CONTENTS

SPECIAL BULLETINS

None

COMMERCIAL AIR TRANSPORT

GENERAL AVIATION

SPORT AVIATION / BALLOONS

CONTENTS (Continued)

ADDENDA and CORRECTIONS

None

(ALL TIMES IN THIS BULLETIN ARE UTC)

INCIDENT

Aircraft Type and Registration:	BAe 146 200, EI-CZO
No & Type of Engines:	4 Lycoming ALF502R-5 turbofan engines
Year of Manufacture:	1984
Date & Time (UTC):	20 February 2007 at 0833 hrs
Location:	London City Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 5 Passengers - 55
Injuries:	Crew -None Passengers - None
Nature of Damage:	Main landing gear tyres burst, wheels damaged
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	33 years
Commander's Flying Experience:	4,750 hours (of which 470 were on type) Last 90 days - 95 hours Last 28 days - 32 hours
Information Source:	AAIB Field Investigation

Synopsis

During a landing on Runway 10 at London City Airport, the aircraft came to rest in the paved undershoot area of Runway 28, having burst all four main landing gear tyres. It was established that the lift spoilers had not deployed after touchdown. The lack of normal deceleration resulted in the flight crew selecting the braking hydraulic system to Yellow from Green, and then to the Emergency Yellow system; this system provides no anti-skid protection for the wheels.

In light of several similar overrun events involving the BAe/RJ 146 since its introduction into service, the Chief Inspector of Air Accidents had ordered an Inspectors Investigation to be carried out into this incident.

History of the flight

Background

Following a flight from Paris Orly Airport to London City Airport (LCY), the aircraft commenced an ILS approach to Runway 10, which has a 5.5º glide slope. The weather conditions were benign; the ATIS at the time stated that the surface wind was from 170º at 5 kt, variable between 140º and 220º, visibility was 10 km or more, there were one or two octas of cloud at 600 ft aal, five to seven octas at 1,300 ft aal, the temperature was 10ºC, the dewpoint 8ºC, and the mean sea level pressure was 1006 mb. The runway surface was damp.

The landing weight of the aircraft was approximately 32.0 tonnes, at which weight a V_{REF} of 110 kt is appropriate[1]. The landing data card prepared prior to the approach showed a V_{REF} of 119 kt.

The approach and landing

Analysis of the data from the FDR shows that the latter part of the approach was flown at approximately 124 kt. The aircraft touched down immediately before the end of the touchdown zone, some 330 metres beyond Runway 10 threshold, at 119 ± 2 kt, and in a level pitch attitude. The data also shows that the lift spoilers did not deploy and suggests that the aircraft was probably close to 'wheel-barrowing' during the early part of the landing roll, mainly as a consequence of the lack of spoilers. The pitch attitude was slightly more nose-down than recorded in previous landings at LCY, with the main landing gear wheels in contact with the ground. It is likely that the main landing gear was compressed only just enough to 'make' the weight on wheels switches, with the aircraft mainly supported by aerodynamic lift from the wings.

The commander, who was the pilot flying (PF), selected the engines to ground idle and, later, recalled that he also selected the airbrake/lift spoiler lever to LIFT SPOILERS. However, he also recalled pressing the brake pedals to their full extent but perceiving that there was "not a hint of deceleration". He then called "brakes, brakes", interrupting the co-pilot's monitoring of the correct thrust setting, spoiler deployment and brake pressure.

Perceiving that the Green hydraulic system brakes had failed, the commander selected the Yellow hydraulic brake system, but did not notice any change in the deceleration; instead, he felt that "the aircraft was only coasting down the runway". He then selected the Emergency Yellow brake system, which provides no anti-skid protection for the wheels. The aircraft seemed to decelerate slowly and came to rest in the undershoot area of Runway 28, 161 metres short of the dock edge at the eastern end of the airport[2]. Toward the end of the skid, all four main landing gear tyres burst although, at the time, the flight crew were unaware that this had occurred.

Skid marks were evident for each of the four main wheel tyres over a distance of 473 metres leading up to the position in which the aircraft came to rest. The aerodrome fire and rescue service arrived promptly, there was no fire, and the passengers disembarked normally.

Engineering examination

An exhaustive investigation of the aircraft revealed no malfunction in any relevant system, and the aircraft was returned to service after the wheels and tyres had been replaced.

However, a friction test of the airbrake/lift spoiler lever revealed that movement of this lever through the detent at the rear of its airbrake travel to lift-spoiler, required a force of 14 lb, whereas zero force was required to move the lever from lift-spoiler back to the airbrake quadrant. Both these forces were within the aircraft's maintenance manual limits.

In March 1988 the aircraft manufacturer issued service bulletin (SB) 27-73-00889 to amend the operating

Footnote

1 According to the appropriate landing technique, in the conditions pertaining at the time, the approach speed at this weight should be 115 kt (V_{REF} plus 5 kt) and, during the final approach, the speed should reduce to 110 kts over the runway threshold (V_{REF}), with touchdown occurring at 103 kt (V_{REF} minus 7 kt).

Footnote

2 The length of the pavement surface on Runway 10 is 1,508 m, and the declared Landing Distance Available (LDA) is 1,319 m;

force characteristics of the lift-spoiler selector lever. The lever's characteristics were amended such that a force of 12 lb would be required to move the lever from lift-spoiler to airbrake. The SB is not mandatory and, initially, was applicable to 114 aircraft, 105 of which, including EI-CZO, are still in service. EI-CZO had not been modified.

