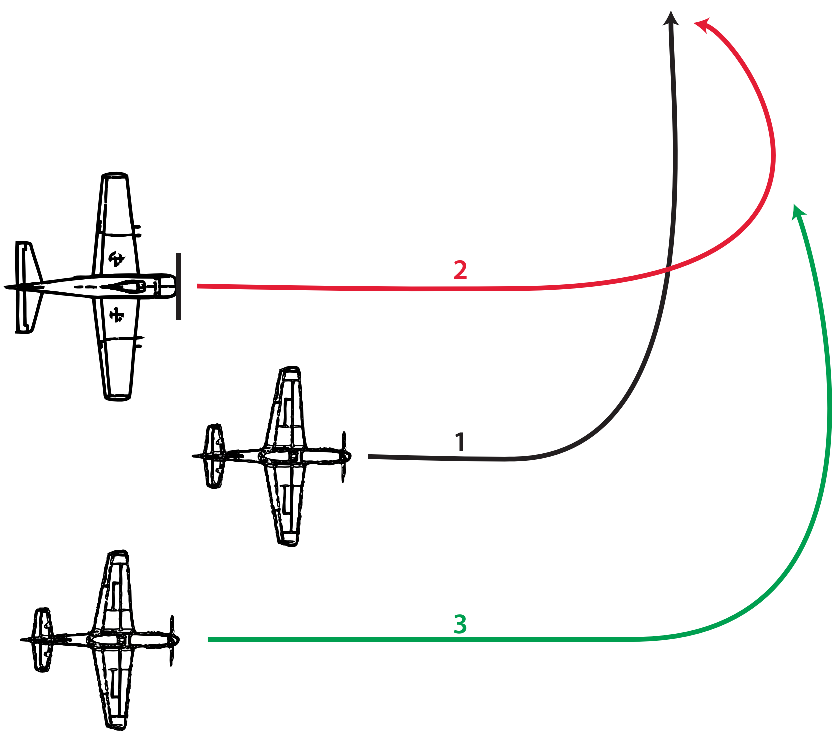

Figure 4

The approximate relative tracks adopted by the aircraft in the accident element

ACCIDENT

Aircraft Type and Registration:	Agusta A109E, G-GCMM
No & Type of Engines:	2 Pratt & Whitney Canada PW206C turboshaft engines
Year of Manufacture:	2002
Date & Time (UTC):	19 July 2011 at 1105 hrs
Location:	Fiveways Trading Estate, Corsham, Wiltshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Tail rotor blade and gearbox damaged
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	64 years
Commander's Flying Experience:	12,925 hours (of which 580 were on type) Last 90 days - 145 hours Last 28 days - 62 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

Synopsis

Just prior to touchdown the tail rotor struck a hedge and a concrete post, damaging the tail rotor and its gearbox. There were no injuries. On arrival at an industrial depot the normal landing position had been obstructed by two articulated lorries.

History of the flight

The pilot was planning to take a passenger from his office near Stoke-on-Trent first to Gloucester, then to an industrial depot in Corsham, Wiltshire at which the pilot had landed several times, then back to Stoke-on-Trent. Before leaving Gloucester the passenger rang the depot, from inside a car, giving 30 minutes notice of his arrival. The helicopter took off from Gloucester at about 1025 hrs.

Upon arrival at the depot the normal landing position was obstructed by two articulated lorries, so the pilot orbited the site looking for another suitable landing area. As he did so, the passenger pointed out the depot manager, who seemed to be indicating to land at the entrance to the depot, and asked if the pilot could do so. The pilot made an airborne inspection of the intended landing site for obstructions and determined that, although it looked "tight", it was large enough. He then set up an approach into wind. As the helicopter settled in a high hover it encountered turbulence from a warehouse which made control of the helicopter difficult, particularly in heading and height.

After establishing the helicopter in a hover 5 ft over the landing area the pilot started to lower it. As he did so he felt a "slight shudder" at the rear of the aircraft with no perceptible rotor rpm change, followed by some tail rotor vibration through the rudder pedals. Although the landing was then completed without apparent incident the helicopter's tail rotor and skid had struck a hedge, consisting of branches 3-4 cm in diameter, and a concrete post.

Subsequently, the helicopter's tail rotor blades, gearbox and pitch change mechanism were replaced.

Pilot's comments

The pilot commented that he was aware of a private airfield about 1 nm south of the industrial depot, but that when he had suggested this to the passenger on previous occasions the passenger had insisted that he landed at the depot. He had also considered landing in fields adjacent to the depot but had been unable to find out who owned them. He did not think they provided access to the depot.

Depot manager's comments

The depot manager commented that he only became aware of the passenger's arrival about 10 minutes before the accident, believing he would arrive by road. Upon hearing the helicopter making its approach he went out to the landing site and made hand signals that he hoped would indicate to the pilot not to land but to go to the airfield approximately 1 nm south of the depot.

He added that if he had been given 30 minutes notice, as is usual, he would have had the lorries moved or, if unable to do so, he was able to pick up the passenger from the nearby airfield.

Passenger's comments

The passenger commented that the confusion over whether he was arriving by car or helicopter arose because he made the call giving his ETA from a car while he was in Gloucester. He added that in hindsight the helicopter should have landed at the airfield 1 nm away or in Malmesbury, Wiltshire, 9 nm north, where it is based.

Video evidence

A video of the accident was filmed by an occupant of one of the adjacent buildings who was standing about 35 m from the helicopter and shows details of the event consistent with the pilot's recollection. Another person can be seen observing approximately 15-20 m from the helicopter. Figure 1 shows a still from the video at the moment the tail rotor struck the concrete post.

Figure 1

G-GCMM at the moment its tail rotor struck the concrete post

Discussion

The pilot described the landing site as "tight"; it may also have been unsuitable for the prevailing wind conditions. In less turbulent conditions the helicopter might have landed safely. Although the pilot believed the landing site was suitable, he was landing in an area surrounded by buildings occupied by businesses, unconnected with the passenger, whose staff may not have been familiar with helicopter operations outside their premises and could have been endangered by a more serious outcome.

ACCIDENT

Aircraft Type and Registration:	Boeing A75N1 Stearman, G-BTFG
No & Type of Engines:	1 Continental Motors Corp W-670-6N piston engine
Year of Manufacture:	1940
Date & Time (UTC):	14 October 2011 at 1410 hrs
Location:	Manston Airport, Kent
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Left wingtip and aileron were damaged
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	58 years
Commander's Flying Experience:	928 hours (of which 8 were on type) Last 90 days - 84 hours Last 28 days - 20 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot was flying circuits to Runway 10 at Manston Airport. The weather conditions were good, with a surface wind from 120° at 10 kt. The aircraft was reported to have landed after the fourth circuit, at the correct speed, on the runway centreline in the target area the pilot had selected. The aircraft touched down on its main wheels and the pilot held the tailwheel off the runway surface. As the aircraft's speed decayed to a fast walking speed, the tailwheel started to settle and the aircraft suddenly veered to the right. The aircraft ground looped through 360º, during which the left wingtip and aileron made contact with the runway. The pilot was uninjured.

The pilot was not aware of any weather conditions which could have induced the sudden turn to the right, concluding that he had relaxed as the aircraft's speed decayed and did not apply the appropriate amount of rudder to counter the initial yaw.

ACCIDENT

Aircraft Type and Registration:	Cessna 152, G-CCHT
No & Type of Engines:	1 Lycoming O-235-L2C piston engine
Year of Manufacture:	1983 Serial no: 152-85176
Date & Time (UTC):	17 September 2011 at 1540 hrs
Location:	Redhill Aerodrome, Surrey
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Failure of nose landing gear and damaged propeller
Commander's Licence:	Private Pilot's Licence
Commander's Age:	31 years
Commander's Flying Experience:	72 hours (of which 72 were on type) Last 90 days - 5 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

During an approach to land at Redhill the pilot was distracted by rain showers and parallel landing traffic. The aircraft bounced twice on landing and the pilot attempted a go-around but too late to prevent the failure of the nose landing gear.

History of the flight

The pilot had planned a local flight to the east of Redhill. The pilot reports that during the flight a window latch broke and he diverted into Headcorn to fix it. After making the repair at Headcorn, and planning the return flight to Redhill, the pilot checked the Redhill ATIS, which advised of rain showers in the vicinity.

Inbound to Redhill the pilot encountered a light rain shower while joining the circuit overhead. He flew a short downwind leg and was cleared to land on Runway 26R. The rain grew more intense and the pilot was conscious that there was a rotorcraft on final approach for the parallel Runway 26L as he was about to land. The aircraft bounced twice on landing and the pilot attempted a go-around but too late to prevent the failure of the nose landing gear leg, followed by the aircraft skidding to a stop, still upright, at the left edge of Runway 26R.

The pilot considers that the primary causal factor in the accident was that he held too high an airspeed on final approach, resulting from the distractions of the rain and the parallel landing traffic. He considers that he should have made an earlier decision to go around, before landing, and waited for the shower to pass before making another approach. He also considers that it would have been wise for him to wait longer at Headcorn for the showers to clear before he departed for Redhill.

ACCIDENT

Aircraft Type and Registration:	Emeraude CP301A, G-BXAH
No & Type of Engines:	1 Continental Motors Corp C90-14F piston engine
Year of Manufacture:	1962
Date & Time (UTC):	19 November 2011 at 1341 hrs
Location:	Henstridge Airfield, Somerset
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	64 years
Commander's Flying Experience:	296 hours (of which 63 were on type) Last 90 days - 3 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

Following an engine failure during takeoff, the aircraft stalled and was destroyed when it struck the ground.

History of the flight

After starting and warming the engine, the pilot taxied the aircraft to the intersection of the runway where he satisfactorily carried out the engine power checks and tested the carburettor heat. The aircraft was then taxied, at a low power setting, for approximately 340 m to the threshold of Runway 07. The pilot applied full power and the takeoff and initial climb were normal until the aircraft was at about 100 ft (agl) when the engine started to run rough and lost power. The pilot started to lower the aircraft nose whilst making a MAYDAY call and looking for somewhere to land. He then recalls the ground rapidly rushing up and his next recollection was of finding himself trapped in the aircraft wreckage. The pilot, who suffered minor injuries, was released from the wreckage by a medic from the air ambulance unit that was based at the airfield. Photographs of the accident site indicate that the aircraft was in an incipient spin to the left when it struck the ground.

The pilot stated that he did not appreciate that when flying at the glide airspeed there would be such a marked difference in the pitch attitude of the aircraft with the engine stopped. Following the engine failure he considers that he did not move the control column quickly enough, or sufficiently far forward, to prevent the aircraft stalling and entering a spin to the left. The pilot also felt that with a temperature of 15°C and dew point of 13°C the engine probably stopped as a result of carburettor icing. On reflection he believes that following the long taxi to the runway threshold he should have applied carburettor heat to melt any ice before taking off.

ACCIDENT

Aircraft Type and Registration:	Europa XS, G-KDCC
No & Type of Engines:	1 Rotax 912 ULS piston engine
Year of Manufacture:	2007
Date & Time (UTC):	23 October 2010 at 1130 hrs
Location:	Private airstrip, Sewards Hall Farm, Dunmow, Essex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to wings, propeller and fuselage
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	72 years
Commander's Flying Experience:	387 hours (of which 35 were on type) Last 90 days - None Last 28 days - None
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent AAIB enquiries

Synopsis

On landing, the aircraft overran the runway and collided with a fence, sustaining damage. The pilot's lack of recent experience and his interaction with a passenger who was also a qualified pilot were identified as possible causes. His decisions to adopt a new landing technique and to land with a downwind component may also have contributed to the accident.

History of the flight

The aircraft was kept at a private airstrip near the owner's home. It had been repaired following a previous heavy landing, and immediately before the accident flight, a Light Aircraft Association (LAA) inspector carried out a check flight during which it performed satisfactorily. The owner then wished to fly, but because he was not in recent practice (his last flight had been in April 2010), the inspector suggested he should take an experienced Europa pilot with him as a passenger, and he did so. The passenger was a qualified pilot, but not an instructor.

The weather was benign with good visibility and a light south-easterly wind. The pilot chose Runway 22 (approximately 500 metres long with a grass surface and a downhill gradient of 1:300) for takeoff, as the wind favoured it. After a flight lasting 20-30 minutes, the aircraft returned to the airstrip to land, and following a discussion with his passenger, the pilot chose Runway 04 for landing.

The pilot stated that previously he had found that closing the throttle just before the threshold and flaring for landing with one hand on the throttle, ready 'to arrest or retard any excess sinking' was a successful technique. He also reported that he had been told the throttle should not be closed for landing, and that the landing should be carried out with power applied. He reported that he employed this latter technique for the landing, and it resulted in too fast a landing speed.

When it became apparent that the landing was not going well, the passenger suggested a go-around. The pilot applied power but the aircraft impacted a fence at the end of the runway.

An eyewitness stated that he observed the approach, landing, and accident, and that he saw several pilot-induced oscillations on the approach.

Landing technique

The aircraft Owner's Manual stated:

> *'Smoothly reduce power over the threshold to flare and touch down at 45-50 kts (depending on weight) in a two point attitude (mainwheel and tail wheel together).'*

Reporting of the accident

The pilot did not report the accident, although one witness stated that he was advised that he must do so because the accident was serious. The AAIB was informed of the accident by a third party on 12 July 2011 and contacted the pilot, who then provided details.

Date of the accident

The pilot reported that the accident occurred on 13 November 2010. However, police logs showed that on 23 October 2010 officers had attended an accident to G-KDCC at the airstrip, the circumstances of which matched those reported. The aircraft insurance broker reported that the pilot telephoned the broker on 25 October 2010, stating that the aircraft had been involved in an accident and cancelling his policy. Accordingly, the AAIB records that the accident occurred on 23 October 2010.

Discussion

Several factors may have combined to cause this accident, including the interaction between pilot and passenger, the technique used by the pilot, the pilot's lack of recent experience on type, and the pilot's decision to land uphill but with a tailwind component. The Owner's Manual did not clarify whether to close the throttle or maintain some power during the landing.

Because the pilot had not completed three takeoffs and landings within the preceding 90 days, he should have flown either solo or with an instructor. An instructor may have been able to intervene appropriately to prevent the accident.

ACCIDENT

Aircraft Type and Registration:	Falconar F-11-3, G-AWHY
No & Type of Engines:	1 Continental Motors Corp O-200-A piston engine
Year of Manufacture:	1995
Date & Time (UTC):	7 October 2011 at 1300 hrs
Location:	North Hill Airfield, Devon
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to the right wing
Commander's Licence:	Private Pilot's Licence
Commander's Age:	35 years
Commander's Flying Experience:	78 hours (of which 18 were on type) Last 90 days - 21 hours Last 28 days - 11 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Prior to departure, the pilot extensively planned a cross-country flight from Chichester (Goodwood) Airfield to Dunkeswell Airfield, including a 30 minute fuel reserve. Just after takeoff, he noted a fault with the aircraft's fuel gauge but continued the flight using fuel remaining calculations, based on his flight plan assumption of a fuel consumption rate of 15 litres per hour. As the flight progressed, the pilot realised the sectors were taking longer than he had anticipated. Despite rerouting onto a shorter flight plan, as he commenced his approach into Dunkeswell, the engine began to falter. The pilot realised he would not reach his intended airfield, and when the engine stopped completely, he identified a nearby gliding club where he could land. Although the pilot completed the initial touchdown without incident, a flock of sheep ran in front of the aircraft during the landing roll. The resulting collision caused damage to the aircraft's right wing, but the sheep and the pilot were uninjured. The pilot later identified that a planned fuel consumption rate of 22 litres per hour was more realistic for the aircraft.

ACCIDENT

Aircraft Type and Registration:	Great Lakes Sports Trainer, G-GLST
No & Type of Engines:	1 Warner Aircraft Corp Scarab 165 piston engine
Year of Manufacture:	2010
Date & Time (UTC):	23 September 2011 at 1145 hrs
Location:	Approx 2.5 miles from White Waltham Airfield, Berkshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Substantial
Commander's Licence:	Private Pilot's Licence
Commander's Age:	48 years
Commander's Flying Experience:	178 hours (of which 22 were on type) Last 90 days - 12 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The engine lost power and its rpm dropped to a low idling speed as the aircraft climbed through 900 ft after takeoff. The pilot confirmed the engine controls were correctly selected and declared a MAYDAY. During the subsequent forced landing, the aircraft struck bushes at the end of the landing roll causing damage to its propeller, lower wings, elevator and rudder. The pilot was uninjured. The aircraft was later recovered to White Waltham Airfield where, at the time of writing, it was awaiting investigation of the power loss. If the results of this investigation reveal any significant safety information, an addendum to this report will be published.

ACCIDENT

Aircraft Type and Registration:	Grumman AA-5 Traveller, G-OBMW
No & Type of Engines:	1 Lycoming O-320-E2G piston engine
Year of Manufacture:	1975
Date & Time (UTC):	25 October 2011 at 1430hrs
Location:	Sherburn-in-Elmet Airfield, West Yorkshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 2
Injuries:	Crew - None Passengers - None
Nature of Damage:	Nosewheel, propeller, aerials and cowling damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	58 years
Commander's Flying Experience:	629 hours (of which 437 were on type) Last 90 days - 33 hours Last 28 days - 18 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot was returning from a short local flight to perform a touch-and-go on grass Runway 24 at Sherburn-in-Elmet Airfield. The pilot reported that the approach was normal and the wind conditions were calm. However, the initial touchdown was heavy, leaving propeller strike marks on the ground. The aircraft bounced and ballooned into the air. Despite applying maximum power and attempting to hold the aircraft off the ground, it pitched forward and touched down again. The nose gear collapsed and aircraft skidded to a halt. The pilot and passengers, all of whom were wearing lap and diagonal harnesses, were uninjured.