Safety action

Previous AAIB investigations have found that pilots commonly mis-diagnose spoiler failure on landing as brake failure. The safety factors incorporated into landing performance calculations mean that, in the event of spoiler failure, an aircraft which touches down within the correct margins of speed, at the touchdown position, will stop before the end of the LDA, provided that appropriate braking effort is made by the flight crew.

In light of several similar overrun events involving BAe146 aircraft since its entry into service, the Chief Inspector of Air Accidents has ordered an Inspectors Investigation to be carried out into this incident.

INCIDENT

Aircraft Type and Registration:	Dornier 328 100, TF-CSB
No & Type of Engines:	2 Pratt and Whitney 119B turboprop engines
Year of Manufacture:	1997
Date & Time (UTC):	22 June 2006 at 1952 hrs
Location:	Aberdeen Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 3 Passengers - 16
Injuries:	Crew - None Passengers - None
Nature of Damage:	Minor damage to wheels
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	62 years
Commander's Flying Experience:	13,000 hours (of which 300 were on type) Last 90 days - 111 hours Last 28 days - 64 hours
Information Source:	AAIB Field Investigation

Synopsis

During the landing roll, the crew could not decelerate the aircraft sufficiently because they were unable, repeatedly, to select the power levers into the beta range. The aircraft overran the runway and the Runway End Safety Area, coming to rest some 350 metres beyond the end of the runway. There were no injuries. Three Safety Recommendations are made.

History of the flight

The aircraft departed Stavanger at 1850 hours on a scheduled commercial air transport (passenger) flight to Aberdeen with the commander, co-pilot, one cabin crew member, and 16 passengers on board. The co-pilot flew the sector and before descent, he briefed for a radar-vectored visual approach to Aberdeen's Runway 34. The flight crew obtained ATIS[1] information which indicated that the surface wind was from 300° at 7 kt, visibility was greater than 10 km, and the lowest cloud was one or two octas[2] at 1,500 ft. The ATIS described the runway as being wet along its entire length, though the flight crew later recalled that the runway was dry. The approach was flown normally with flaps at 20º; the final approach speed was 121 kt. The crew were visual with the runway approximately nine miles from touchdown, and were cleared by Air Traffic Control (ATC) for a visual approach on their request.

Footnote

1 Automatic Terminal Information Service.
2 Or 'eighths' of the visible sky covered by cloud.

With the aircraft approximately seven miles from touchdown, ATC transmitted that the surface wind was from 300° at 5 kt. The co-pilot then disconnected the autopilot and began configuring the aircraft for the approach. Slightly more than three miles from touchdown, the flaps were selected to 20º, and the propeller condition levers were set to maximum; the flight crew then completed the 'Final Approach' checklist. The target speed for the final approach was 121 kt, and the aircraft's speed stabilised at about 120 kt. Approximately two miles from touchdown, the aircraft had deviated slightly below the glideslope and a 'soft' EGPWS[3] "GLIDESLOPE" annunciation was generated. The co-pilot acknowledged the annunciation, re-confirmed to the commander that he had visual contact with the runway, and re-established the aircraft on the glideslope.

As the aircraft descended through 50 ft radio altitude, the power levers were retarded and the co-pilot began the flare. The touchdown occurred approximately 530 metres from the runway threshold (with approximately 1,300 metres of runway remaining) at an airspeed of 105 kt. The commander stated later that the touchdown was a little further along the runway than he would have preferred, but he considered it to be entirely safe. After touchdown, the co-pilot attempted to select the power levers into the beta range. (Selection of the beta range produces considerable deceleration, as the propellers 'disc' and provide drag.) The co-pilot found, however, that he was unable to move the latches on the power levers which prevent inadvertent selection of the beta range below flight idle. In accordance with normal practice for this situation he advanced and then retarded the power levers again, and made a second attempt to select the beta range, but found that the latches would still not disengage.

Footnote

3 Enhanced Ground Proximity Warning System (EGPWS).

The co-pilot said to the commander "WE DON'T HAVE BETAS". The commander took control, applied heavy braking, and made four further attempts to achieve the beta range, each time smartly advancing the power levers and then retarding them to the flight idle stop, before attempting to disengage the latches. These attempts were also fruitless. He transmitted to ATC that the aircraft was in difficulties.

The tower controller activated the crash alarm, alerting both the airport and local authority emergency services by means of an Omnicrash[4] system.

As the aircraft approached the end of the runway the commander steered the aircraft to the left to avoid colliding with the approach lights and localiser antenna on the extended runway centreline. The aircraft left the end of the runway surface at about 43 kt, and continued across grassy terrain beyond the runway end. Recognising that the aircraft had left the runway, the cabin crew member instructed the passengers to adopt the 'brace' position, and braced herself. As the aircraft travelled across the grass, the commander attempted to shut down the engines, but found that the rough ride made grasping and moving the condition levers and their latches awkward. The engines were shut down and the aircraft came to a standstill some 350 metres beyond the runway end. The ground spoilers remained stowed throughout the landing roll.

After the aircraft had come to rest, the commander made a Public Address (PA) announcement to the passengers, instructing them to remain seated and explaining to them that the crew had experienced "A STUCK THROTTLE". The flight crew completed the 'Shutdown' checklist and the commander then left the flight deck and entered the

Footnote

4 Omnicrash is a system which enables simultaneous telephone communication with various emergency services.

passenger cabin, where he spoke to the passengers about the incident.

The aircraft sustained no apparent damage and all on board were uninjured. The Rescue and Fire Fighting Service (RFFS) attended the aircraft and the passengers disembarked normally.

Initial engineering evaluation

The aircraft was initially examined where it had come to rest, in a grassed area some 350 metres beyond the end of Runway 34. No obvious damage was evident. Tyre skid markings consistent with heavy braking on all four main-wheels were evident, beginning towards the over-run end of the paved surface. These began close to the centre-line and deviated to the right before deviating progressively to the left. They indicated that the aircraft departed the paved surface close to the junction of Runway 34 with Taxiway 'W' by the Runway 19 threshold, travelling at an angle to the left of the centreline. Wheel marks on the grass showed that the aircraft then turned back until it was travelling parallel with the runway, but significantly to the left of the extended centreline.

The previous flight

During the previous landing at Stavanger, the co-pilot had experienced difficulties in operating the latches to reduce below flight idle. He had brought this to the attention of the commander, who had assisted successfully with the selection. The landing had been otherwise normal and the aircraft decelerated to taxi speed well before the end of the runway.

Flight Recorders

General

The aircraft was equipped with a solid state Flight Data Recorder (FDR) that was capable of recording and retaining data for a minimum duration of 25 hours, and a solid state Cockpit Voice Recorder (CVR) that was capable of recording 120 minutes of communication and ambient sound from the cockpit environment. The recorders were removed and replayed at the AAIB. Data for the incident flight was available from both recorders.

Recorded Data

Times quoted are FDR-recorded UTC. Extracts from the CVR are in "SMALL CAPITALS". Aircraft heading is magnetic, airspeed is Knots Calibrated AirSpeed (KCAS) and altitudes are referenced to altitude above mean sea level (amsl) unless otherwise stated.

Figure 1 provides the salient parameters of the final approach and landing. As the aircraft passed through 50 ft radio altitude, the power levers were retarded and the aircraft started to flare; airspeed was 119 kt. The aircraft touched down approximately 530 metres from the threshold of Runway 34 (approximately 1,300 metres from the end of the runway), at an airspeed of about 105 kt (a ground speed of 109 kt). Almost immediately the engine torque started to increase (from about 5% to 40%) before rapidly decreasing (Figure 1, point A), at which point the aircraft started to settle on to its wheels and the ground speed started to reduce. The engine torque then rapidly increased and decreased twice in quick succession (Figure 1, point B) and the aircraft momentarily became light on both main gears. During the second engine torque increase the co-pilot said "WE DON'T HAVE BETAS" to which the commander acknowledged "NO"; the aircraft was about 600 metres from the end of the runway and ground speed was about 92 kt.

Ground speed continued to reduce, but engine torque continued to increase. When the aircraft was