ACCIDENT

Aircraft Type and Registration:	Midget Mustang, G-IIMT
No & Type of Engines:	1 Continental Motors Corp O-200-A piston engine
Year of Manufacture:	2005
Date & Time (UTC):	24 August 2011 at 1500 hrs
Location:	Gloucester Airport, Gloucestershire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to landing gear structure and wing
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	39 years
Commander's Flying Experience:	9,815 hours (of which 52 were on type) Last 90 days - 173 hours Last 28 days - 61 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

Synopsis

The engine suffered a loss of power after takeoff and the ensuing forced landing on an intersecting runway resulted in damage to the landing gear structure and wing. The fuel filler cap of the pressurised fuel tank was found loose which would have resulted in a loss of header pressure and this probably contributed to a fuel vapour lock.

History of the flight

The pilot had refuelled the aircraft at Edge Hill farm strip in Oxfordshire and had completed an uneventful 20 minute flight to Gloucester Airport. The air temperature at Gloucester was about 19°C. About 40 minutes later, after normal engine power checks, the pilot lined up for a takeoff from Runway 22 to return to Edge Hill. The acceleration during the takeoff was normal, but at about 100 to 200 feet above the runway the engine suffered a rapid loss of power. The engine continued to run but only at about idle power. The pilot considered landing straight ahead but thought he might overrun the end so he banked left to land on the intersecting Runway 18 which extended into a taxiway at its end. The aircraft touched down heavily on Runway 18 with the left mainwheel and tailwheel first. The pilot was able to stop the aircraft on the taxiway just beyond the end of the runway, and was able to exit the aircraft without assistance.

Aircraft description

The Midget Mustang is a homebuilt aircraft operated under a Permit to Fly and has a maximum takeoff weight of 454 kg (Figure 1). It has a single fuel tank, located in front of the instrument panel with a gravity feed system to the engine. No engine-driven fuel pump is fitted but there is an electric fuel pump which is normally used for takeoff and landing. According to the Light Aircraft Association (LAA) Inspector who examined G-IIMT, the gravity feed fuel system provides marginal fuel pressure so the kit manufacturer had developed a modification that results in the fuel tank being pressurised by ram air from a pitot tube fitted under the belly. This modification was fitted to G-IIMT. The ram air passes through a plastic hose fitted to the top of the fuel tank filler cap and the filler cap is secured by a hinged clamp and knurled screw (Figure 2).

Figure 1

Midget Mustang G-IIMT prior to the accident (photograph courtesy of Roger Syratt)

Aircraft examination

When the pilot first examined the aircraft after the accident he discovered that the knurled screw was loose and the filler cap was no longer sealing the tank. This would have resulted in the loss of ram air pressure and reduced the fuel header pressure. The pilot reported that although he normally turned on the electric fuel pump for takeoff he could not recall if he had done so on this occasion. Further examination of the aircraft and fuel system by the LAA inspector did not reveal any further anomalies. The LAA inspector reported that without the ram air pressure the fuel pressure was probably insufficient to allow the fuel to flow through a potential vapour lock or build up of vapour around the fuel pipe loop near the electric fuel pump. He also stated that because the aircraft

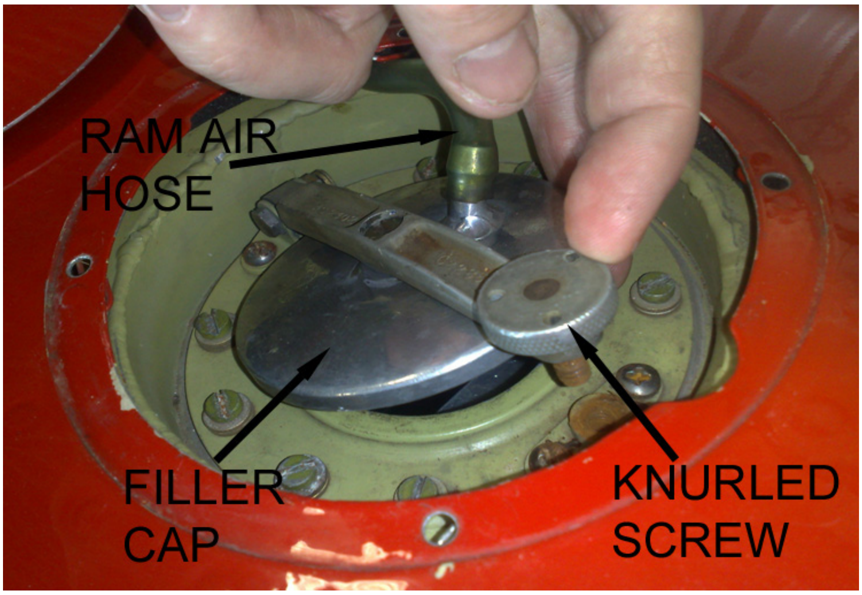

Figure 2

Fuel Filler Cap arrangement on G-IIMT

had been on the ground for about 40 minutes this could have provided sufficient time for vapour to build up inside some of the un-insulated fuel lines in the engine compartment.

Analysis

Apart from the loose fuel filler cap, no other faults with the aircraft were found. It is therefore probable that a fuel vapour lock resulted in the loss of power during takeoff due to insufficient header pressure in the tank to clear it. It is also possible that the electric fuel pump had not been turned on and this contributed to the reduced fuel pressure.

ACCIDENT

Aircraft Type and Registration:	Morane Saulnier MS.893E Rallye 180GT, G-BFGS
No & Type of Engines:	1 Lycoming O-360-A1A piston engine
Year of Manufacture:	1975
Date & Time (UTC):	31 July 2011 at 1545 hrs
Location:	Holmbeck Farm Airfield, Buckinghamshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nose landing gear leg collapsed and damage to propeller, engine mount, silencer and cowling
Commander's Licence:	Private Pilot's Licence
Commander's Age:	64 years
Commander's Flying Experience:	418 hours (of which 253 were on type) Last 90 days - 12 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot had established the aircraft on approach to Runway 29 at 60 kt with full flap - the wind was from 220° at 10 kt. The runway was a 500 m unlicensed grass strip with an upslope at the Runway 29 end. The pilot was aiming to touch down at the location where the runway became level, but he touched down just before it and the aircraft bounced. The aircraft bounced a second time with a nose-high attitude, then the nose dropped and the aircraft touched down nosewheel first, causing the nose landing gear leg to fail. After the aircraft came to rest on its nose the pilot was able to exit the aircraft unassisted. The pilot assessed that the aircraft probably stalled during the second bounce.

ACCIDENT

Aircraft Type and Registration:	Piper PA-18-150 Super Cub, G-BIDK
No & Type of Engines:	1 Lycoming O-320-B2B piston engine
Year of Manufacture:	1958
Date & Time (UTC):	1 September 2011 at 1420 hrs
Location:	Cranfield Airport, Bedfordshire
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Left wing spar, left main wheel and tyre damaged
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	75 years
Commander's Flying Experience:	24,000 hours (of which 500 were on type) Last 90 days - 60 hours Last 28 days - 30 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

On landing, the aircraft bounced slightly and then ground looped, damaging the left wing spar, wheel and tyre. The handling pilot, who was in the front seat, was under instruction and was making an approach to Runway 21 with an 8 kt crosswind from the left. The aircraft touched down left wheel first and bounced slightly before settling back onto the runway. This pilot described the second contact as "firm". The left wing then lifted and the pilot lost directional control of the aircraft, which yawed to the right through approximately 90°. During this manoeuvre the left tyre burst, the left wheel was damaged and the left wing tip struck the ground, causing damage to the left wing spar.

BULLETIN CORRECTION

The report erroneously refers to the handling pilot being in the left seat when he was actually occupying the front seat. Therefore, the second sentence should now read:

> The handling pilot, who was in the **front** seat, was under instruction and was making an approach to Runway 21 with an 8 kt crosswind from the left.

This was corrected in the online version of the report on 20 February 2012 and a correction will appear in the April 2012 Bulletin.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28-151 (Modified) Cherokee Warrior, G-BSCY
No & Type of Engines:	1 Lycoming O-320-D3G piston engine
Year of Manufacture:	1975
Date & Time (UTC):	1 September 2011 at 1114 hrs
Location:	Wellsbourne Mountford Aerodrome, Warwickshire
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Propeller and right wing damaged
Commander's Licence:	Student
Commander's Age:	36 years
Commander's Flying Experience:	32 hours (of which 32 were on type) Last 90 days - 32 hours Last 28 days - 13 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot was returning to Wellesbourne Mountford from his first solo navigation flight, in fine weather, with a wind of 6 kt from the west. He considered the touchdown on Runway 18 was "fine and smooth" but to the right of the centreline. The aircraft veered further to the right which the pilot then attempted to correct. However, the aircraft then veered to the left, departed the runway paved surface and impacted a fence. The wire from the fence contacted the propeller causing the aircraft to rotate to the right and come to a halt.

The pilot was wearing a lap and diagonal harness and was uninjured. He considered that his lack of experience in crosswind landings contributed to his loss of control of the aircraft.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28-181, N4514X
No & Type of Engines:	1 Lycoming O&VO-360 SER piston engine
Year of Manufacture:	1975
Date & Time (UTC):	15 October 2011 at 1325 hrs
Location:	Cambridge Airport
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Propeller, engine, nosewheel and runway light damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	42 years
Commander's Flying Experience:	443 hours (of which 384 were on type) Last 90 days - 17 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot was executing a touch-and-go on Runway 23 at Cambridge with a crosswind from the left reported as 140° at 9 kt, varying between 080° and 190°. During the landing roll the left wing lifted and rolled the aircraft about the nose gear and right main gear such that the right wingtip contacted the ground. The pilot was unable to maintain directional control of the aircraft which then turned rapidly to the left and exited the paved runway onto grass, during which the nosewheel struck a runway landing light. The nose gear then collapsed causing the propeller to strike the ground, with the aircraft coming to stop approximately 10 m from the side of the runway.

ACCIDENT

Aircraft Type and Registration:	Piper PA-34-220T, N6920B
No & Type of Engines:	Two Continental Motors TSIO-360 piston engines
Year of Manufacture:	1985
Date & Time (UTC):	5 July 2011 at 1200 hrs
Location:	Shipdham Airfield, Norfolk
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to left propeller and structure of left wing
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	53 years
Commander's Flying Experience:	1,170 hours (of which 36 were on type) Last 90 days - 6 hours Last 28 days - 6 hours
Information Source:	AAIB investigation

Synopsis

During a training flight, the aircraft landed heavily and the left propeller blades were damaged. Following a go-around, three further landings were completed; during two of these the aircraft touched down in standing crop short of the runway. The instructor indicated that she may have placed too much confidence in the student's ability and that she had not paid sufficient attention to indicated airspeed during the approaches.

History of the flight

The commander, occupying the right seat, was an instructor. The student, in the left seat, was employed as a co-pilot flying Boeing 737 aircraft and had last flown multi-engine piston aircraft some years before the accident. The student was being trained in preparation for a practical test for issue of an Airline Transport Pilot's Licence.

The instructor had briefed the student to carry out some circuit flying at Shipdam. Runway 21 was in use, in good weather conditions with the wind assessed as from 230° at less than 10 kt. The aircraft took off from Runway 21 and the student flew a left-hand circuit culminating in a touch-and-go into a further circuit.

On the second landing, the aircraft touched down heavily and bounced, before touching down a second time, again heavily. During the second touchdown, the left propeller tips contacted the runway. The instructor told the student to go around, and he did so. Neither the instructor nor student was aware of the damage to the propeller immediately after the heavy landing.

On the next approach, the aircraft touched down in a standing crop short of the runway threshold and proceeded through the crop for some distance before becoming airborne again; the instructor told the student to go around during the ground roll.

The instructor took control of the aircraft as it climbed away, and flew a circuit with the intention of landing. From this approach the aircraft again touched down in the crop short of the runway, before climbing away into a further circuit, from which it landed uneventfully.

Inspection of the aircraft after the flight, identified damage to the left propeller blade tips, and later inspection found damage to the wing structure. Although the marks on the runway were consistent with the propeller strike having occurred during the second touch-and-go, it was not possible to determine whether the structural damage occurred simultaneously, or separately, perhaps during the ground rolls in the crop or when the aircraft passed from the crop onto the paved runway surface (the transition from crop to runway involved crossing a prominent 'lip' in the surface). Tracks consistent with the aircraft's landing gear dimensions were measured in the crop running for distances of 52 and 156 m respectively.

The instructor indicated that knowledge of the student's experience in turboprop and turbojet airliners, amounting to approximately 3,500 hours, may have caused her to place too much confidence in his ability. He had not, in fact, flown piston-engined aircraft for several years and, after the accident, it became apparent to the instructor that he did not understand the relationship between the throttles, propeller controls, and power delivered.

The approaches were all flown with 10º or 20º of flap, and the instructor stated that although she did not pay close attention to the indicated speed during the approaches, she would normally use an approach speed of 70 to 80 kt. The aircraft flight manual stated that the final approach should be flown with full flap at 90 kt, and that the speed may be reduced to 79 kt if the aircraft was lightly loaded. Approaches with less flap would necessitate a higher approach speed, in order to ensure a similar margin above the stall.

The instructor stated that in future she would be more inclined to take control promptly to correct a student's error.

ACCIDENT

Aircraft Type and Registration:	Piper PA-34-220T Seneca III, G-GFCD
No & Type of Engines:	2 Continental Motors Corp TSIO-360-KB piston engines
Year of Manufacture:	1981
Date & Time (UTC):	16 October 2011 at 0909 hrs
Location:	Private airstrip at Kimberley, near Norwich, Norfolk
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Right wing, propeller, nose and fuselage damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	42 years
Commander's Flying Experience:	922 hours (of which 692 were on type) Last 90 days - 11 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent AAIB enquiries

Following successful power checks, the pilot applied full power against the brakes before beginning the takeoff roll on the south-eastbound runway. The strip was approximately 755 m long, of "relatively long" grass which the pilot stated was damp from overnight dew. Approximately half-way along the strip, the aircraft ran over a bump and became airborne, but with insufficient speed to climb away, and it touched down again. The pilot judged that takeoff would not be achieved within the distance remaining, but that there was sufficient runway ahead to stop safely, and he aborted the takeoff. The aircraft decelerated, but ran into a hedge at the end of the strip at 15-20 kt. The forward door was jammed shut by branches during the impact, and the pilot exited by the rear door. There was no fire.

No technical defect was apparent that might have affected normal power being available. It was not possible to determine whether continuing the takeoff would have been successful, but the pilot commented that the consequences, had the aircraft not reached flying speed within the distance available, would have been more severe.

ACCIDENT

Aircraft Type and Registration:	Piper PA-38-112 Tomahawk, G-BOMO
No & Type of Engines:	1 Lycoming O-235-L2C piston engine
Year of Manufacture:	1981
Date & Time (UTC):	23 August 2011 at 1150 hrs
Location:	Swansea Airport, West Glamorgan
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to propeller, engine shock-loaded and nose landing gear collapsed
Commander's Licence:	Student pilot
Commander's Age:	60 years
Commander's Flying Experience:	59 hours (of which 55 were on type) Last 90 days - 24 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and comment from instructor

Synopsis

The student pilot was landing on Runway 10 at Swansea. The aircraft bounced on landing and the nose landing gear collapsed.

History of the flight

The student pilot had been undertaking his first 'land away' cross-country navigation exercise and was reported to have made a good landing at Haverfordwest. On return to Swansea he carried out a standard overhead join into the circuit and his approach to landing on Runway 10 appeared stable. He touched down at the intersection with Runway 04-22 but the aircraft bounced on this landing and at the aircraft's second touchdown. The pilot attempted to apply power to recover but the aircraft bounced again and the nose landing gear collapsed.

The wind speed at landing was reported as 130º at 8 kt. The instructor commented that the student pilot had previously flown five days previously and had recently flown dual and solo in crosswind conditions.

ACCIDENT

Aircraft Type and Registration:	Pitts S-1C Special, G-BUWJ
No & Type of Engines:	1 Lycoming O-320-A2B piston engine
Year of Manufacture:	1976
Date & Time (UTC):	2 October 2011 at 1405 hrs
Location:	Lower Upham Farm, Swindon, Wiltshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to landing gear, propeller and lower wing
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	43 years
Commander's Flying Experience:	198 hours (of which 22 were on type) Last 90 days - 7 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

During the approach to Runway 18 at the grass airfield the pilot experienced some sink near the threshold. He added power to arrest the descent and reported that the aircraft "settled onto the runway positively". After an apparently normal ground roll of about 180 m the pilot applied light braking which resulted in the landing gear collapsing and the propeller striking the ground. The pilot later determined that he had touched down short, at the edge of the threshold separating the runway from a crop field and this had damaged the landing gear. He considered that it would have been better to have initiated a go-around at the initial indication of sink.

ACCIDENT

Aircraft Type and Registration:	Taylorcraft BC12D Twosome, G-BSDA
No & Type of Engines:	1 Continental Motors Corp A75-8 piston engine
Year of Manufacture:	1946
Date & Time (UTC):	29 September 2011 at 1348 hrs
Location:	Shoreham Airport, West Sussex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Serious) Passengers - N/A
Nature of Damage:	Propeller tips, cowling, windscreen, left lift strut, fin and rudder tips
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	75 years
Commander's Flying Experience:	282 hours (of which 129 were on type) Last 90 days - 9 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The aircraft took off from Rowhook in West Sussex for a flight to Shoreham. The pilot was expecting an approach to Runway 20 but was instead directed to land on Runway 13, with a reported wind of 9 mph from the south-east. However, he reported that he "mentally scrambled" the runway numbers and positioned for an approach to Runway 31. He touched down smoothly at an airspeed of 55 mph after which he observed the remaining landing distance available reducing rapidly. He applied heavy braking and the aircraft flipped over, ending up inverted at the end of Runway 31.