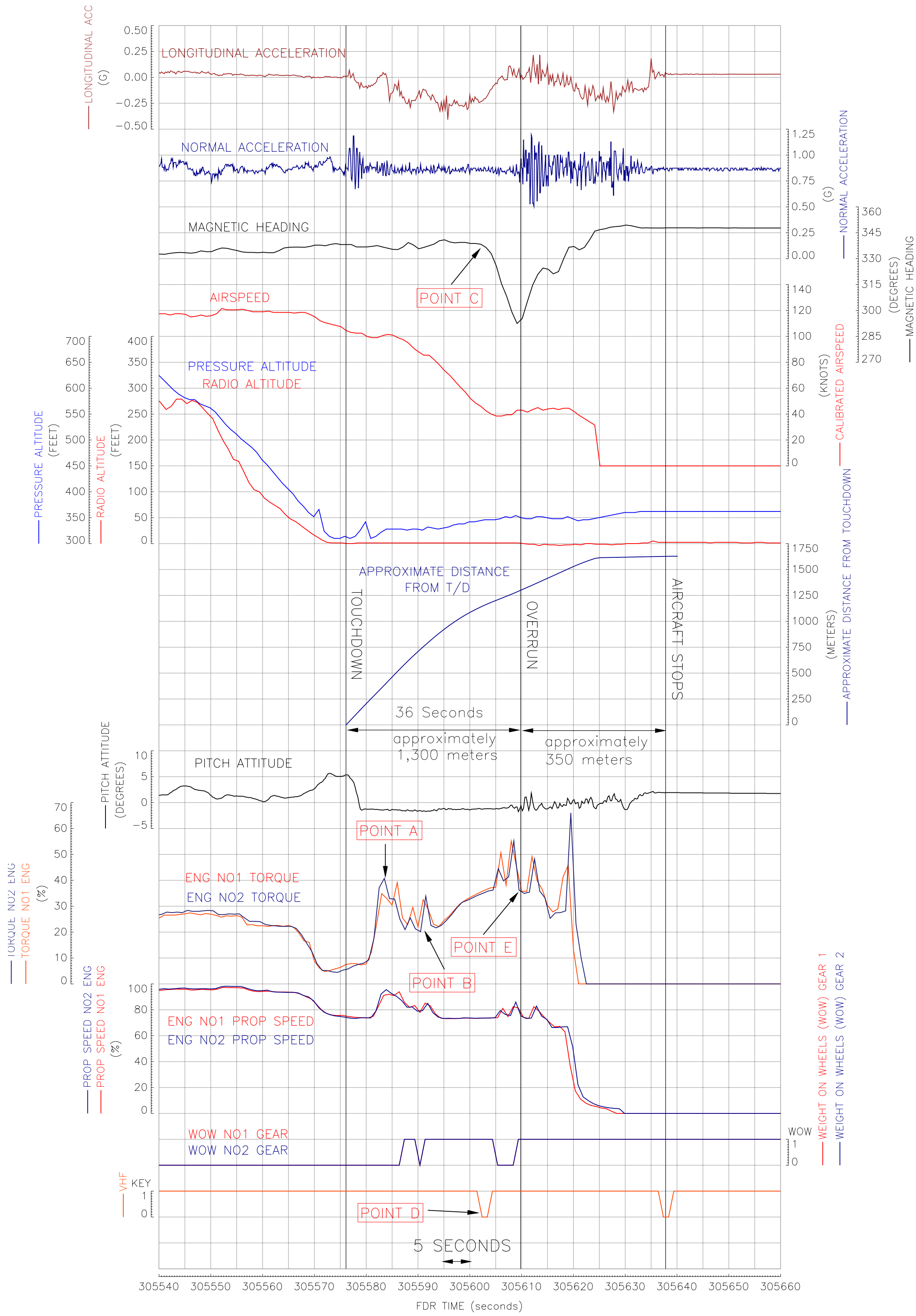


Figure 1

Salient FDR Parameters

approximately 190 metres from the end of the runway it started to deviate from the runway centre line (Figure 1, point C), turning to the left, almost coincidentally the commander advised the tower "WE GOT A PROBLEM" (Figure 1, point D) ; ground speed was about 40 kt and engine torque was at 37%.

When the aircraft was approximately 150 metres from the end of the runway the engine torque increased and decreased rapidly again (Figure 1, point E), the aircraft became momentarily light on both main gears and started to accelerate slightly. As the aircraft overran the end of the runway ground speed was about 43 kt, and it turned left reaching a heading of 299º. The aircraft then started to turn to the right again and the engine torque increased and decreased twice, in rapid succession, before the commander gave the instruction to shut down the engines; the aircraft was approximately 300 metres beyond the end of the runway at the time. As the engines ran down the aircraft started to decelerate, eventually coming to a stop approximately 350 metres beyond the end of the runway on a heading of 348º. During the landing the ground spoilers had remained stowed.

After coming to a stop, the commander gave a brief to the passengers, during which he explained "WE HAD A STUCK THROTTLE". ATC advised the crew that the RFFS were on the way and the crew proceeded with the shutdown checklist. As the crew shut the aircraft down, the co-pilot said "IT WOULDN'T MOVE". RFFS personnel then arrived and boarded the aircraft, during which the commander was heard to say "THE PROPS WOULDN'T MOVE BACK...I USED MAXIMUM BRAKING BUT IT JUST WOULDN'T HOLD IT SO I SHUTDOWN THE ENGINES AS WE LEFT THE RUNWAY". Battery power was removed at 1957 hrs at which time the recorders ceased to function.

The power levers and the flight idle baulk

The aircraft's power levers are fitted with mechanical baulks to prevent inappropriate selections. One baulk prevents selection of settings below flight idle unless certain conditions are met. To select settings below flight idle (after landing or in the event of a rejected takeoff), the pilot must first ensure that the power levers are at the flight idle position, and then pull two latches (one on each power lever) upwards to disengage the locks, before retarding the power levers below flight idle into the beta range. Further rearward movement of the power levers causes selection of increasing amounts of reverse thrust. The latches are operated with the tips of the fingers, whilst the palm of the hand rests on (or grasps) the power lever itself (see Figure 2).

Landing technique

Both pilots stated that it was normal to select the power levers to flight idle just before touchdown, and that selection of the beta range once the aircraft had landed, caused adequate deceleration. They stated that it was unusual to use the aircraft brakes on landing until a fast taxi speed had been achieved.

The company was operating under another organisation's Air Operator's Certificate, and using the relevant operations manual. The operations manual section entitled *'Standard Operating Procedures'* included the following remarks in the section on *'Landing'*:

> *'It is vital that the power levers are moved to the flight idle position BEFORE attempting to lift the latches and continue to ground idle. There have been instances of premature lifting of these latches causing the power levers to become jammed. If the power levers are left in flight idle residual torque will exceed 30% and it will be difficult to stop the aircraft without damage. Should this*

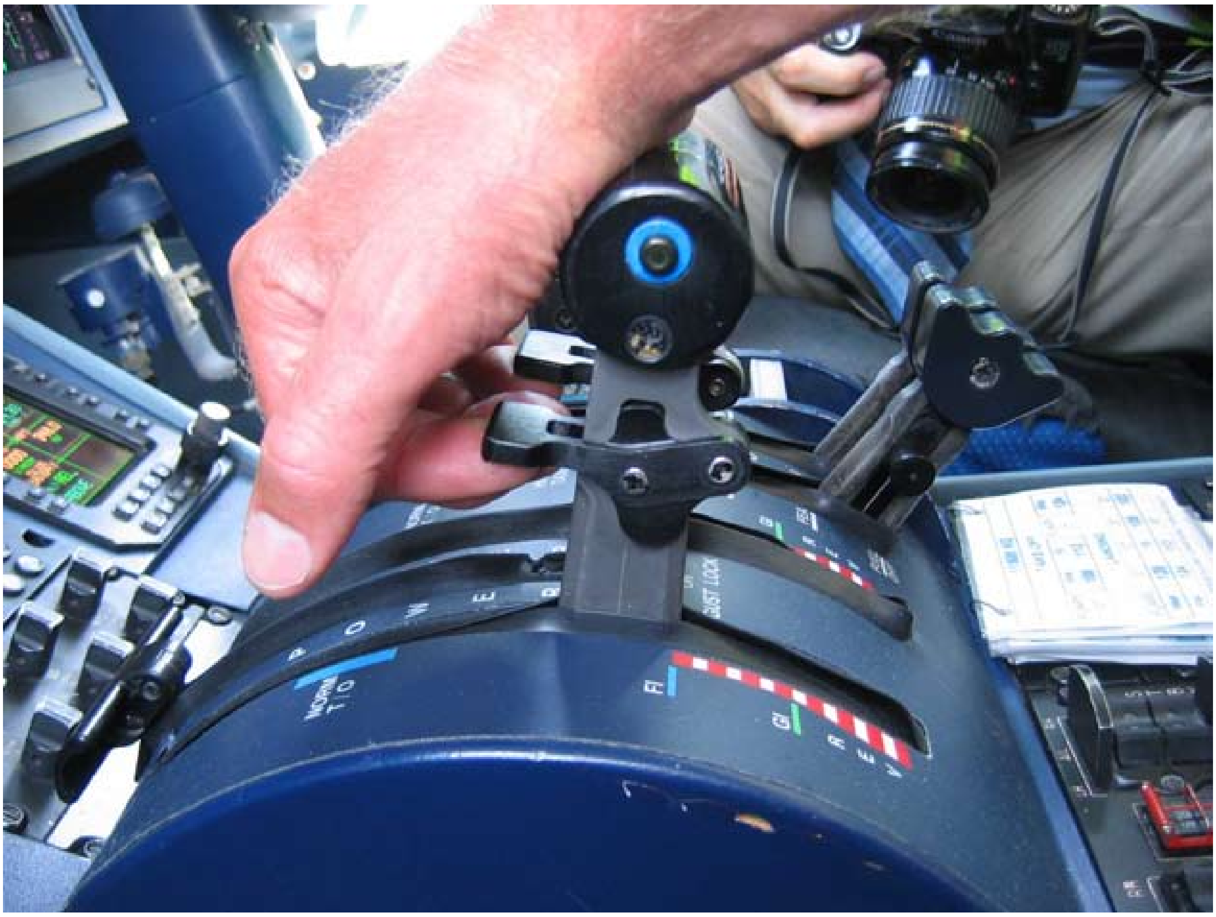


Figure 2

Power levers and latches

> *situation arise, the pilot flying should release the latches and push the power levers forward with the flat of his hand. He should then bring the power levers smartly backwards to the flight idle position before attempting to lift the latches and continue to ground idle'.*

Following a fatal accident in Genoa, Italy, in 1999 (see 'Previous incidents' below), two additional paragraphs were inserted into the airplane operating manual.

The first, headed *'Baulked Landing'* stated:

> *'whenever the captain deems it necessary to discontinue landing roll to avoid a catastrophic situation after touch down, given sufficient runway length is remaining, he may apply the following baulked landing procedure:*
>
> *POWER levers (both)………. Set GA TQ*
> *GA button…………………….....Press*
> *T/O config warning…..……….Disregard*
> *Accelerate airplane…..……….V_{REF}*
> *Airplane……………………….Rotate to GA-FD bar (8°)*
> *Once airborne*
> *GO-AROUND procedure…..Apply*
>
> ***This manoeuvre is an emergency evasive action, and may be practised in the simulator only.'***

One UK operator of a fleet of Dornier 328 aircraft stated that their flight crews were routinely trained in this procedure during simulator training. The operator of TF-CSB did not carry out similar training.

The second additional paragraph, headed *'Power Lever Gate'*, stated:

'Certification requirements demand means to prevent inadvertent operation of reverse thrust and propeller settings below the flight regime. These means must have a positive lock or stop at the flight idle position and must require a separate and distinct operation by the crew to displace the control from the flight regime.

The power lever gate of the Dornier 328 has been designed accordingly. For a selection of power settings below Flight Idle the Power Levers must be retarded to the Flight Idle position stop first (Hands off the latches) before the latch handles are lifted and lower Power Lever settings can be selected after landing.

Also be aware, that if the Power Levers are not completely retarded to the Flight Idle stop they may be positioned at Location "X" (see Figures 3 and 4). If this occurs the latches cannot be lifted at all and the Power Levers may jam if rearward pressure is on the latches. If the latches are lifted before Flight Idle, the Power Levers cannot be moved beyond the stop shown in the Power Lever Gate thus preventing the selection of Flight Idle and non-flight regimes.

<u>NOTE</u>: If this happens

1. *Remove any backpressure on the Power Levers and release the latches completely.*
2. *Hold the Power Lever only and smartly retard the Lever to Flight Idle.*
3. *Normal selection to Ground Idle is now possible.*
4. *If the Power Lever still cannot be moved below the Flight Idle position, the aircraft can be stopped by applying maximum braking while maintaining a wings level attitude.'*