The pilot considered that insufficient preparation and "momentary confusion" led him to land on Runway 31 which had a higher tailwind component. He was wearing a full harness and despite sustaining a serious injury, exited the aircraft unassisted.

ACCIDENT

Aircraft Type and Registration:	Vans RV-6, G-ORVG
No & Type of Engines:	1 Lycoming O-360-A3A piston engine
Year of Manufacture:	2001
Date & Time (UTC):	16 October 2011 at 1630 hrs
Location:	Biggin Hill Airport, Kent
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Tail wheel and surrounding structure damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	57 years
Commander's Flying Experience:	1,252 hours (of which 246 were on type) Last 90 days - 7 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

An airfield security vehicle, leaving the airfield fire training area, entered a live taxiway immediately ahead of a taxiing aircraft, causing the pilot to brake hard in an attempt to avoid a collision resulting in damage to the tail wheel and surrounding structure.

History of the flight

After landing and completing customs formalities at the terminal building, the pilot was given clearance to taxi back to the aircraft's hangar. After crossing the runway at the Link taxiway intersection the aircraft entered Taxiway A heading in a southerly direction, see Figure 1. As the aircraft approached the airfield fire training area, the pilot observed an airfield security vehicle emerge from the bushes and trees surrounding the fire training area and drive towards Taxiway A on a connecting roadway. The vehicle did not stop on the roadway and entered the taxiway ahead of the taxiing aircraft before coming to a halt. The pilot braked hard in an attempt to prevent a collision, causing the tail of the aircraft to rise and fall striking the ground hard. The aircraft stopped approximately 10 ft away from the vehicle. A subsequent examination of the aircraft revealed damage to the tail wheel and surrounding structure.

Investigation

Immediately after the incident the airfield operator initiated an investigation into the incident which identified the following contributory factors:

- At the time of the incident, when leaving the fire training area, the vehicle was driving towards the setting sun which obscured the driver's vision.
- The driver did not stop at the double white lines on the fire training area access to confirm that the taxiway was clear before entering it.
- At the time of the incident, there was no requirement for vehicles leaving the fire training area to contact ATC for permission to enter Taxiway A.

Safety action

As a result of their investigation, the airfield operator has introduced a requirement for all vehicles leaving the fire training area to obtain permission from ATC prior to entering Taxiway A. As a result of this action no further safety action is considered necessary at this time.

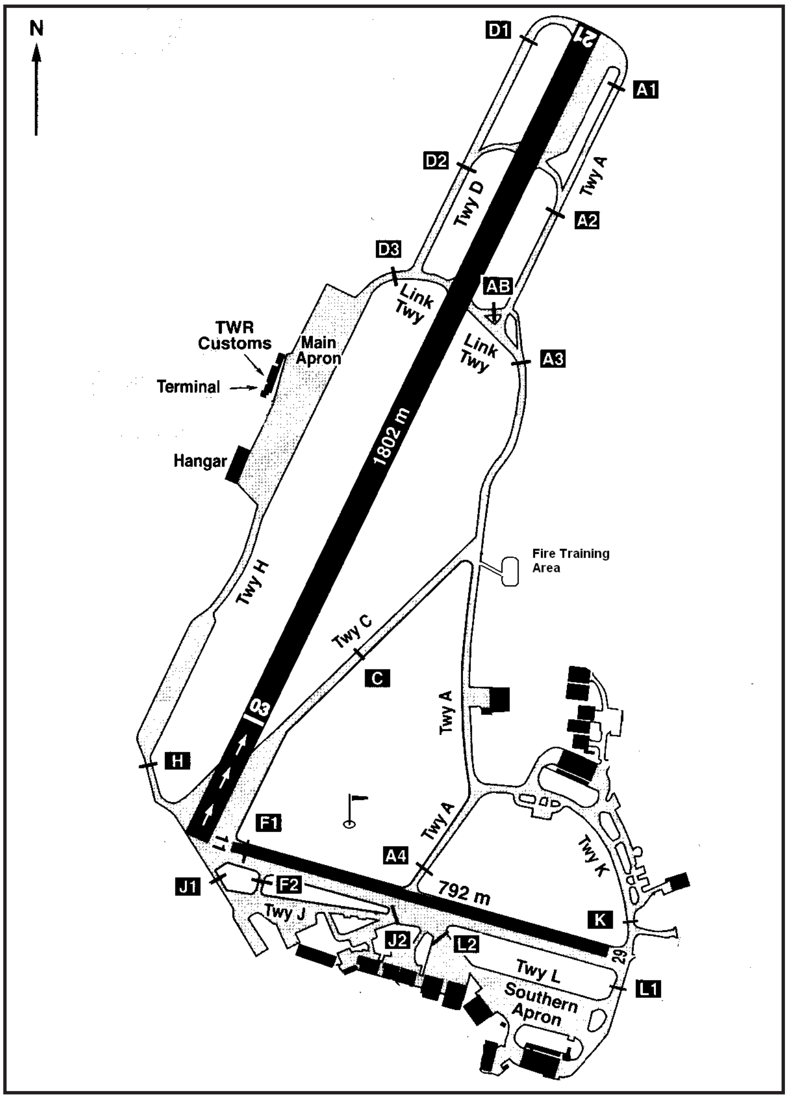

Figure 1

Biggin Hill Airport

ACCIDENT

Aircraft Type and Registration:	1) Zlin Z.526F Trener Master, G-PCDP 2) Ikarus C42 FB80, G-CDVI
No & Type of Engines:	1) 1 Walter M137A piston engine 2) 1 Rotax 912-UL pistion engine
Year of Manufacture:	1) 1971 2) 2006
Date & Time (UTC):	13 November 2011 at 1200 hrs
Location:	Popham Airfield, Hampshire
Type of Flight:	1) Private 2) Private
Persons on Board:	1) Crew - 1 Passengers - None 2) Crew - 1 Passengers - 1
Injuries:	1) Crew - None Passengers - N/A 2) Crew - None Passengers - None
Nature of Damage:	1) Propeller and left wing 2) Right wing and tail
Commander's Licence:	1) Private Pilot's Licence 2) National Private Pilot's Licence
Commander's Age:	1) 60 years 2) 59 years
Commander's Flying Experience:	1) 760 hours (of which 397 were on type) Last 90 days - 15 hours Last 28 days - 1 hour 2) 195 hours (of which 195 were on type) Last 90 days - 12 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Forms submitted by both pilots

Synopsis

A ground collision occurred on a taxiway between an Ikarus C42, which had just landed, and a Zlin Trener Master which had taxied from its parking position.

History of the flight

Having landed on Runway 08, G-CDVI began a 180° left turn onto the parallel taxiway. The pilot of G-CDVI reported in his statement that he had observed G-PCDP and that it was stationary on its parking position to the north of the taxiway with its propeller turning. He stated that G-PCDP was still stationary as he completed the turn onto the taxiway before losing it from view.

The pilot of G-PCDP (a monoplane with a conventional tailwheel undercarriage) taxied his aircraft from its parking position to join the taxiway, which was located several metres in front of the aircraft. He stated that he had noticed G-CDVI, which was converging from the left, but he continued to taxi ahead as he expected the other aircraft to give way to him. He also stated that, when taxiing, the forward view from the cockpit was limited and that on the day his view was further impaired by the relative position of the sun. As he turned right to join the taxiway, the pilot saw that G-CDVI was almost directly in front of him. Unable to stop in time, the propeller struck the right wing of G-CDVI. G-PCDP then yawed to the right and its left wing struck the tail of the other aircraft.

BULLETIN CORRECTION

Following receipt of an Aircraft Accident Report Form from the pilot of the second aircraft involved, the report published in Bulletin 2/2012 has been updated to clarify the movements of both aircraft prior to the ground collision. The updated report is reproduced here in full and the online version of the report was updated on 21 February 2012.

ACCIDENT

Aircraft Type and Registration:	McDonnell Douglas Helicopters Hughes 369E, G-KSWI
No & Type of Engines:	1 Rolls Royce Allison C250-C20B turboshaft engine
Year of Manufacture:	1986
Date & Time (UTC):	19 June 2011 at 1317 hrs
Location:	Glastonbury, Somerset
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Serious) Passengers - N/A
Nature of Damage:	The aircraft was destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	57 years
Commander's Flying Experience:	730 hours (of which 720 were on type) Last 90 days - 20 hours Last 28 days - 10 hours
Information Source:	AAIB Field Investigation

Synopsis

While flying in the cruise at an altitude of 2,200 ft amsl, it is probable that the helicopter sustained a mechanical failure that resulted in the loss of pitch control to one of the tail rotor blades. During the subsequent attempt to land in a field, the airspeed reduced to the point where directional control of the helicopter seems to have been insufficient to maintain heading. At a height of approximately 50 ft, the helicopter yawed rapidly to the right before the rotation ceased and it developed a high rate of descent. The helicopter struck the ground heavily and was destroyed. The pilot survived but sustained serious injuries. There was no fire.

The investigation established the presence of fatigue cracks emanating from corrosion pits on the tail rotor blade pitch horn on one blade, which led to its failure. Also, the associated tail rotor pitch link had failed. The sequence of the two failures could not be established but either could explain the helicopter's behaviour before it crashed. Neither the failed section of this tail rotor blade pitch horn nor the associated pitch link were recovered from the accident site.

Four Safety Recommendations are made.

History of the flight

The pilot flew the helicopter from his home in Cornwall to Draycot Airfield, near Swindon. Two hours after arriving at Draycot the pilot was seen to complete his checks prior to departing westwards, at around 1250 hrs, on the return flight back to Cornwall. Witnesses to the departure say the helicopter looked and sounded normal. Weather conditions at the time were good. Thirty five miles to the west, the Bristol Airport actual weather was reported as: wind 14 kt from the southwest, visibility greater than 10 km and a temperature of 15ºC. At 1255 hrs, whilst flying at an altitude of 2,200 ft, the pilot established communications with Bristol ATC who provided him with a Basic Service. At 1317 hrs, Bristol ATC called G-KSWI but there was no reply; about the same time the radar return from G-KSWI indicated that the helicopter was descending. The radar return then disappeared when the helicopter was in the vicinity of Glastonbury Tor.

At approximately 1315 hrs, witnesses in the area of Glastonbury saw a helicopter descending in a westerly direction to the south of Glastonbury Tor. Many witnesses described the helicopter as making a loud "clunking sound", which they considered to be abnormal. The helicopter was seen to descend to low level, where it flew an orbit to the right and then at an estimated height of about 50 ft it started to spin, with the nose rotating to the right. Witnesses reported that the noise from the helicopter then reduced and it appeared to stop spinning, before "dropping" to the ground. The helicopter was severely damaged but there was no fire. The emergency services were quickly on the scene and airlifted the pilot, who had sustained serious injuries, to hospital.

Witnesses

A teacher was playing with her young children on a school tennis court (see Figure 3) when she heard the noise of a helicopter, which was descending towards her house 40 m away. She reported that the helicopter flew at low level, almost over her house, before it started to fly around an adjacent field, which contained a herd of cows. It had almost completed a full orbit to the right, approximately 100 m from where she was standing, when it began to spin clockwise. It completed at least two rotations before the noise reduced and it "dropped" to the ground. She immediately ran into the house to alert her husband and the emergency services.

The teacher's husband was inside the house when he heard a noise which he described as "like something being stuck in a Hoover but a lot louder." He ran outside and went towards the wreckage where he found the pilot, who was unconscious, hanging from his seatbelt partly out of the left side of the helicopter. There was a strong smell of fuel.

There were a number of other witnesses to the accident and their accounts were consistent with the teacher's statement. The only difference was the number of rotations the helicopter made before it "dropped" to the ground, with reports varying between two and six.

Meteorology

The weather around the accident site was under the influence of a transient ridge of high pressure which maintained a westerly flow over the area. Cells of convective cloud had developed over southern England and close to the Glastonbury area which produced light showers. Visibility was generally between 26 and 40 km, reducing to 7 km in these light showers. The surface wind was from between 250ºM and 270ºM at a strength of 12 to 15 kt.

Recorded flight data

The helicopter was equipped with a FlymapL GPS, which is able to record a flight log of GPS time, position, altitude, track and groundspeed, for any flight that exceeds a user defined groundspeed, which in this case was set to 40 kt[1]. Data was successfully recovered for the accident flight, together with a number of previous flights. Radar data was also recovered from the Clee Hill radar head, positioned about 70 nm to the north of the accident track; however, coverage was lost as the helicopter descended below 1,500 ft when line-of-sight contact was lost. Figure 1 compares the GPS and radar recorded data for the last two minutes of the flight. The radar groundspeed is an average speed based on the straight-line distance covered between each consecutive radar contact, every eight seconds, and the radar pressure altitude is based on 1013 mb with ±50 ft accuracy.

From the GPS it was determined that, on the morning of the accident, a flight of 55 minutes duration was made. The accident flight commenced

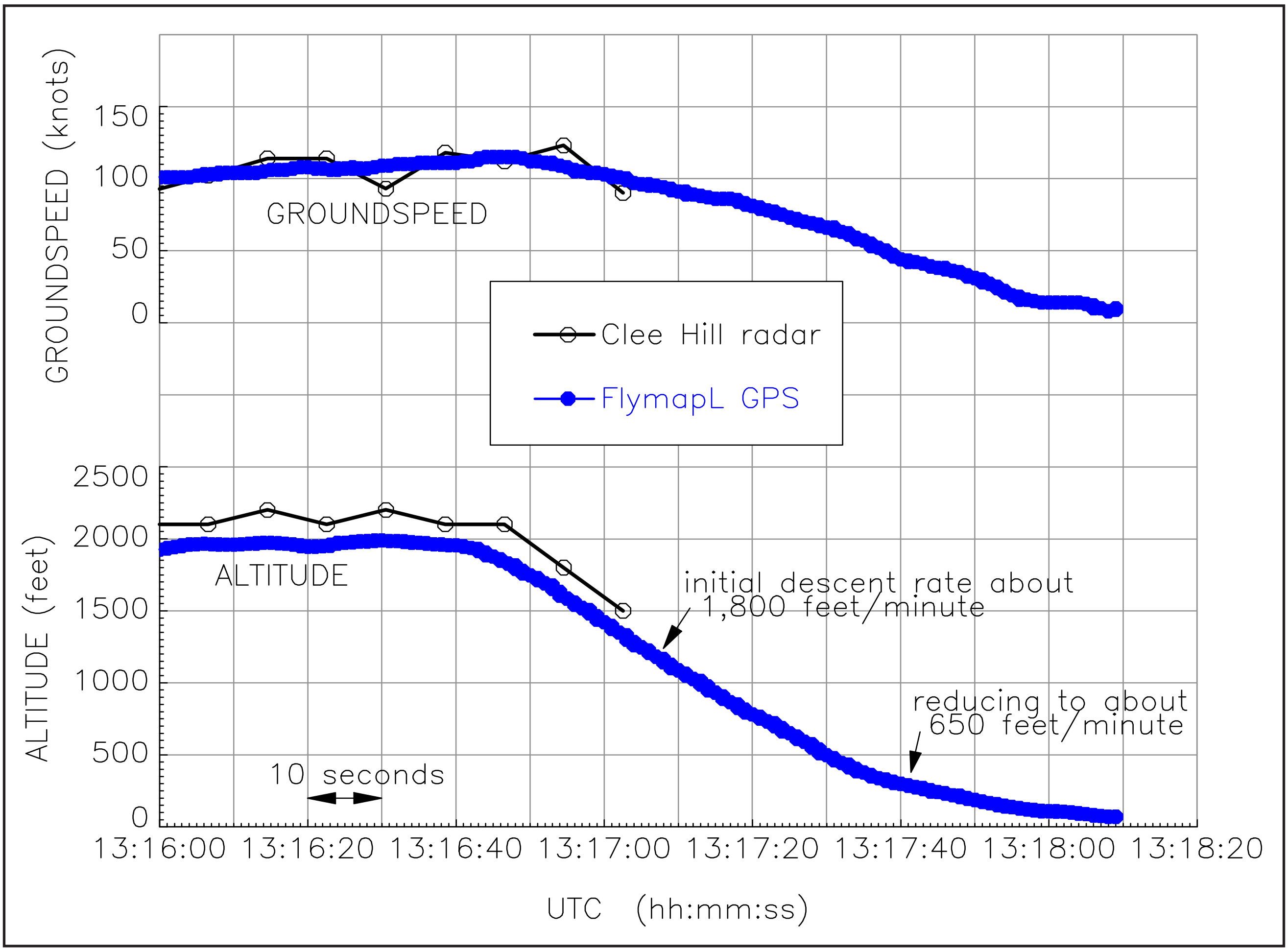

Figure 1

Recorded GPS and radar data for the final descent

Footnote

[1] The user can pre-select either a groundspeed of 2, 10, 20 or 40 kt. When the groundspeed falls below the selected value, the GPS starts writing the flight log to its non-volatile memory. This writing process takes a finite amount of time, during which additional data points are logged and recorded. For the accident flight this amounted to an additional 25 seconds worth of data below 40 kt.

2 hours 25 minutes later. Due to the logging logic, the actual time of the flight would have been slightly longer than the 55 minutes recorded and the period the helicopter spent on the ground without the engine and rotors turning would have been slightly less than 2 hours 25 minutes.

For the accident flight, 25 minutes of flight data was recorded, starting at 1253:11 hrs. Again, the actual flight time would have been longer.

Approximately 90 seconds before the end of the log, the helicopter started to descend. The first part of the descent lasted about 50 seconds and the rate of descent (ROD) averaged about 1,800 ft/minute, during which G-KSWI decelerated from 110 kt to approximately 60 kt groundspeed. During the final part of the descent, the ROD averaged about 650 ft/minute with the groundspeed reducing to below 30 kt 18 seconds before the last logged point. During the last three seconds of the log, the groundspeed reduced from 10 kt to 8 kt, before increasing to a final value of 10 kt. Figures 2 and 3 show the final part of the aircraft's GPS track to the accident site.

Figure 2

Radar and GPS tracks for the last 90 seconds of flight

Figure 3

GPS track for the last 35 seconds of flight

Accident site

The helicopter came to rest on a heading of 060°M in a grass field approximately 170 m x 160 m (Figure 4). Low voltage overhead power cables ran along the eastern and southern edges of the field, with 'visibility' markers attached at regular intervals along the cables.

There were a number of main rotor blade strike marks on the ground between the 6 and 11 'o' clock position relative to the helicopter. The tail section had separated from the fuselage and was found with the 'blue[2]' tail rotor blade resting on the ground (see Figure 5). The section of the tail cone still attached to the fuselage had bent approximately 90° in an anti-clockwise direction. The rear section of the left skid had broken away from the helicopter and the shattered transparency from the left side of the cockpit was scattered approximately 10° to 20° to the right of the aircraft. Debris from the tail cone, drive shaft and tail rotor pitch control rods

Footnote

[2] The two tail rotor blades were annotated as 'blue' and 'green'.

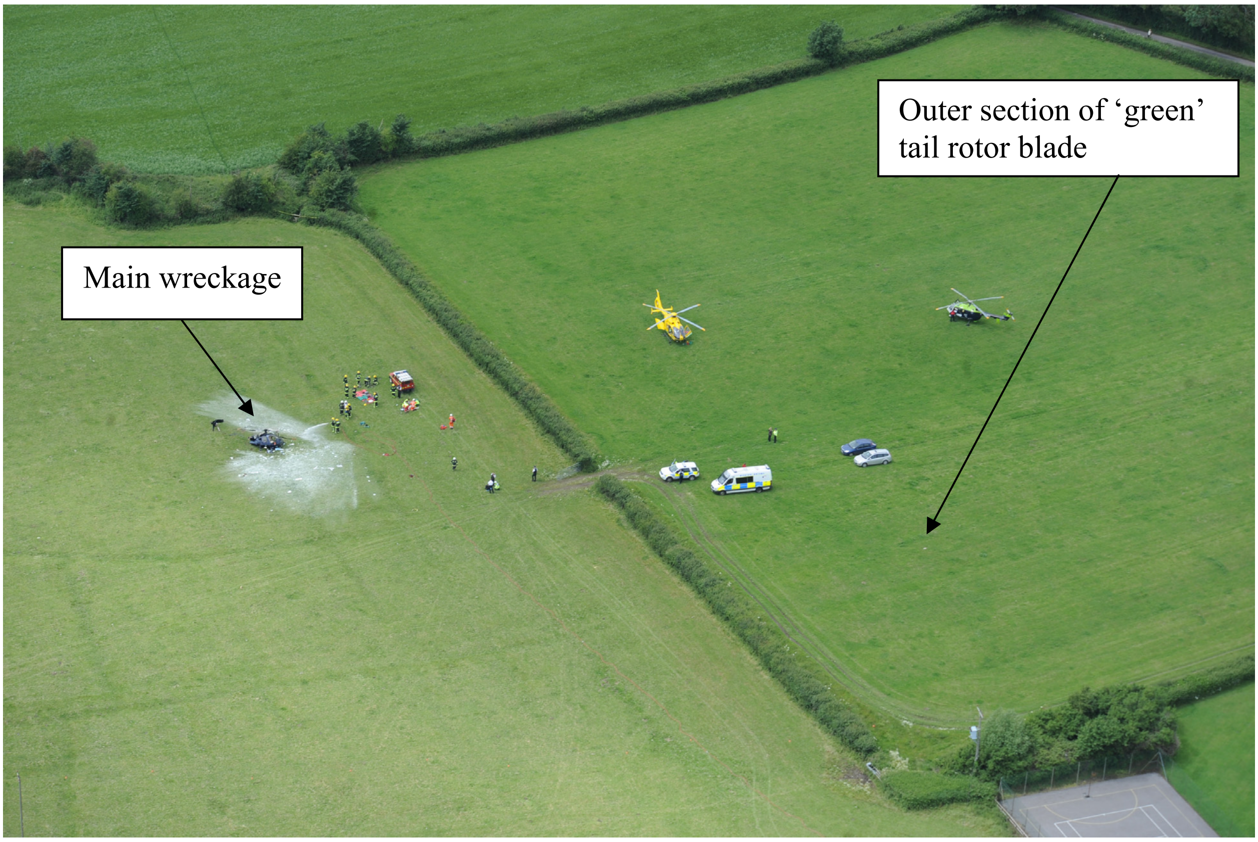

Figure 4

Accident site

were found up to 30 m to the right of the helicopter across an arc of 160°. The outer section of the 'green' tail rotor blade was found approximately 90 m away and 40° to the right of the helicopter (see Figure 4). The grass in the area of the engine exhaust had been burnt and there was a strong smell of aviation fuel around the aircraft.

The ground marks indicated that the helicopter initially struck the ground on the rear section of its left skid with little or no forward speed. The helicopter then appears to have rotated slightly in an anti-clockwise direction before the right skid firmly contacted the ground. Ground marks indicated that, at the same time as the skids made contact with the surface, the main rotor blades struck the ground and the tail section detached.

Description of the helicopter

The MD 369E is a five-seat helicopter, primarily constructed from aluminium alloy. It has a five-blade fully articulated main rotor system, which rotates anti-clockwise when viewed from above, and a two-bladed semi-rigid tail rotor. The pilot, who is provided with a four-point harness, sits on a deformable seat base and normally flies the helicopter from the left seat. The helicopter is equipped with a skid-type landing gear.

The helicopter can be fitted with dual flying controls. A throttle twist grip is fitted to each of the collective levers. Rolling the throttle outboard, past a detent, engages a latch in the head of the collective lever and puts the engine gas producer (N_1) in the ground idle

Figure 5

Helicopter wreckage, as found

position. Rolling the throttle fully outboard causes the speed of the engine power turbine (N_2) to increase to 100%. The governor will now maintain the main rotor speed within prescribed limits by automatically adjusting the engine power.

The flying controls are manually powered, with the cyclic, collective and tail rotor pedals controls connected to the main and tail rotor assemblies by a series of control tubes passing through a number of bell cranks. An electrical cyclic trim actuator, operated by a switch on top of the cyclic control, allows the pilot to trim out the flight loads.

The tail rotor blades, which are secured to the hub assembly by a torsion strap, consist of an aerofoil and a root section that incorporates a pitch horn. A pitch link connects the pitch horn to the pitch control assembly which, in turn, is connected through the control system to the pedals in the cockpit. In the event of a disconnect in the tail rotor control system, the torsion strap will rotate the blade to a preset pitch. The rotor assembly is balanced by weights which can be attached to either the tip of the aerofoil section of the blade or the bolt which secures the pitch link to the pitch horn. (See Figure 6.)

The tail rotor blades fitted to the accident aircraft were identified with colour markings as being either the 'green' or 'blue' blade. While both blades were produced by the same manufacturer, they were of slightly different design with the 'blue' blade incorporating a pocket in the pitch horn.

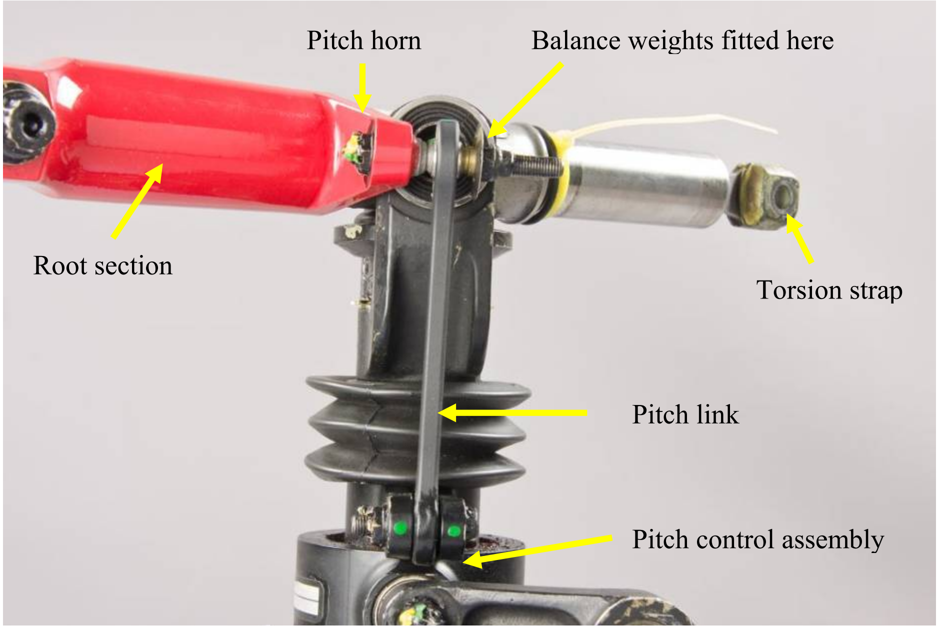

Figure 6

Significant features on the tail rotor assembly

The normal operating speed of the main rotor (N_R) is 487 to 492 rpm which, with a gearing of 5.965:1, gives a tail rotor speed range of 2,904 to 2,935 rpm. The flight manual advises that a minimum rate of descent, with power-off, is achieved at an indicated airspeed of 60 kt and 410 N_R and that the maximum range in autorotation is attained at 80 kt and 410 N_R.

On-site examination of the wreckage

General

The left skid tube had fractured just aft of the forward saddle mount, with the forward supporting strut having twisted and bent forward; the rear section of the broken skid had been forced into the underside of the helicopter. The left side of the cabin had been extensively deformed and there was deformation to all the major structural frames and floor, consistent with a relatively high speed vertical impact. The aircraft skin below the cabin had been torn and forced upwards, puncturing the flexible fuel tank linings in several places. The transparencies in both doors on the left side of the aircraft and the windscreen in front of the pilot had broken into a number of pieces. The pilot's harness, which had been released by the emergency services, was intact. His seat base had deformed. Overall, the left side of the helicopter had sustained more damage than the right side.

Main rotor blades and transmission

The transmission decking had deformed and the transmission supporting frames had buckled. All five main rotor blades had been damaged and paint transfer from the tail cone to the blades indicated that three of the blades struck the tail cone with increasing severity. The damage to the blades was consistent with them having struck the ground and the aircraft structure, while still being driven by the engine.

All five droop stops had been damaged; three were split, and two were flattened. The aircraft manufacturer advised the investigation that this damage was consistent with the helicopter sustaining a high vertical impact with the ground. There was damage to the upper shoe of the hub that was indicative of extensive blade flapping; however, it was not possible to establish if this flapping occurred before the helicopter struck the ground.

The controls between the rotor head, cyclic stick and collective lever were intact, with no evidence of a control restriction having occurred prior to ground impact.

Engine

The engine had moved downwards, relative to the airframe, and the lower part of the combustion chamber had contacted the ground. Both lower engine mounts, the engine transmission drive shaft and the fuel supply pipe fitting at the engine driven fuel pump filter had fractured and failed. The collective head on the pilot's collective lever had detached and the engine control linkage had fractured at the bell cranks situated beneath the front seats and the engine firewall. It was not possible to establish the position of the throttle at the time of the accident.

Tail rotor section

The tail section had broken away from the helicopter as a result of the tail cone having been struck by the main rotor blades. The only other damage to the tail section was on the left horizontal stabiliser, which was consistent with the aircraft having landed heavily.

The tail rotor drive shaft had broken into five sections and the pitch control rod into four sections as a result of having been struck by the main rotor blades. The tail rotor gearbox was full of oil, its magnetic chip detector was clean and the gearbox turned freely. Control continuity was established between the pedals in the cockpit and the tail rotor pitch links; there was no evidence of a disconnection or control restriction prior to the rotor blades severing the tail cone.

The 'green' tail rotor blade had failed approximately 33 cm from the centre-line of the tail gearbox output shaft and was found approximately 90 m from the aircraft. Although it was not possible to identify any ground marks from the blade striking the ground, the helicopter and blade manufacturer advised the investigation that the damage to the blade and the position at which it failed was consistent with it having struck the ground. They also stated that it is not unusual for tail rotor blades to strike the ground without leaving any recognisable ground marks. The pitch link to the 'green' blade was intact.

The 'blue' tail rotor blade had a bend approximately 40 cm from the centre of the tail gearbox output shaft, such that the outer section of the blade had bent away from the tail pylon. This damage was consistent with the blade tip having made contact with the ground after the drive to the tail rotor gearbox had been lost.

The outer portion of the pitch horn had broken away from the 'blue' blade. The 'blue' pitch link was also missing, though its bearing was still bolted to the pitch control assembly. Despite three extensive searches, covering an area 150 m around the wreckage and 300 m along the final ground track of the helicopter, the parts were not recovered.

Relevant maintenance

On 17 June 2009, at 3,056 airframe hours, corrosion was rectified around the pitch horn on the 'green' tail rotor blade.

On 12 March 2010, at 3,153.4 airframe hours, the pilot reported that both pedals were '*very stiff*' to operate. The maintenance organisation reported that the restriction was caused by the swelling of the bushes (bearings) inside the root section of both tail rotor blades. The bushes were replaced and the helicopter flew without any further reports of stiff pedals.

On 28 May 2010, at 3,181.3 airframe hours, both tail rotor blade pitch links were replaced with new items during the annual inspection. Documentation showed that the links had been purchased from the helicopter manufacturer and both had the part number 369D21723-13. The maintenance organisation, on the advice of the blade manufacturer, removed corrosion and restored the finish on the aerofoil sections of both tail rotor blades. No work was carried out on the blade roots.

On 4 May 2011, at 3,290.6 airframe hours, the helicopter completed its Annual / 100 hour inspection during which corrosion was discovered on the aerofoil section of both tail rotor blades and their pitch links. There were no reports of corrosion in the area of the blade roots or pitch horns. The blades were returned to the blade manufacturer to have the corrosion rectified and the erosion strip on the blue blade replaced. The maintenance organisation rectified the corrosion and restored the surface finish on both pitch links. Following the fitting of the blades, the tail rotor was balanced and, from the work sheets, it was established that 23.7 g of weights[3] had been attached to the pitch horn on the 'blue' blade. No balance weights had been added to the pitch horn on the 'green' blade.

Detailed examination of the tail rotor assembly

Apart from the damage to the tail rotor blades and the missing pitch link, there was no other significant damage to the tail rotor assembly. See Figure 7.

The bearing from the missing 'blue' pitch link, which connects the pitch link to the pitch control assembly fork end, had been retained by the securing bolt. Apart from some slight play, the bearing was found to be in relatively good condition and was free to rotate with no evidence of it having seized. There was some mechanical damage and missing paint at the end of the fork end that was believed to have occurred during the accident sequence.

Figure 7

Tail rotor assembly

Footnote

[3] A maximum of 26.91 g of balance weights are allowed to be added to the pitch horn.

There was also some mechanical damage on the pitch control assembly that had been caused by the blade hub knocking against it.

Examination of the 'blue' tail rotor blade pitch horn

Significant features on fracture surface

The fracture surface on the 'blue' tail rotor blade pitch horn was examined by metallurgists at QinetiQ, using high magnification optical devices and a Scanning Electron Microscope (SEM). The following six significant features, which are highlighted in Figure 8, were identified:

- A fatigue crack, identified as 'Crack A', which started at a corrosion pit on the lip of the pocket. The fracture surface in this area was flat with visible striations, from which it was possible to identify the direction of propagation that is highlighted by the blue arrows. The corrosion pit was 0.146 mm deep and 0.153 mm wide at the widest point.