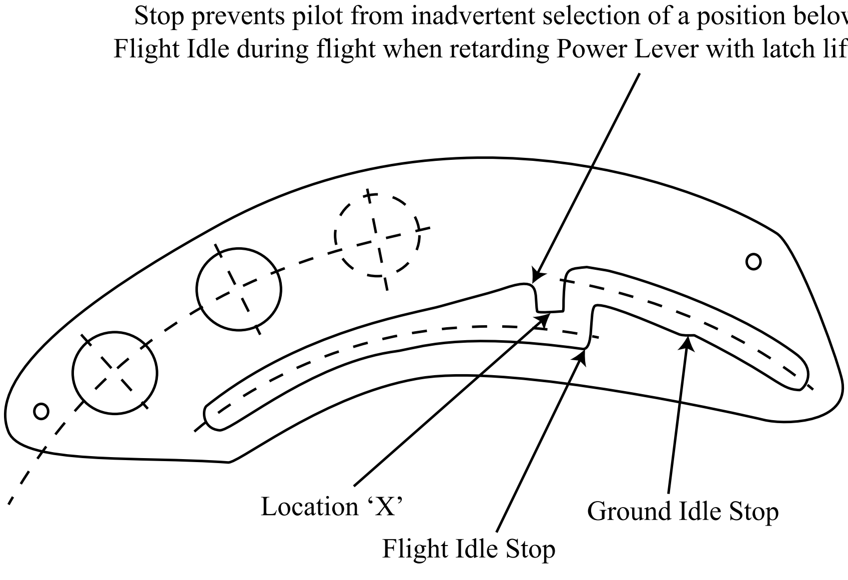


Figure 3

Power Lever Gate

Figure 4

Internal view of power lever, gate and latch

Asymmetric use of beta power

Experienced Dornier 328 pilots and training pilots commented that they believed selection of one engine in the beta range with the other in flight idle would give rise to difficulty controlling the aircraft in yaw. The Flight Manual makes no provision for such operations.

Previous incidents

In February 1999, a Dornier 328 overran the end of Runway 29 at Genoa Airport, Italy, and came to rest partially submerged in the sea beyond the runway end. There were four fatalities amongst the 31 passengers and crew on board, and two of the occupants sustained serious injuries. The Italian Ministry of Infrastructures and Transport carried out an investigation into the accident and concluded:

> *'the accident…, was caused by the pilot being unable to move the power levers from the flight idle position to the ground idle position and then to the reverse thrust position. The power levers remaining in the flight idle position meant that the propellers kept turning which prevented the aircraft from slowing sufficiently and frustrated the use of the brakes and emergency brake.'*

The report made several Safety Recommendations, including:

> *'To the Dornier-Fairchild company: if this has not already been done, define an emergency procedure allowing the crew to manage incidents where it is repeatedly impossible to move the power levers from the flight idle position during the period of travel after landing.'*

In July 2004, a Dornier 328 crew rejected a takeoff at Glasgow Airport when they found that the left engine power lever would not move forwards through the Flight Idle position. Subsequently, it would not move rearwards from the position. The CAA investigation stated:

> *'Upon restoring the levers into the normal range, the power lever sometimes cannot be moved past flight idle. Rectification of this situation is usually achieved by lubricating the cam.'*

The inspection and lubrication interval for the power lever cam followers was reduced from 4,000 to 2,000 flight hours. The report concluded that:

> *'the hazard is adequately controlled by the actions stated above.'*

Earlier, in January 2004, a Dornier 328 crew at London City Airport experienced difficulty moving the No 1 power lever, finding that it could not be moved from the Flight Idle position during an attempt to take off. The reporter noted that the latch on the No 1 power lever was sticking in the up position, but could be forced downwards, allowing forward power lever movement. The operator reported that, following cleaning and lubrication, the lever operated correctly. The lever, latch, and cam should be cleaned, inspected, and lubricated every 4,000 hours, and the operator reported that this interval was satisfactory. The report concluded that:

> *'the hazard is adequately controlled by existing requirements, procedures and documentation.'*

In February 2005, a Dornier 328 crew carried out a baulked landing at Southampton Airport, when the co-pilot (who was pilot flying) found that he could not select ground idle after touchdown. The baulked landing and subsequent visual circuit and landing were without incident. The CAA report stated that:

> *'the airline has introduced a safety instruction detailing how to carry out the correct procedure with the throttle… based on Dornier service information leaflet SI-328-00-067.'*

The report concluded that:

> *'the hazard is adequately controlled by existing requirements, procedures and documentation.'*

Other pilots' accounts

Experienced Dornier 328 pilots and training captains, including one with test flying experience, were interviewed in the course of the AAIB investigation. They were all aware of the potential for the power levers to jam, and a number of them had experienced this themselves. In each of these cases, however, further attempts to achieve the Ground Idle range had been successful.

AAIB evaluation of the power levers and latches

An AAIB Inspector, with previous experience on turboprop aircraft, evaluated the operation of the power levers and latches from both pilot seats. With the aircraft stationary and the engines shut down, the power levers were moved as though after landing. On one of ten attempts from the left seat, it was found impossible to disengage one of the latches.

Further evaluation of the manner of operation of the latches indicated that with rearwards pressure applied to the power lever, considerable upwards pressure was necessary to operate the latch. If the latch was forced upwards in this manner, the power lever was caused to move slightly forwards as the latch was operated. The effort required to force the latch up was considerable, and was not achievable with the palm of the hand resting lightly on the power levers and the tips of the fingers operating the latch.

Operator's documentation and crew training

Both pilots had undertaken ground school training with an established UK operator of the aircraft type. During this training, they had been informed that difficulties had been experienced by pilots attempting to select the power levers below the flight idle position after landing. They had been told that the appropriate technique in this situation was to advance the power levers again, then retard them to the flight idle stop, before making a further attempt to disengage the latches.