- A fatigue crack, identified as 'Crack B', which started at a corrosion pit on the lip of the pocket. The fracture surface in this area

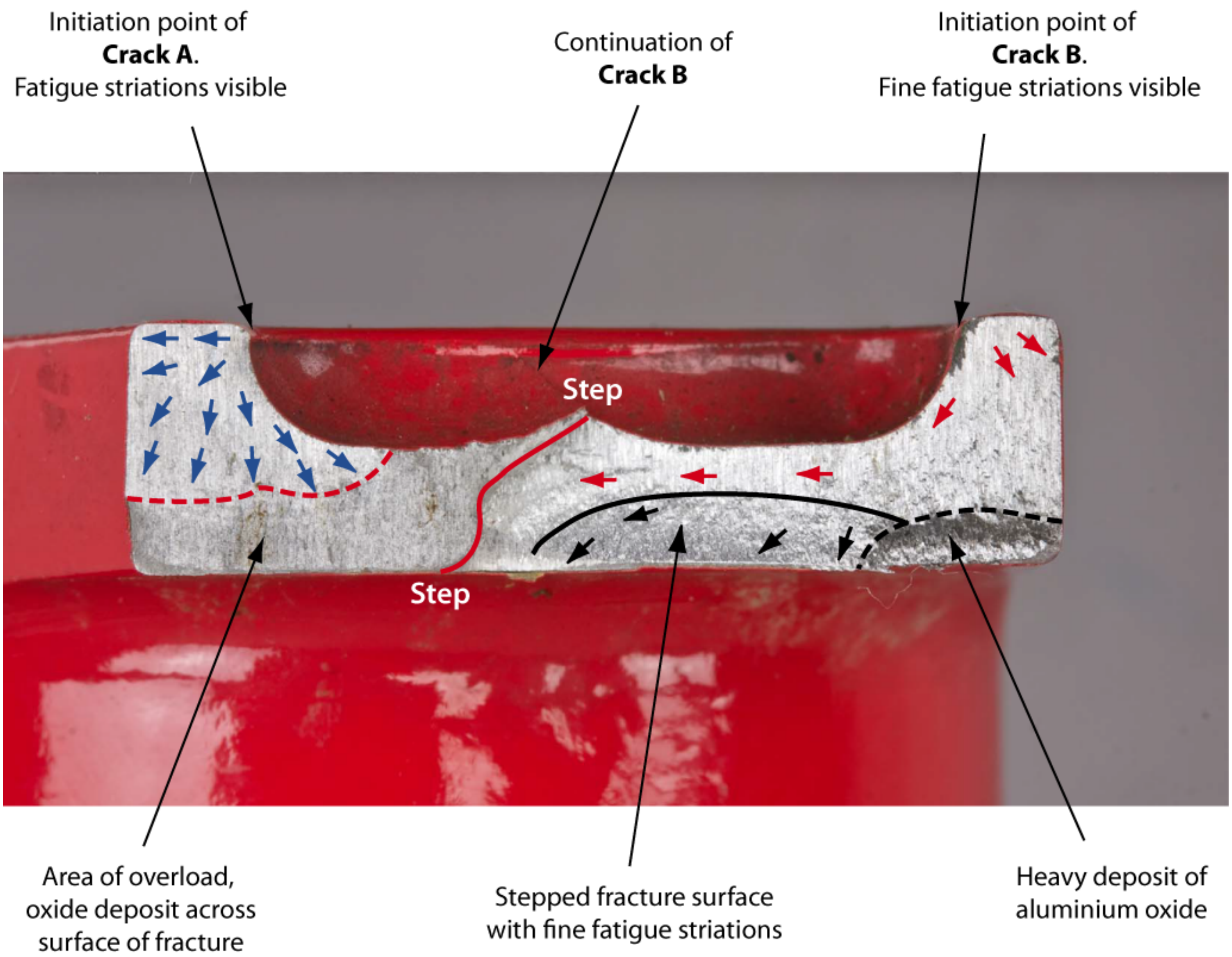

Figure 8

Significant features on the fracture face of the pitch horn was flat, with visible signs of heavy and fine striations which were difficult to resolve. The direction of propagation is highlighted by the red arrows. The corrosion pit was 0.487 mm deep and extended 1.8 mm around the radius into the pocket and 0.9 mm along the external surface.

- A step, which ran across the fracture face and is marked by the solid red line.
- An area that had failed in overload and was covered in an oxide deposit. When examined by the AAIB, within four hours of the accident, this section had the same bright appearance as the remainder of the fracture; therefore, the oxidisation must have occurred in the days following the accident. This area is bounded by the dashed and solid red lines.
- A rough, stepped, fractured surface with fine striations associated with fatigue cracking. Due to the nature of the surface it was difficult to resolve the striation marks with any great confidence. This area is bounded by the solid black line and the direction of propagation is highlighted by the black arrows.
- A dark area that was identified as a heavy deposit of aluminium oxide, approximately 5 mm long and up to 1.7 mm deep, which appeared to run from an area of mechanical damage; there was no evidence of any fatigue cracking in this area. The blade manufacturer advised the investigation that this section of the blade root is normally subject to a compressive load and it is not unusual to see damage to the surface finish in this area as a result of slippage of the tools used to tighten the pitch link attachment bolt. This corrosion was present four hours after the accident and would have been present prior to the failure of the pitch horn. This area is bounded by the dashed black line.

Estimation of time for crack to propagate to its critical crack length

There are three stages in the initiation and growth of a fatigue crack: initiation and formation of the crack; crack propagation; the crack reaches its critical length and failure occurs. Initiation and formation of the crack can take significantly longer than the time for the crack to propagate and reach its critical crack length. However, there was insufficient evidence to determine, with any great confidence, the time taken for the initiation and formation of either of the cracks identified in the fracture surface.

Crack propagation and the time to failure can be determined by counting the number of striations on the failed surface and considering the frequency of the cyclic loads that, in this case, were applied to the pitch horn. However, while striations were identified across a number of areas of the fracture surface, apart from those associated with 'Crack A', they were very fine and in places difficult to resolve. It was, therefore, not possible in these areas to count the number of striations with any great confidence.

The striations associated with 'Crack A' were more clearly defined in the region 1.47 mm to 6.15 mm from the initiation point; it was also noted that some of the striations in this region were stronger than others. The total number of striations in the region between 1.47 mm and 6.15 mm was calculated as 52,300, which, by extrapolation back to 0.13 mm from the initiation point, gave an estimated 109,209 striations. It was considered that, at most, the pitch horn would have experienced two cyclic loads per revolution of the tail rotor. Assuming that during the cruise the helicopter was being flown at the upper limit of the normal operating speed for the main rotor (492 rpm), then the tail rotor would have been rotating at 2,935 rpm, which would give a time of 18.6 minutes for the crack to propagate and reach its critical length. The time taken for the crack to have initiated and formed would need to be added to this time in order to achieve the total time from crack initiation to failure.

The number of strong striations was calculated as 2,461 in the region between 1.47 mm and 6.15 mm, which by extrapolation back to 0.13 mm from the initiation point, gave an estimated 8,713 striations. At two loading cycles per tail rotor revolution this would give a crack propagation time of 1.48 minutes.

QinetiQ have seen this combination of strong and weak striations in fatigue cracks on helicopter main rotor blades; the strong striations being caused by blade loading and the weaker striations by vibration. It is, therefore, possible that the strong striations were caused by the changing loads on the blade as it rotated. The weaker striations may have been caused by vibration or the loads from the flaying, broken pitch link which might still have been attached to the pitch control assembly.

Despite the presence of thousands of striations, there was no evidence of any beach-marks on the fracture face. Beach-marks can contain thousands of striations and form when the load is removed for a sufficient period to allow corrosion products to form. The lack of beach-marks suggests that crack growth was rapid and probably occurred during the accident flight.

Condition of the surface of the pitch horn

QinetiQ established that the pitch horn had been manufactured from 7075 aluminium alloy and the properties conformed to the heat treatment specified in the blade manufacturer's drawing number 500P3120.

The paint layer was removed with a chemical paint stripper and a more detailed inspection of the pitch horn was carried out; abrasive products were not used in order to ensure that the process did not damage the surface of the metal or remove any products of corrosion. A photograph of the pitch horn after the paint had been removed is at Figure 9.

The examination revealed evidence of corrosion up to several hundred microns deep, in several places, including around the lip of the pocket and the bush: this corrosion had not been evident before the paint had been removed. There was evidence that the surface of the pitch horn had been shot peened and a chromate treatment, such as Alodine 1200, had been applied to provide protection against corrosion. However, the Alodine had been mechanically abraded away along the edges of the pitch horn, inner bush and part of the lip of the pocket. The dimples from the shot peening also appeared to have been abraded away in these areas. Optical micrographs of polished micro-sections, that had been etched with Keller's reagent, and strain maps, using Electron Backscatter Diffraction, were produced. These indicated that, where there was visible evidence of dimpling, on average the shot peening had affected the microstructure up to a depth of 0.075 mm. Where the dimpling had been abraded away the effect of the shot peening had reduced to a depth of around 0.04 mm.

It could also be seen from the SEM image, reproduced at Figure 10, that the surface of the pitch horn was covered with scratch marks that appear to have

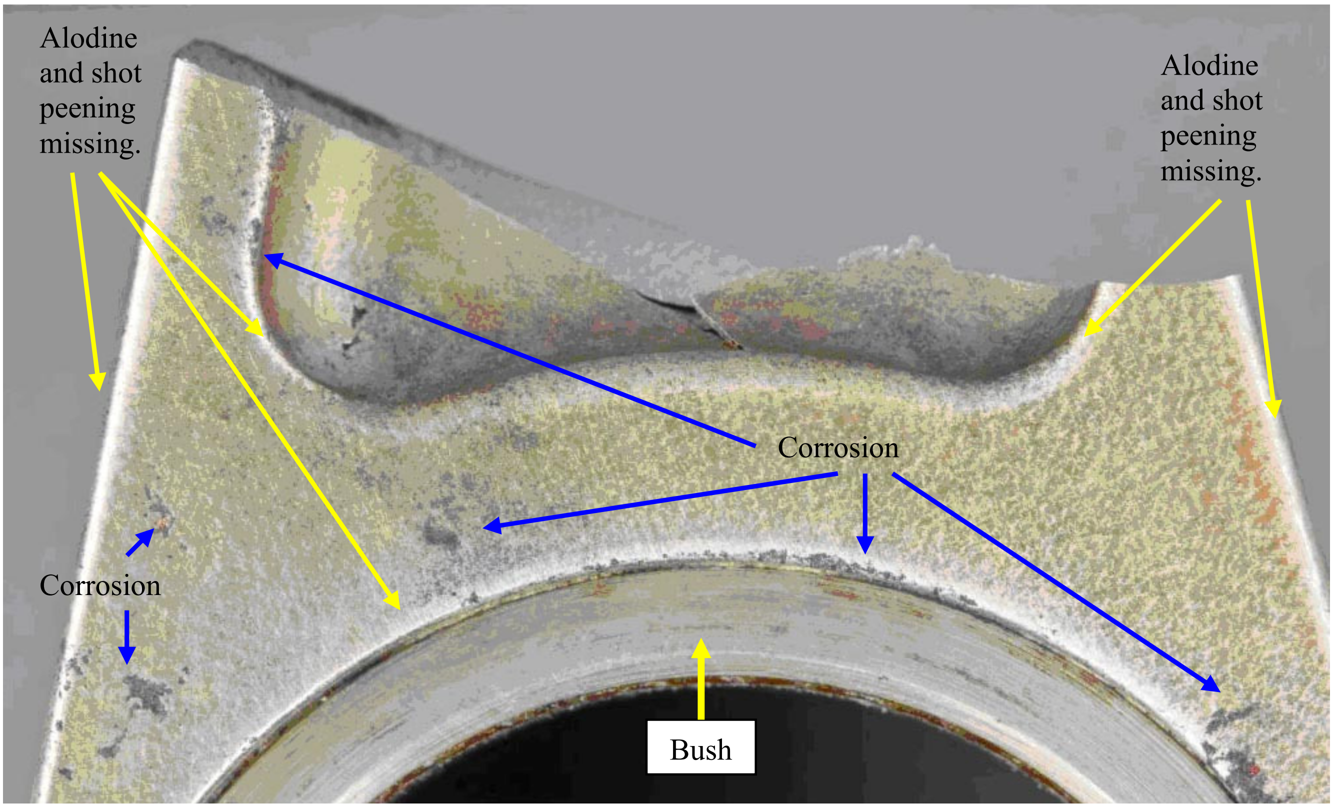

Figure 9

Pitch horn with paint removed

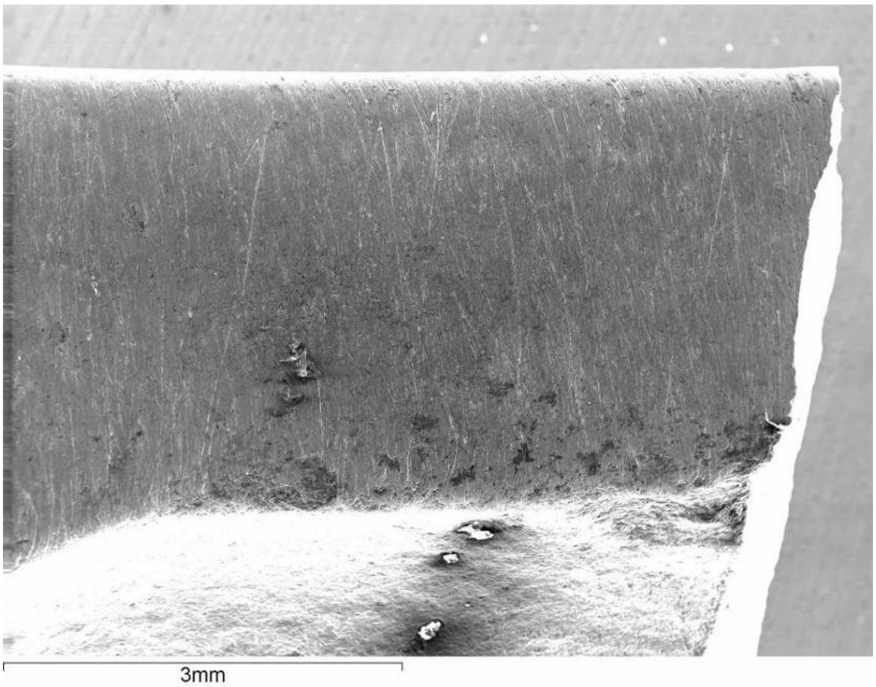

Figure 10

SEM image showing scratch marks on the surface of the pitch horn

penetrated through the Alodine surface finish. The sharp edges of these scratches could act as stress concentrators. The scratches were consistent with the surface having been rubbed with an abrasive material.

There was also a burr around the lip of the pocket where, in places, the metal appeared to have folded over on itself: it was from this area that 'Cracks A' and 'B' appear to have originated. See Figure 11. The blade manufacturer advised the investigation that the burr can be formed during the shot peening process.

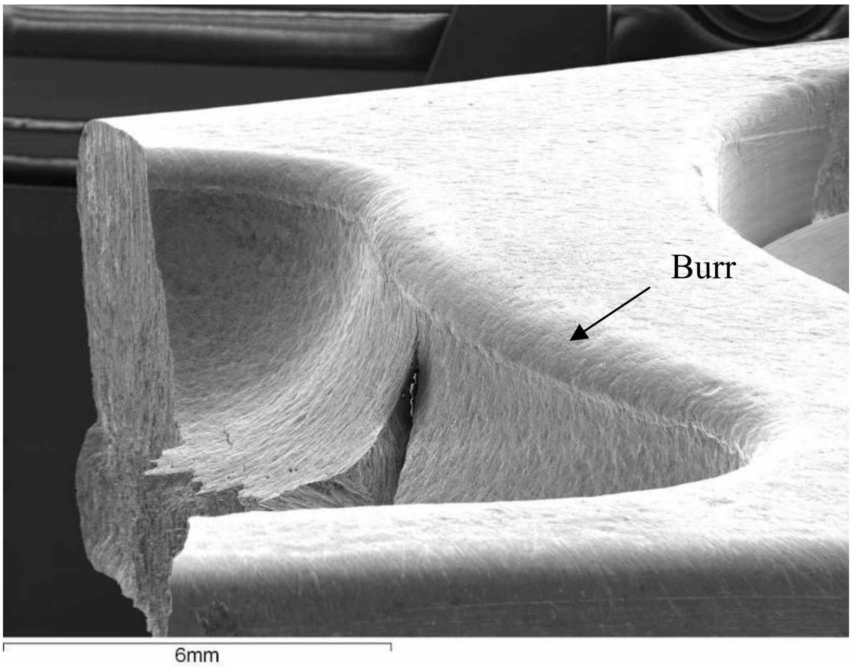

Figure 11

SEM image showing burr around the edge of the pocket

Examination of 'green' tail rotor blade pitch horn

The paint was chemically removed from the 'green' tail rotor blade (serial number B391) which was then examined using high magnification optical devices. With the exception of one small area, see Figure 12, there was evidence that all of the pitch horn, including the edges and radius had been shot peened. The surface was free of scratches and apart from the radius at the end of the pitch horn it was evenly covered in Alodine. There were a number of areas of corrosion, particularly around the bush and the insert for the pitch link securing bolt. In addition there was an area of mechanical damage that was covered with an intact layer of paint.

There was also a small repaired section where the Alodine and the dimples from the shot peening had been rubbed away leaving scratches in the surface. The aircraft documentation recorded that corrosion had been removed, in the field, on 17 June 2009 at 3,053.5 airframe hours. This was prior to the blade being returned to the blade manufacturer during the annual maintenance in May 2011 for corrosion to be removed from the aerofoil section.

Detailed examination of the 'green' tail rotor blade pitch link

QinetiQ established that the pitch link had been manufactured from 2024 aluminium alloy in the T4 heat treatment condition and contained 4.1% copper. The drawing specifies that the pitch link can be manufactured from one of three aluminium alloys; 2014, 2024 or 7075. The link had the part number 369D21723-13 painted on the side, which is the same part number listed in the purchase order for the links the maintenance organisation fitted during the annual inspection, completed on 28 May 2010. The bearing from the blue pitch link, that remained attached to the pitch control assembly, had the part number 369A7951-57 which is specified in the Illustrated Parts Catalogue (IPC) as the bearing for use in the pitch link with the part number 369D21723-13.