After this incident the operator provided additional training to all crews to familiarize them with the circumstances of the event and to re-brief them on the contents of Dornier 328 Service Information Leaflet SI-328-00-067. Items discussed were the event background, the Service Information Leaflet contents and the balked landing procedure. This was followed by a practical demonstration of power lever / reverse latch operation whilst the aircraft was on the stand. This has also now been emphasized in the simulator training syllabus.

AAIB Special Bulletin S7/2006

As a result of these concerns, in August 2006 the AAIB published a Special Bulletin, S7/2006, publicising the incident to TF-CSB. The bulletin contained the following Safety Recommendation:

Safety Recommendation 2006-104

It is recommended that Avcraft Aerospace GmBH i.I advise all operators of Dornier 328 turboprop aircraft to detail procedures, and provide adequate training, to ensure that their pilots are able to act appropriately if the beta control range on the power levers cannot be selected after landing.

The CAA responded to this Safety Recommendation as follows:

'This Recommendation is not addressed to the CAA. However, the recommendation has been acted upon by the CAA and Inspectors, assigned to the UK companies operating Do328 aircraft, have been made fully aware of the issue and will be discussing the incident with the companies as necessary.'

In December 2006 the Type Certificate holder published Temporary Revision 20-006 to the Airplane Operating Manual, which introduced an option of a baulked landing, to be carried out at the pilot's discretion, if a power setting below Flight Idle could not be achieved. This was supported by the re-issue of Flight Ops Information FOI-328-76-01 on 19 December 2006.

Protection of the overrun area

The aircraft came to rest 350 metres beyond the end of the runway. CAP 168 *'Licensing of Aerodromes'* defines a *'Runway Strip'* as follows:

'A runway strip is an area enclosing a runway and any associated stopway. Its purpose is to… reduce the risk of damage to an aeroplane running off the runway by providing a graded area which meets specified longitudinal and transverse slopes, and bearing strength requirements...'

CAP 168 also requires the provision of Runway End Safety Areas (RESAs), which are defined as:

> *'intended to minimise risks to aircraft and their occupants when an aeroplane overruns or undershoots a runway'.*

Runway 34 at Aberdeen is a Code 4D runway, according to the categorization in CAP 168. Thus the runway strip extends 60 metres beyond the runway end. The RESA is required to extend 90 metres, and recommended to extend 240 metres, beyond the runway end, although CAP 168 instructs aerodrome operators to provide RESAs of length appropriate to the runway and operations on it, based upon assessment of overrun risk and other factors.

The RESA at the end of Runway 34 is 240 metres long, and the aircraft came to rest 110 metres beyond its end in an area where no protection for overrunning aircraft is required or specifically recommended.

Engineering investigation

Description of significant components

The aircraft type is powered by two Pratt and Whitney (Canada) PW 119B engines driving Hartzell six-bladed, composite, reversible-pitch propellers. The aircraft in question was also equipped with automatic lift spoilers, although not all Dornier 328s are so fitted. Each engine/propeller combination, or powerplant, is controlled via a power lever and a condition lever, which are mounted conventionally on a console between the two flight crew seats. These levers are connected to the propeller and fuel control units in the nacelles by a system of cables running in conduits and passing over pulleys. The power levers are offset towards the left flight crew seat, the condition levers towards the right. During flight each power lever operates between the geometric flight idle position and maximum power position. Latch levers on the forward face of each power lever must be raised to enable selection of the beta (ground idle) propeller range. Once these latches are raised, the power levers are free to move further aft, commanding a progressively lower blade pitch angle. Further movement aft causes the levers to reach the ground idle position. Aft movement beyond the ground idle position increases power, providing reverse thrust. This movement into the reverse thrust range compresses a spring within the quadrant which provides tactile information to the pilot.

Undesired movement of each power lever from the flight idle position to the ground idle position is prevented by contact between a roller on the lever mechanism and a fixed stop in the console (see Figures 4 and 5). Each roller is mounted on a pin, which in turn is attached to a fitting on a vertical rod mounted within its power lever. Each roller moves aft within a curved track as its power lever is moved backwards, until the flight idle stop is encountered. Raising the latch lever against spring pressure lifts the rod, which raises the roller clear of the flight idle stop. This allows the roller and hence the power lever to move further aft towards the reverse position, the roller travelling in a curved track having greater radius than that of the track within the flight range forward of the flight idle stop position.

The two sections of curved track and the flight idle stop at each power lever location each take the form of a continuous shaped cut-out in one of a pair of titanium alloy plates orientated in a vertical and longitudinal plane. Each roller is manufactured from a bronze alloy and moves within its cut-out forming the curved tracks and the relevant flight idle stop.