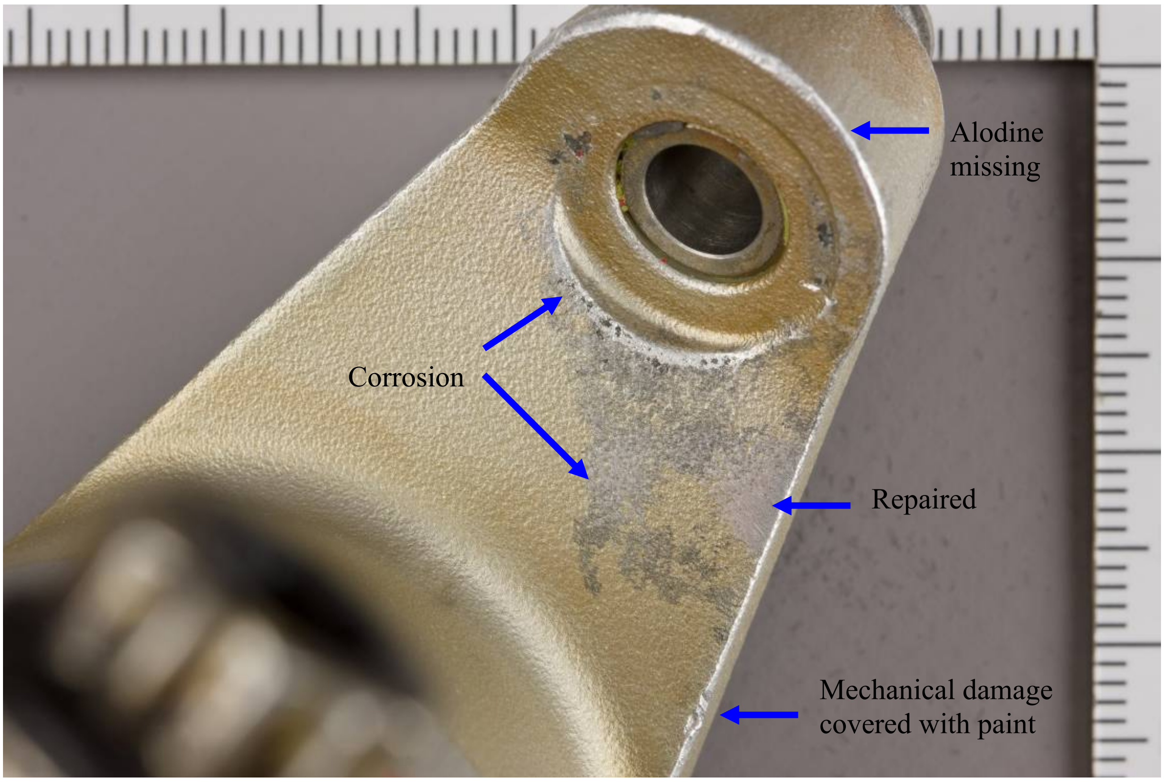

Figure 12

Damage on 'green' blade pitch horn

There was slight play in the bearing on the 'green' blade pitch link, which had been connected to the tail rotor pitch control assembly, and evidence that the paint in this area had been 'touched up.' The maintenance organisation that replaced the pitch link at the last annual maintenance informed the investigation that in their experience, wear normally occurs in the bearing which is connected to the pitch horn, whereas they rarely find wear in the other bearing. Their normal practice, if the bearing wear is within limits, is to rotate the link so that the bearing with the wear is then connected to the pitch control assembly. This practice is consistent with the advice given in the Aircraft Maintenance Manual (Chap 64-30-00).

The paint was chemically removed and the link was examined using high magnification optical devices and a SEM. In the areas where the paint had been 'touched up', there was no evidence of the Alodine surface finish and the tops of the dimples, caused by the shot peening, had been removed by a coarse abrasive that had left scratches in the surface. Corrosion products were present in this area. (See Figure 13.)

The maintenance organisation advised the investigation that they followed the instructions in the Aircraft Maintenance Manual (Chap 64-20-10, Table 502) and the Corrosion Control Manual which states with regard to the removal of corrosion in the pitch link:

> *'abrasive blend and polish minor surface defects.....using 400 grit silicon carbide abrasive paper.'*

The mechanic who carried out the work stated that he removed the paint and corrosion by lightly buffing

Figure 13
Section of 'green' pitch link with paint removed

the pitch link with 600 grade followed by 1500 grade silicon carbide paper. He then cleaned the surface with Alumiprep 33 before applying Alodine 1201 with a paper cloth and brush. Finally, he applied two coats of zinc chromate primer and a top coat of matt black paint. The technical sheet for Alumiprep 33 states that it is a phosphoric acid based cleaner, brightener and pre-paint conditioner that should not be used on high copper bearing aluminium alloys. The manufacturer of Alumiprep 33 advised the investigation:

> *'... this product due to its composition is not capable of dissolving copper or copper oxide. This might theoretically lead to relatively higher copper concentration at the Al surface, when used on 2000 series aluminium. High copper concentrations at the surface may reduce the corrosion resistance of the material.'*

A corrosion expert within QinetiQ confirmed that Alumiprep 33 should not be used on 2000 series aluminium as it leaves concentrations of copper rich precipitates. As copper is less reactive than aluminium, a galvanic cell could be established that leaves the surface susceptible to subsequent corrosion; moreover, the copper rich surface may reduce the effectiveness of the Alodine treatment.

Previous failures of the tail rotor blade pitch link

The helicopter manufacturer reviewed the service history and accident history of tail rotor pitch links. The review included available data for the 369A (OH-6A), 369H, 369HE, 369HS, 369HM, 369D, 369E and 369FF model helicopters and found only one previous report of a tail rotor pitch link having failed. This occurred in 1997 and the helicopter landed safely without sustaining any further damage. The cause of the failure was fatigue, attributed to extensive damage to the pitch link bore caused by movement of the bearing in the bore. Wear and damage to the bearing and pitch link was visibly apparent.

Previous failures of tail rotor blades

Background

The design standard of the 'blue' tail rotor blade, which has a pocket machined into the pitch horn to reduce weight, was introduced onto the Hughes 369 series of helicopters by a Supplemental Type Certificate in March 1999. In 2001, the manufacturer of the blade became the Original Equipment Manufacturer (OEM) supplier of tail rotor blades to the helicopter manufacturer. At the time of the accident approximately 1,100 of these blades had been delivered, of which the manufacturer estimated that there were around 200 still in service.

Failures prior to 2004

In 2002, there were two reported occurrences of the pitch horn fracturing on blades with a pocket in the pitch horn. Initially, this was thought to have been caused by overload failure. The following year there were a further two occurrences. These were found to have been caused by fatigue cracking that had started in the area of the pocket. A review by the blade manufacturer of the evidence from the earlier occurrences concluded that they may also have failed as a result of fatigue cracking.

As the helicopters involved in the occurrences prior to 2004 landed safely, no formal reports into the circumstances of the incidents were produced. However, the helicopter manufacturer was able to provide the investigation with the pilot's report and some simple field notes for an incident on 26 February 2003 involving a MD369 helicopter, registration N234RF.

The pilot reported that the helicopter was being flown at 115 kt and had just commenced a right turn when he heard a "loud snap" accompanied by very strong medium frequency vibrations. He established that the helicopter would not respond to full left pedal input and assumed that he had had a tail rotor control malfunction. The vibration was sufficiently strong to "unlatch and pop open" the passenger door. The pilot flew the helicopter for a further five minutes, with full left pedal applied, during which he descended at an airspeed of approximately 70 kt. He performed a running landing, touching down at an airspeed of approximately 30 kt, using the throttle to maintain directional control during the landing and subsequent ground run.

The field notes for this accident included a photograph of the failed tail rotor blade pitch horn fracture surface, annotated with the significant features (see Figure 14). The features were very similar to those seen on the fracture face of the tail rotor blade from G-KSWI, with two fatigue cracks emanating from the lip of the pocket.

There was also a sketch and photographs of the pitch link which, with the failed part of the pitch horn, had remained connected to the pitch control assembly. The sketch showed that the pitch link had bent sideways and that there was a gap between the bearing and the recess in which it was fitted. This indicated that the metal in the pitch link around the bearing had undergone plastic deformation. A note on the sketch stated that the pitch link had made contact with the bell crank, which is part of the pitch control assembly.

Action by the FAA

As a result of these findings, the blade manufacturer reviewed the stresses in the area of the pockets. This resulted in the FAA issuing an Emergency Airworthiness Directive (2003-08-51), in April 2003, to reduce the service life of these blades from 5,140 hours to 400 hours. In June 2003, the FAA issued an alternative means of compliance that allowed the original life to be restored.

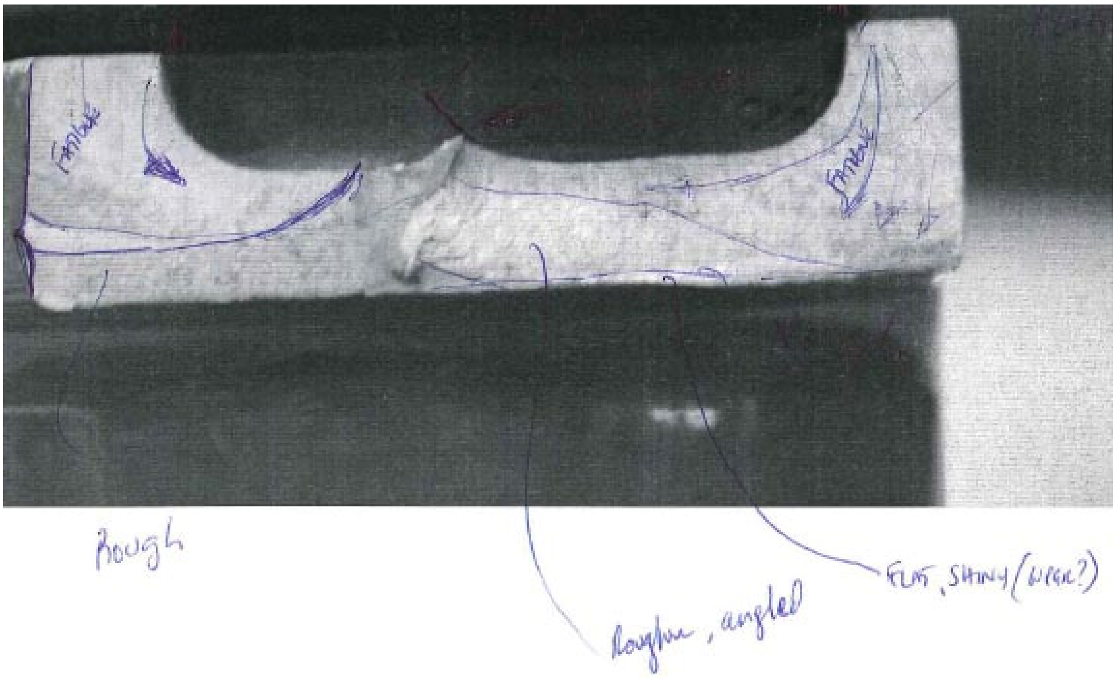

Figure 14
Fracture face of pitch horn that failed on N234RF in February 2003

This required blades that had zero time to be shot peened in the area of the pitch horn and identified with the letter 'M' painted on the blade root fitting. Blades in-service were returned to the manufacturer to have the paint removed around the area of the pitch horn, which then had to undergo an eddy current inspection to ensure that it was free of cracks. On blades that passed this check the inside edge of the pocket was machined to provide a corner radius of 0.254 mm (0.01"). The surface was then shot peened and the surface finished restored. These blades were identified with the letter 'I'. In addition, the design of newly manufactured blades was changed so that they no longer incorporated the pocket.

Failures after 2004

The investigation was advised of a further failure of a tail rotor pitch horn that occurred on 24 February 2010. On that occasion an experienced helicopter pilot, whilst flying in the cruise, identified that he had had a tail rotor control malfunction and successfully performed a running landing without damaging the helicopter. A metallurgy report concluded that the failure of the tail rotor blade occurred as a result of corrosion fatigue cracking which initiated at two, or possibly more, locations around the lip of the pocket. The examination also identified extensive corrosion that had caused blistering and flaking of the paint finish. A photograph of the fracture face is at Figure 15.

Finite Element Analysis of the pitch horn

The blade manufacturer produced a Finite Element Analysis (FEA) model of the tail rotor blade using Abaqus/CAE, version 6.11-1, software. The analysis considered the probable maximum loads with the pitch link intact and the pitch link having failed at the pitch control assembly. The modelling did not include any compressive stresses resulting from the shot peening or any additional loads resulting from increased friction in the bushes (bearings) fitted inside the root of the tail rotor blades.

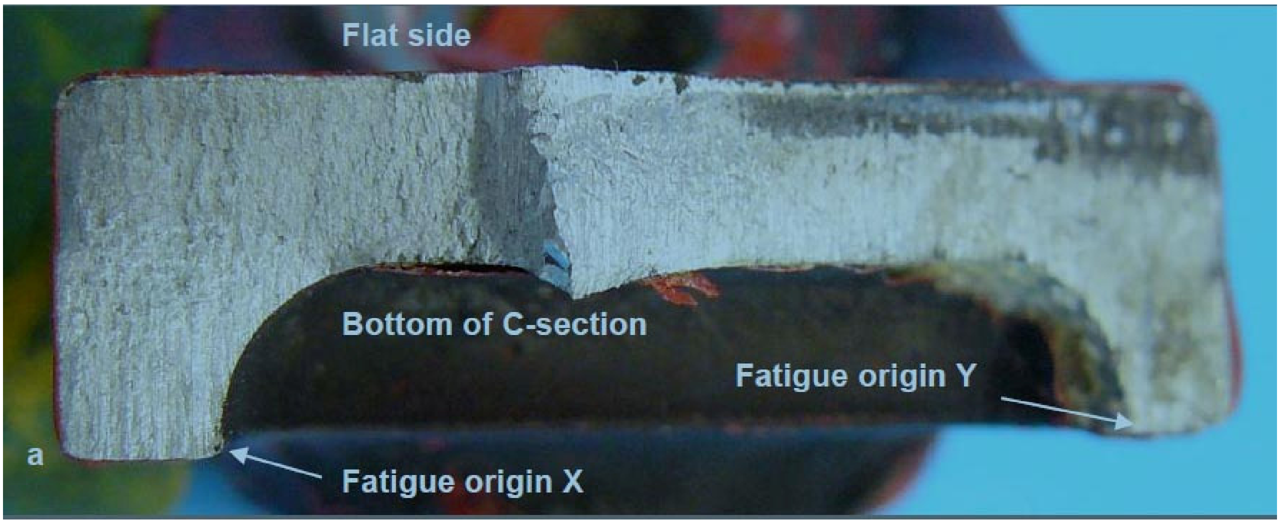

Figure 15

Fracture face of pitch horn that failed on the 24 February 2010

For the normal maximum loading condition, Figure 16a shows that the maximum stress occurs in the outboard upper corner of the pocket. As the pitch link loads are reversible, the maximum stress would be mirrored. In Figure 16b it can be seen that, for the failed pitch link condition, the maximum stress occurs at all four corners of the pocket with the highest stress at the inboard corners. During the previous incidents the fatigue cracks, highlighted in Figures 9, 14 and 15, emanated from points close to the inboard corners.

History of the 'blue' tail rotor blade

The 'blue' tail rotor blade, on which the pitch horn failed, had a data plate that identified it as part number 500P3100-101MT and serial number A881. The letter 'M' was painted on the root section of the blade which,

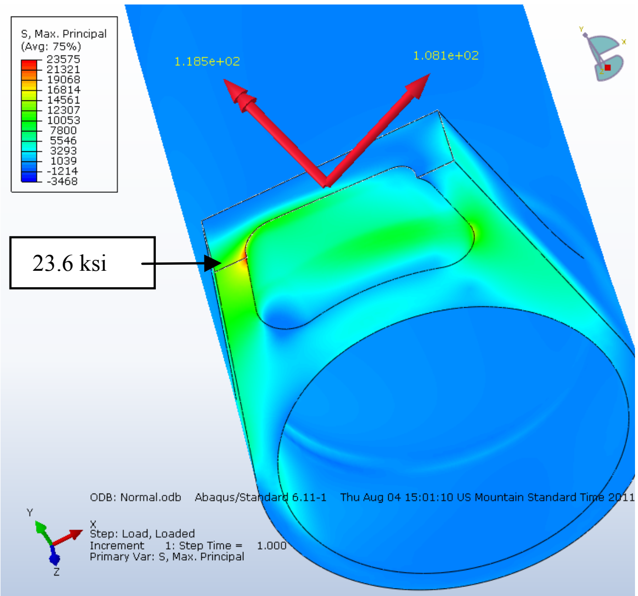

Figure 16a

Maximum stress - normal loading

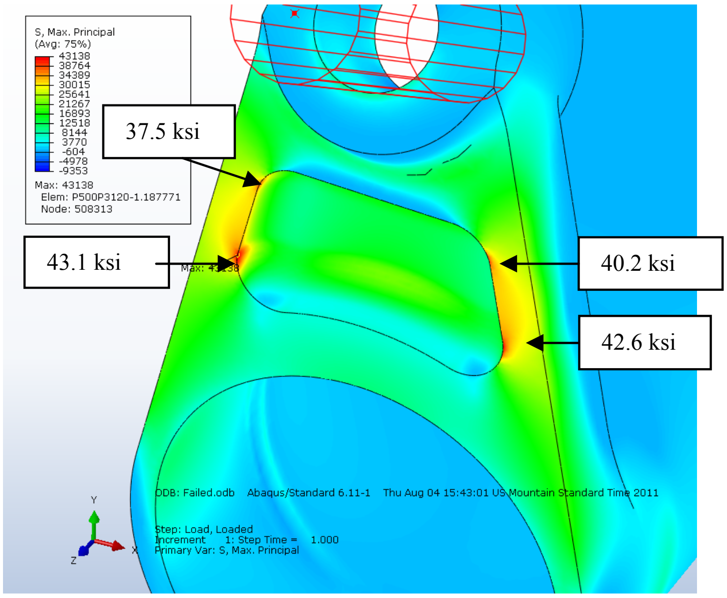

Figure 16b

Maximum stress - failed pitch link

with the letters at the end of the part number, signified that the area around the pitch horn had been shot peened before the blade had entered service.

The blade was manufactured in April 2003 and returned to the blade manufacturer in August 2006 (life used 150 hours) for two Service Bulletins to be embodied; these were not related to the pitch horn. It was next returned to the blade manufacturer in April 2011 (life used 761 hrs) to replace the erosion strip and rectify corrosion which had been found on the blade skin and the tip of the blade during the annual / 100 hour inspection. The blade manufacturer advised the investigation that the paint finish was removed from the aerofoil section prior to removing all visible signs of corrosion in the blade skins and at the tip of the blade. As there was no visible evidence of corrosion in the blade root and pitch horn, it was only considered necessary to lightly abrade the paint in this area, to provide a keyed surface prior to the painting of the entire blade.

Damage on other tail rotor blades fitted to MD 369 helicopters

During the investigation, the organisation that maintained G-KSWI informed the investigation of a set of tail rotor blades from another MD 369 helicopter that were being returned to the blade manufacturer to rectify corrosion in the area of the pitch horn pockets. There was also evidence of mechanical damage and chips in the paint work (see Figure 17). These blades had been fitted to the helicopter since 2004, had flown 262 hours and had never been returned to the blade manufacturer.

The paint finish was removed from the pitch horn on one of the blades using a chemical paint stripper in order not to damage the metal surface or remove any of the corrosion products. The majority of the corrosion discovered in the area of the pocket had been visible through the paint layer as blisters. However, there were patches that were not detectable with the

Figure 17

Corrosion in the area of the blade pocket paint in place. The surface showed evidence of having been shot peened and appeared to have been treated with Alodine. There was no evidence of any abrasion or scratch marks on the areas that had been exposed during the examination.

The blade manufacturer advised the investigation that it is common to see evidence of corrosion and mechanical damage, due to tool usage, in the area of the pitch horn. The normal practice when the blades are returned to the blade manufacturer is to remove the corrosion mechanically and restore the shot peening, chromate conversion coating (Alodine 1200) and paint finish.

Removal of corrosion

The instructions on the removal of corrosion are specified in the manufacturer's Component Overhaul Manual (CSP-COM-5) and the Corrosion Control Manual (CSP-A-3). While the corrosion Control Manual has an issue date of 9 February 1981, it is still an active document listed on the manufacturer's website, with a latest revision date of 30 July 1993.

Pitch link

The repair of the pitch links is specified in Table 502 in Chapter 64-20-10 of the Component Overhaul Manual. The maximum repairable limit is '*minor surface defects*', for which the corrective action is to *'Abrasive blend and polish minor surface defects.'* Chapter 4-14 in the Corrosion Control Manual provides advice on removing corrosion from aluminium and aluminium alloy surfaces and, in addition to the use of 400 grit silicon carbide abrasive paper, it also describes the use of Triacid etch solution to clean the surface. The maintenance organisation that removed the corrosion from the pitch links on the accident aircraft used Alumiprep 33 as an alternative surface cleaner to Triacid, which they advised is not commercially available in the UK. The investigation could find no advice in the helicopter maintenance manuals regarding the restoration of shot peening following rework of the pitch links.

Tail rotor blades

With regard to the root fitting on the tail rotor blades, Table 501 in Chap 64-20-10 of the Component Overhaul Manual states:

> *'Cracks, scratches, nicks and gouges….Defect depth must not exceed 0.020 inch (0.508 mm) after rework…Abrasive blend and polish allowable defect…'*

The metallurgy established that the effective depth of shot peening was around 0.075 mm, which is considerably less than the depth to which damage can be blended out. The investigation could find no advice in the helicopter or blade manufacturer maintenance manuals regarding the need to restore shot peening following rework of the tail rotor blade pitch horns.

Procedures following a loss of thrust from the tail rotor

The Flight Manual contains advice on the actions to take in the event of a tail rotor (anti-torque) failure. It states:

> '- *The nose of the aircraft will turn right with power application. The nose of the aircraft will turn left with power reduction.*
>
> - *Anti-torque failure, fixed tail rotor pitch setting. The procedure to follow is: 'Adjust power to maintain 50 to 60 kt airspeed. Perform a shallow approach and running landing to a suitable area, touching down*

into wind at a speed between effective translational lift and 30 kt……

- *Complete loss of thrust in the hover…is normally indicated by an uncommanded right turn.' The procedure to follow is: 'Place the twistgrip in the ground idle position and perform a hovering autorotation'. There is also a warning to 'reduce altitude to 12 ft or less prior to placing the twistgrip in the ground idle position and performing a hovering autorotation'.*

Pilot's continuation training

The pilot last flew his Licence Proficiency Skill check on 6 November 2010. The examiner reported that they practised a tail rotor failure in the hover, but did not practise a loss of tail rotor control in forward flight. The examiner considered it unlikely that the pilot would practise emergencies, such as a loss of tail rotor control, when he was not flying with him.

Medical information

The pilot held a current JAA Class 2 medical with the limitation that he was required to wear spectacles. A pair of spectacles was recovered from the wreckage.

During the accident sequence the pilot sustained fractures to his pelvis, lower back and ribs as well as extensive head injuries and several large cuts and puncture wounds to his body. The pilot previously flew helicopters wearing a helmet but around eight months prior to the accident he started to use a noise cancelling headset.

The pilot spent several months in hospital and was not able to recall any details of the events immediately prior to the accident.

Analysis

General

As far as could be established, the pilot was flying a direct route back to Cornwall. The flight appeared to progress satisfactorily until the helicopter was in the vicinity of Glastonbury, when, without making any radio calls, the pilot commenced a rapid descent and appeared to position the helicopter for a landing in a field. The description of the helicopter starting to spin is consistent with the airspeed becoming too low for the pilot to maintain directional control, following a loss of tail rotor authority.

Examination of the accident site and wreckage indicated that the helicopter struck the ground with a high rate of descent and low forward speed. The tail section was severed by the main rotor blades after the helicopter struck the ground and the distribution of the light wreckage indicated that the fuselage had been rotating anti-clockwise after initial contact with the ground. While this is the opposite direction to that experienced during a tail rotor failure, it was consistent with the direction the fuselage would rotate if the tail cone was struck by the main rotor blades. The burnt grass and damage to the helicopter caused by the blade strikes suggested that the engine had been running at a low power setting. It would have stopped after the main fuel feed pipe was severed during the impact. Due to the damage to the pilot's collective lever and engine control linkages it was not possible to establish the position of the throttle. Apart from the failure of the pitch horn and pitch link on the 'blue' blade, the investigation could identify no other reason why the pilot would suffer a reduction in yaw control.

Loss of pitch control to one tail rotor blade would result in it being moved by the torsion strap to a pre-set position, with the result that the maximum thrust available from the tail rotor would be reduced. It is likely that this would have resulted in sudden severe vibration which the pilot would probably have felt through his pedals and the airframe, as experienced by a pilot in a previous event. Given that the pilot made no emergency call to ATC, and made no apparent attempt to divert to another airfield, it is likely that the problem commenced shortly before the helicopter's rapid descent. He was probably then pre-occupied with selecting a suitable field in which to undertake a precautionary landing.

Initially, the helicopter was being flown at an airspeed of around 120 kt when the tail fin would have provided the majority of the thrust required to counter the torque reaction from the main rotor. It is, therefore, possible that the pilot was unaware that he had lost pitch control of one of the tail rotor blades. The collective lever would have been lowered during the descent, which would have reduced the engine power and the torque reaction from the main rotor. During the last 37 seconds the pilot reduced the rate of descent, which would have required an increase in engine power, increasing the torque reaction from the main rotor. The flight manual recommends that, in the event of the tail rotor assuming a fixed pitch setting, the pilot should adjust power to maintain an airspeed of 50 to 60 kt, perform a shallow approach and carry out a running landing between effective translational lift and 30 kt. The witnesses stated that the pilot appeared to orbit the field and the GPS data shows that the helicopter ground speed reduced to around 10 kt.

The evidence indicated that one tail rotor blade had assumed a fixed pitch setting and that the pilot reduced the helicopter's airspeed to the point at which there was insufficient thrust available from the tail rotor to counter the torque reaction from the main rotor. As a result, the helicopter started spinning to the right. Once the helicopter had started rotating at low airspeed, the pilot would have needed to reduce torque, by rolling the throttle off, to stop the rotation, and use the collective lever to arrest the subsequent descent and cushion the touchdown. Witness reports of the engine noise reducing and the helicopter rotation stopping, before it rapidly descended, suggest that the pilot moved the throttle towards the ground idle position. The damage to the helicopter was consistent with the engine having been at a low power setting.

Aircraft handling

In the five previously reported failures of the tail rotor pitch horn, the pilots were able to land the helicopters with no further damage. On this occasion, it seems likely that the pilot, who had not recently practised loss of tail rotor control emergency procedures, was uncertain of the nature of the malfunction until the aircraft started to spin and he, probably, realised that he had suffered a loss of tail rotor thrust.

Failures that could have resulted in a loss of yaw control

The investigation identified two failures that could have resulted in the loss of pitch control of the 'blue' tail rotor blade; failure of the pitch horn and failure of the pitch link.

There were two fatigue cracks and an area of overload on the fracture surface of the 'blue' blade pitch horn where the FEA established that the maximum stress occurs. Assuming a blade loading of two cycles per tail rotor revolution, counting all the strong and weak striations in 'Crack A' would give an estimated minimum time of 18.5 minutes for the crack to have propagated and failed. However, if it is assumed that the strong striations are formed by the cyclic blade loading and the weaker striations by high frequency vibration, or the flaying of a broken pitch link if it failed first, then the minimum time for the crack to propagate and fail is 1.5 minutes. The time between the start of the descent and the loss of GPS data was 1.5 minutes. Therefore, it is possible that the pitch link could have failed first, at the pitch control assembly, and the increased load on the pitch horn might then have been sufficient to cause 'Crack A' and 'Crack B' to grow and for the pitch horn to eventually fail in overload.

In summary, failure of the pitch horn could have resulted in the failure of the pitch link; similarly, failure of the pitch link could have resulted in failure of the pitch horn. However, without being able to recover the missing pitch link, and severed part of the pitch horn, it was not possible to establish the failure sequence.

Stiff yaw pedals

The increased force that the pilot had to apply through the yaw pedals, as a result of the swelling of the bushes (bearings) in the root section of the tail rotor blades, would have increased the static and cyclic loads applied to the pitch horn. However, the report of 'stiff pedals' occurred over one year and approximately 150 flying hours prior to the accident and both pitch links were replaced after this fault had been rectified. Following the accident, both tail rotor blades were found to be free to rotate on their spindles and the investigation could identify no evidence to indicate that the increased loads resulting from the 'stiff pedals' contributed to the eventual failure of either the pitch horn or pitch link.

Tail rotor pitch horn

The fatigue cracks that resulted in the previous failures of the pitch horn are reported to have originated in the area of the pocket, where the FEA undertaken by the blade manufacturer showed that the maximum stress occurs. The investigation identified a burr on the accident blade that ran along the edge of the pocket; the blade manufacturer believed that this could be caused by the shot peening process. The alternative means of compliance with Emergency Airworthiness Directive 2003-08-51 required the edges of the pockets to be machined, to introduce a 2.29 mm (0.090") radius, on blades that have been in-service prior to them being shot peened: these blades were subsequently identified with the letter 'I'. Zero time blades, such as the one involved in this accident and marked with the letter 'M', did not require the pockets to be machined. The manufacturer advised that approximately 200 blades were manufactured to the 'M' configuration. It is not known how many 'M' configuration blades remain in-service.

It was also established that the blade manufacturer regularly receives blades that have corrosion and mechanical damage on the pitch horn. However, they only remove the paint around the pitch horn if there are visible signs of mechanical damage or paint blistering. Examination of three tail rotor blades (both blades removed from G-KSWI and one blade removed from another helicopter) established that not all the corrosion is visible through the surface finish.

The fatigue cracks on the tail rotor blade pitch horn appear to have formed in the same areas as in the previous occurrences. Also, it is not possible to check if there is corrosion on the blade root and pitch horn without first removing the surface finish. Therefore, the following Safety Recommendation is made:

Safety Recommendation 2011-100

It is recommended that the Federal Aviation Administration review Helicopter Technology Company's service life and approved maintenance programme, with regards to the inspection for corrosion, for tail rotor blades fitted to the MD 369 series of helicopters that have a pocket in the pitch horn (Part number 500P3100-101), to ensure their continued airworthiness.

The investigation established that, at some point, the pitch horn on the 'blue' tail rotor blade had been rubbed down with an abrasive material which removed some of the Alodine and left sharp scratches that appeared to penetrate through the Alodine layer across most of the surface. The shot peened surface was also missing in a number of areas covered in scratch marks. Similar damage was seen on a small area of the 'green' blade that had been repaired in the field. There was no documented evidence of the surface finish on the 'blue' blade having been disturbed other than when it was returned to the blade manufacturer 15 flying hours prior to the accident, when the paint around the root was lightly abraded. The blade manufacturer was adamant that their processes would not cause such damage, a position which was supported by the fact that the 'green' blade, which had been returned to the manufacturer at the same time for similar work to be carried, displayed none of this damage. The scratches would have compromised the corrosion protection and, with the lack of shot peening, would have made the blade pitch horn more susceptible to fatigue cracking. Given that there might be blades in service where the effectiveness of the shot peening on the tail rotor pitch horn has been compromised, the following Safety Recommendation is made:

Safety Recommendation 2011-101

It is recommended that the Federal Aviation Administration requires that Helicopter Technology Company ensures that there is an effective layer of shot peening on the pitch horns of in service tail rotor blades (Part number 500P3100-101) fitted to MD 369 helicopters.

Tail rotor pitch link

During the previous reported failure of the pitch link and five failures of the pitch horn, the pitch link remained attached to the pitch control assembly. In this accident, it would appear that the pitch link detached in flight, leaving no evidence as to how it failed.

The 'green' and 'blue' tail rotor pitch links had been replaced with new items just over one year and approximately 124 flying hours prior to the accident. They were both removed and inspected during the last annual inspection, when corrosion had been removed from both links using 600 and 1500 grade abrasive paper, and had flown on G-KSWI for a further 15 hours prior to the accident. While the maintenance organisation appears to have followed the advice in the Corrosion Manual, the use of 600 grade silicon carbide paper on the 'green' pitch link introduced sharp edges and compromised the effectiveness of the shot peening, leaving the link more susceptible to corrosion and fatigue cracking. There was also no requirement in the maintenance and overhaul manuals to restore material properties following the rectification of corrosion. The following Safety Recommendation is made:

Safety Recommendation 2011-102

It is recommended that the Federal Aviation Administration requires that MD Helicopters ensures that an effective layer of shot peening is maintained on the pitch links fitted to MD 369 helicopters.

Maintenance, Overhaul and Corrosion Manuals

The MD 369 Maintenance, Overhaul and Corrosion Manuals contain no advice on the need to ensure that the surface properties, such as shot peening, are restored following the rectification of corrosion on tail rotor blades and pitch links. Therefore, the following Safety Recommendation is made:

Safety Recommendation 2011-103

It is recommended that MD Helicopters, in consultation with Helicopter Technology Company, updates the advice in the MD 369 helicopter Maintenance, Overhaul and Corrosion Manuals, with regard to the removal of corrosion and restoration of the surface finish and material properties on the tail rotor blades and pitch links, to ensure that the information is appropriate.

ACCIDENT

Aircraft Type and Registration:	Cameron Z-275 hot air balloon, G-CBZZ
No & Type of Engines:	None
Year of Manufacture:	2003
Date & Time (UTC):	24 August 2011 at 0700 hrs
Location:	Pearson Farm, Cromford, Derbyshire
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 1 Passengers - 11
Injuries:	Crew - None Passengers - 1 (Serious) 2 (Minor)
Nature of Damage:	Burner damage to four panels
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	59 years
Commander's Flying Experience:	2,147 hours (of which 1,900 were on type) Last 90 days - 46 hours Last 28 days - 25 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The pilot was landing the balloon in a large grass field. In the final stages of the approach, the balloon was caught in a downdraft and began a more rapid descent. The pilot attempted to climb the balloon but it struck a loose stone wall and a female passenger was seriously injured.

History of the flight

Prior to leaving home at 0500 hrs, the pilot had checked the forecast weather on the Met Office web site. The weather was good, with a surface wind of 210°/2-5 kt, increasing to 270°/9-15 kt at 2,000 ft, visibility in excess of 10 km, cloud FEW at 4,000 ft and an outside air temperature of 13°C.

On arrival at the departure site, the weather was as forecast and the pilot met the passengers and carried out the flight and safety briefings. This included inviting passengers to declare if they had any medical condition that might preclude them flying. They were given a verbal briefing at the balloon basket with a physical demonstration by the pilot of the landing position that the passengers must adopt. This position requires the passengers to stand facing away from the balloon's direction of travel with their backs braced against that side of the basket. They should bend their knees slightly and hold onto the handles provided. There were four passenger compartments in the basket, one at each corner with a central area for the pilot to control the gas-fuelled burners.

When the balloon was inflated, the passengers boarded the basket. The pilot reaffirmed his briefing and the passengers were instructed to adopt their landing positions. This was checked for correctness by the pilot and members of the ground crew.

The balloon departed for a one hour flight at 0600 hrs and was climbed to 1,500 ft in order to establish the actual wind direction and speed. At this altitude, the onboard GPS equipment indicated a wind speed of 16.8 mph, so the pilot descended to a lower altitude. For the next forty minutes the wind speed was between 1 and 6 mph.

At 0650 hrs, the balloon approached some high ground and the wind speed increased to 16 mph. The projected flight path, at this stage, was over horses, a rocky outcrop and some electricity pylons. Despite the wind starting to increase, these obstacles had to be cleared before the balloon could land. The pilot selected a large grass field ahead of the balloon, instructed the passengers to adopt their landing positions and, with the wind speed indicating 17 mph, commenced an approach.

On the final approach, the wind gusted, whereupon the balloon started a more rapid descent. The pilot used all three burners in an attempt to go around from the approach but this did not arrest the rate of descent. The basket struck a fence followed by a wall some 25 metres short of the intended landing point. The basket travelled on its side for approximately 50 metres into the field before coming to a stop. The passengers disembarked, apart from one female passenger who was complaining of pain in her legs. The pilot called an ambulance which conveyed her to hospital where she was found to have broken both her legs. Two other passengers sustained minor injuries.

Discussion

The operator's Operations Manual makes the following statement regarding wind speed limits:

> ***'Wind Speed Limits***
>
> *Balloons shall not normally be operated in wind speed exceeding 8kts on the surface, and not in wind speeds between 8kts and the Flight Manual limit of 15kts without the specific approval of the Chief Pilot.'*

The pilot was authorised to operate the balloon between 8 and 15 kt. The forecast wind speeds and the wind at the departure point were within the limits stated in the Operations Manual. As the flight progressed towards the high ground, the windspeed increased and the pilot elected to land. However, he was unable to do so until the balloon had cleared the obstacles on the ground.

The passengers had all been briefed and instructed on how to adopt the landing position and this was called for by the pilot during the approach. The injured passengers had all adopted the landing position but the impact with the wall was immediately below their corner of the basket and this caused the injuries. The female passenger, who broke both her legs, was 64 years of age and had no medical history that may have contributed to her injuries.

The pilot's assessment of the cause of the accident was that a large gust of wind on the approach to the proposed landing site caused the balloon to increase its rate of descent. The balloon basket subsequently made contact with the fence and the stone wall prior to the proposed landing site.

In a report on a hot air balloon accident involving G-KTKT, published in AAIB Bulletin 8/2010, a reference is made to the number of ballooning accidents which have resulted in *'serious injury'* and that:

> *'in a significant proportion of these reports, the injured passenger was described as 'elderly'.'*

Safety Recommendation 2010-052 was made as a result of that investigation. It stated:

> Balloon landings can take place at unprepared sites and may occasionally be bumpy for the occupants, especially in higher wind conditions if the basket tips over and drags along the ground. At present, not all commercial balloon operators make passengers aware of this, either at the booking stage or prior to a flight. Therefore, it is recommended that the Civil Aviation Authority require all commercial balloon operators to make prospective passengers aware of the varied nature of balloon landings so that they can make an informed decision as to whether or not to undertake a flight. (Safety Recommendation 2010-052)

Following on from the Safety Recommendation, on 30 November 2011, the Civil Aviation Authority issued Safety Notice number: SN-2011/018, *'Balloon Operations-Safety Matters'*. The Safety Notice is a comprehensive document and places particular emphasis on passenger related matters. In this respect, it summarises that:

> *'Operators should ensure that prospective passengers are aware that ballooning is an outdoor activity, normally occurring in the open countryside, requiring a degree of fitness and activeness from participants.'*

ACCIDENT

Aircraft Type and Registration:	Cameron Z-400 hot air balloon, G-VBFV
No & Type of Engines:	None
Year of Manufacture:	2010
Date & Time (UTC):	30 September 2011 at 1510 hrs
Location:	Shuttleworth Park, Old Warden, Bedfordshire
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 1 Passengers - 14
Injuries:	Crew - None Passengers - 1 (Serious)
Nature of Damage:	None
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	44 years
Commander's Flying Experience:	2,666 hours (of which 1,500 were on type) Last 90 days - 51 hours Last 28 days - 9 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

A passenger fell while boarding the basket and broke his arm. The basket had moved as the passenger was boarding, causing him to miss his footing.

History of the flight

Prior to the flight, the pilot briefed the passengers on the procedure for boarding the balloon and the position to adopt during landing. During this briefing, the passengers practised boarding the basket and adopting the landing position. The balloon was prepared for flight and a launch restraint system was connected between the upwind side of the burner frame and a nearby vehicle to restrain the balloon prior to takeoff. When the balloon envelope was inflated and above the basket, the pilot instructed the passengers to board. The basket sides were fitted with foot holes to assist the passengers to board the basket. Figure 1 shows these.

As the passengers were boarding the balloon basket one passenger fell to the ground and sustained a fracture to his upper arm. The ground support crew escorted him clear of the balloon and the flight continued. The passenger stated that the balloon basket tipped as he was boarding causing him to fall to the ground. Two witnesses stated that the basket moved because of a gust of wind. The pilot stated that the basket remained on the ground throughout the passenger embarkation and that he believed the cause of the accident was that the passenger missed his footing on the basket. The mean surface wind strength at the time of the incident, obtained from the Met Office, was below the maximum stated by the manufacturer for takeoff.

Figure 1
Balloon basket with foot holes

ACCIDENT

Aircraft Type and Registration:	Pegasus XL-Q, G-MWKY
No & Type of Engines:	1 Rotax 462 HP piston engine
Year of Manufacture:	1990
Date & Time (UTC):	29 October 2011 at 1200 hrs
Location:	Charley Mill Farm, Markfield, Leicestershire
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Extensive damage
Commander's Licence:	Student
Commander's Age:	49 years
Commander's Flying Experience:	45 hours (of which 45 were on type) Last 90 days - 15 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

The student pilot was on a solo navigation flight when he began to experience difficulty controlling the aircraft in the gusty wind conditions. The forecast indicated wind from 200° at 20 kt, but the pilot's impression was that it was stronger. He decided to land in a field but the aircraft touched down heavily and overturned. The pilot was unhurt.

The pilot reported that he had been unable to control the aircraft during the landing in the gusty conditions.

ACCIDENT

Aircraft Type and Registration:	Rotorsport UK MTOSport, G-LZED
No & Type of Engines:	1 Rotax 912 ULS piston engine
Year of Manufacture:	2010
Date & Time (UTC):	27 June 2011 at 1120 hrs
Location:	Shell Island Campsite, Llanbedr, Gwynedd, North Wales
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Pod, right main and nose landing gear, rotor blades, propeller, tail fin and rudder pedals damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	47 years
Commander's Flying Experience:	380 hours (of which 88 were on type) Last 90 days - 38 hours Last 28 days - 7 hours
Information Source:	AAIB Field Investigation

Synopsis

The pilot selected a field for takeoff which was shorter than that required. There was no evidence of any fault with the gyroplane, which struck a wall shortly after becoming airborne, before crashing. The gyroplane was extensively damaged but neither occupant was injured. A number of similar accidents have highlighted the need to enhance pilot understanding of gyroplane performance.

Two Safety Recommendations are made.

History of the flight

Shell Island is a large campsite located on the coast, 600 m north-west of Llanbedr disused airfield. The campsite consists of a number of close-cut grass fields at an elevation of between 20 and 30 ft amsl. The fields are bounded by low hedging, intermittent stone walls 2 to 4 ft in height or a combination of both.

The pilot had flown in the previous day and, having considered his options, selected the field he wished to use for departure. He estimated, by pacing, that the length of the field was 250 m and noted a slope. In his report, the pilot stated that he considered the field was "tight but achievable" and that "no other options were any better". The pilot had calculated his takeoff mass as 472 kg, which was below the 500 kg structural maximum.

During the morning the pilot had been using a row of flags at the campsite's main building to monitor the surface wind. He estimated that it was from the west at 5 mph and occasionally calm. The pilot decided to take off downslope, which made the departure downwind. He noted, from the rotor bearing temperature sensor, that the ambient temperature was 18.7°C.

The pilot took the precaution of arranging, with the campsite, for staff to close the field for his departure. Having conducted his pre-flight checks, which included a "test run" across the slope, the pilot shut down the gyroplane and, to ensure there was no unused space, positioned it with the tail against the hedge at one side of the field. He then restarted the engine, accelerated the rotor to its maximum pre-rotator speed of 260 rpm and, with the stick fully back, released the brakes. The gyroplane accelerated down the slope and "skipped", which gave the pilot confidence that the takeoff would be successful. He later commented that it felt as if the gyroplane had been "held back"; one witness reported to him that, at some point during the takeoff run, the tail might have struck the ground. The pilot noticed that the gyroplane's rotor had a high angle of attack and was, therefore, generating additional drag, reducing the aircraft's rate of acceleration. He considered that this was due to the downward slope and that he had raised the nose too high. The pilot corrected the pitch attitude and the gyroplane accelerated becoming airborne as the slope flattened out. However, there was insufficient distance remaining to accelerate in ground effect and the right main landing gear contacted the field's far perimeter wall, causing the gyroplane to crash into a bush. Despite extensive damage to the gyroplane, there was no fire and the pilot and his passenger were uninjured.

The pilot concluded that his lack of familiarity with sloping ground operations resulted in an incorrect takeoff pitch attitude and an extended takeoff roll.

Field length

Post-accident measurement of the field, using Ordnance Survey data, indicates that the actual length of the field was 200 m +/- 5 m, with an average downslope of about 1 % in the direction of takeoff.

Takeoff technique

Flying a 'New Generation' Gyrocopter[1] describes the gyroplane take off sequence as:

> *'Prerotate: use the mechanical prerotator to start the rotors turning*
>
> *Rotor speed build up : Using forward airflow through the rotors to build up the speed of the rotors whilst moving forward*
>
> *Wheel Balance: Establishing the correct attitude of the Gyrocopter on the ground before attempting to lift off*
>
> *Lift off and airspeed build up: Flying along level just a few feet above the ground and building up speed to 70 mph*
>
> *Climb out: Climbing to circuit height in the fastest possible time.'*

A performance takeoff, used to achieve the shortest possible ground run, is also described. It explains that:

> *'…as you will have become airborne at a lower forward airspeed it is vital that you extend this section* [lift off and airspeed build up] *of the take off.'*

Footnote

[1] Flying a New Generation Gyrocopter, Phil Harwood; The Gyrocopter Company, 2008.

Performance

The MTOSport Pilot's Handbook includes performance data. Issue 4 (dated 17 December 2010) states:

> *'TAKE OFF DISTANCE (MTOW)*
>
> *Take-off run 20 - 170 m (66-560ft) (depending upon loading and wind force) Take-off distance over 15m (50ft) obstacle 320m (1056ft) in still wind with the rotors at 200rpm on grass, hot conditions.'*

It notes that:

> *'The parameters apply to standard conditions (sea level, normal pressure, 15°C, zero wind, max take-off weight 500Kg or as noted, even field with short grass in good condition).'*

There is no performance data provided for tailwinds. The manual does state:

> *'If possible always take off into wind.'*

Figure 1 gives a pictorial description of the elements of the MTOSport's takeoff to a height of 50 ft, clearing a nominal obstacle.

Off-airfield operations

CAA General Aviation Safety Sense Leaflet 12 '*Strip Sense'* contains advice on how to assess an area for aviation use. It states:

> *'The length of the strip must be accurately established. If you pace out, remember an average pace is not one metre but considerably less. This may decrease still further after walking several hundred metres. A proper measuring device is better.'*

Safety factoring

CAA General Aviation Safety Sense Leaflet 7 '*Aeroplane Performance'* contains advice on performance related issues, it states:

> *'Wind: even a slight tailwind increases the take-off and landing distances very significantly.'*

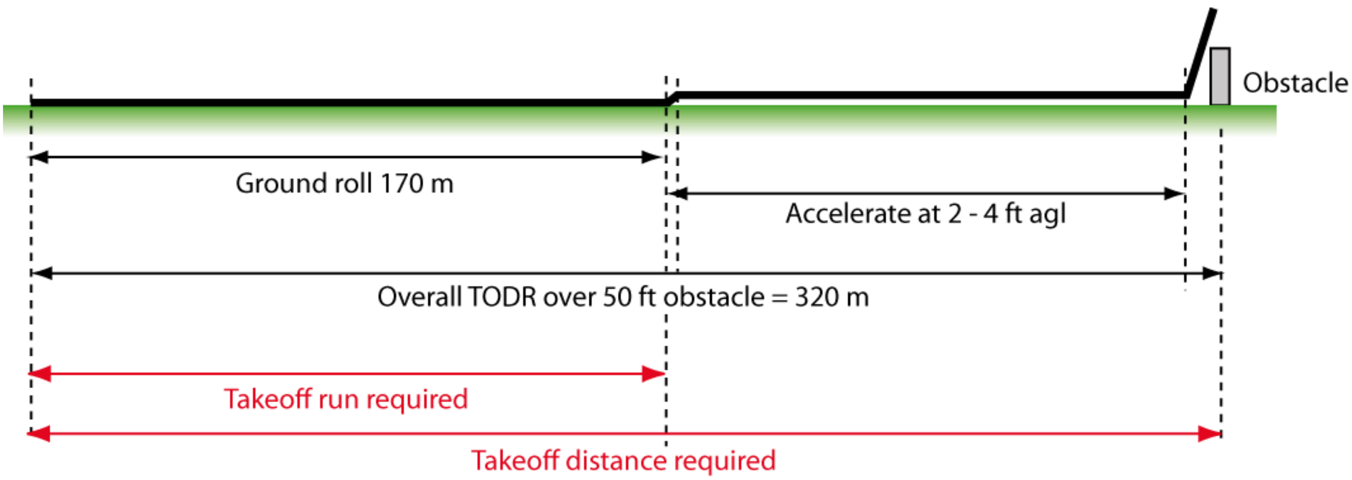

Figure 1

MTOSport gyroplane's takeoff performance at MTOW in still air

It recommends the use of factors to account for possible degraded conditions, such as a tailwind:

> *'a tailwind component of 10% of lift-off speed – factor 1.2'.*

(A 5 mph tailwind is about 10% of the MTOSport lift-off speed.)

A final safety factor should then be added:

> *'It is strongly recommended that the appropriate Public Transport factor, or one that at least meets that requirement, should be applied for all flights. For take-off this factor is x 1.33.'*

It goes on to say that should the Takeoff Distance Required (TODR) then exceed the Takeoff Distance Available (TODA) *'you must offload passengers, fuel or baggage.'*

Previous accidents

The AAIB has published reports on other MTOSport accidents which have occurred during departure. The accidents to G-CGGV in June 2011 (published in AAIB Bulletin 9/2011), G-CGGW in November 2010 (published in AAIB Bulletin 2/2011) and G-DWDW in July 2009 (published in AAIB Bulletin 1/2010) all resulted from the gyroplane becoming airborne but then being unable to clear obstacles safely.

The MTOSport's UK manufacturer commented that they were aware of a developing trend of accidents in which the gyroplane had performed as designed but had been unable to operate safely from the field selected by the pilot. They believed that pilots were failing to realise that, although the gyroplane has a very low Takeoff Run Required (TORR), the period of acceleration close to the ground, to achieve climb speed, can be disproportionately long. This resulted in a larger TODR than pilots had allowed for.

The UK registry, as of September 2011, included 36 MTOSport models.

PPL (Gyroplane) Syllabus

The PPL (Gyroplane) syllabus is issued by the British Rotorcraft Association. The 2009 edition was in force at the time of the accidents referred to in this report. Exercise 8a includes: '*Performance considerations for the type of Gyro'* and requires that students can:

> *'Answer questions relating to the type of Gyro being used for the test. Specifically weights and payloads, fuel weight and consumptions and min/max speeds, especially in turbulence.'*

Analysis

The MTOSport Pilot's Handbook reports a takeoff run of up to 170 m, in still air. Applying the CAA factor of 20% for a tailwind, G-LZED required about 204 m to become airborne. This does not include the 1.33 safety factor which would increase the TORR to 271 m. However, once airborne the gyroplane would still need to accelerate, in ground effect, at a height of between two and four feet before climbing away. As such, even if the pilot's estimate of the field as 250 m long had been correct, the field did not appear to have been of sufficient length to depart safely.

At least three other MTOSport gyroplanes have crashed in similar circumstances in the last two years. This is 11% of the UK registered fleet. The four accidents have included a consistent error, by different individuals, while the flights were being planned. Given this developing trend in reportable gyroplane accidents, the following Safety Recommendations are made:

Safety Recommendation 2011-097

It is recommended that the Civil Aviation Authority emphasise to gyroplane operators the need to consider field suitability and gyroplane specific performance, including the safety factors to apply, when planning a flight.

and

Safety Recommendation 2011-098

It is recommended that the Civil Aviation Authority, in conjunction with the British Rotorcraft Association, review the Private Pilot's Licence (Gyroplane) syllabus to ensure that students receive adequate tuition and examination on the takeoff and landing performance of gyroplanes.

Conclusions

The pilot selected a field for takeoff which was shorter than that required. Hence the TODR, including the relevant safety factors, exceeded the TODA. Safety factors help to take into account variability in conditions and pilot handling. There was no evidence that there was any fault with the gyroplane. Similar accidents highlight the need to enhance pilot understanding of gyroplane performance.

FORMAL AIRCRAFT ACCIDENT REPORTS
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2010

1/2010 Boeing 777-236ER, G-YMMM
at London Heathrow Airport
on 17 January 2008.

Published February 2010.

2/2010 Beech 200C Super King Air, VQ-TIU
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.

Published May 2010.

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.

Published September 2010.

6/2010 Grob G115E Tutor, G-BYUT
and Grob G115E Tutor, G-BYVN
near Porthcawl, South Wales
on 11 February 2009.

Published November 2010.

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.

Published November 2011.

AAIB Reports are available on the Internet
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