The latch levers are positioned forward of and below

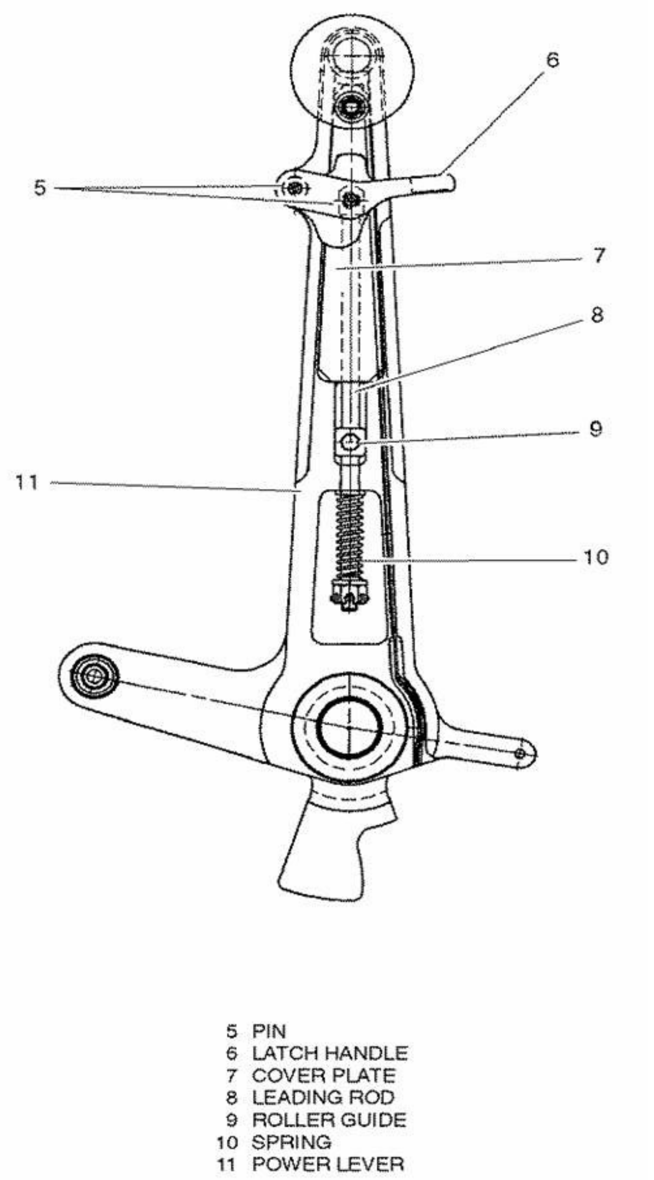


Figure 5

Power lever assembly

the roll handles of the power levers such that they can be grasped by the fingers whilst the palm of the hand rests comfortably on the lever.

Initial examination

No obvious damage to the aircraft was evident. Tyre skid markings consistent with heavy braking on all four main-wheels were evident, beginning towards the over-run end of the paved surface. These began close to the centre-line and deviated to the right before deviating progressively to the left. They indicated that the aircraft left the paved surface close to the junction of Runway 34 with Taxiway W by the Runway 19 threshold, travelling at an angle to the left of the centreline. Wheel marks on the grass show that the aircraft then turned back until it was travelling parallel with the runway, but significantly to the left of the extended centreline.

Detailed technical evaluation

Following the in situ examination by the AAIB Engineering Inspector, the aircraft was towed to a hangar for detailed examination. Particular attention was given to the operation of the engine power and reverse latch lever systems. No evidence of damage or malfunctioning of the engine and propeller controls was found. Slight damage to the aircraft wheels was detected during a hard landing check; this precluded taxiing before replacement wheels could be sourced and prevented functional testing of the wheel brake system. It was noted, however, that the brake system was free from hydraulic leaks and interrogation of recorded data in the aircraft maintenance computer showed that very high temperatures were reached by all four brake units during the landing roll, consistent with normal functioning of the brakes.

Engine ground runs were carried out, during which all propeller functions were operated a number of times. In all cases correct functioning occurred. Finally the condition of the reverse latch rollers within the console was checked in accordance with the requirements in the Aircraft Maintenance Manual (AMM). Neither defects nor evidence of significant wear was found.

This particular aircraft was equipped with spoilers which could only be deployed after a time delay of four seconds, when both power levers were at or below the flight idle position. Examination of the torque variations recorded on the FDR during the ground roll confirmed that the thrust levers were exercised a number of times. Thus they were not allowed to dwell at a flight idle for sufficiently long to allow the required time delay to elapse. Each forward lever movement cancelled the cycle and required the delay time interval to begin again after the levers were retarded.

From the above examination and the assessment of data, it was concluded that the wheel brakes operated correctly, the propellers did not enter the beta range, and the spoilers, although functioning correctly, did not deploy because the power levers did not remain in flight idle for sufficiently long each time they were retarded.

General comments on power lever and latch design

A fully serviceable mechanical engine/propeller control system on the type operates satisfactorily, from a purely mechanical point of view, provided all components are undamaged and no significant wear is present in any of the parts. There was little wear of the profiled plates in the console and the work-hardening characteristics of titanium alloy from which they are manufactured, coupled with the material properties of the soft bronze alloy of the latch rollers which operate in contact with the plates, ensure that the rollers cannot inflict significant wear damage on the plates. The inspection requirement to examine the soft roller material for damage or wear seems to provide a suitable yardstick for controlling and rectifying the overall wear of the plate/roller combination.

Nevertheless the above, difficulties in achieving selection of beta range after landing have been experienced, of which this event is an example. Such problems may occur if the precise angular positioning of the levers is not correct at the time when attempts are made to lift the latches. Incorrect positioning is thought to be facilitated by ergonomic features of the power lever/latch lever combination. These are accentuated by the fairly high degree of friction in the cable/conduit systems that connect the power levers to the propeller and fuel control units in the nacelles.

The power levers (Figure 5) have their middle portions machined away to form a slot which accommodates the latch operating mechanism. This modifies the lever structures from acting as beams in bending to resembling portal frames, significantly reducing their bending stiffness and introducing a slight spring effect in their operation. The friction in the operating systems, combined with the relatively low bending stiffness of the power levers, can significantly mask the tactile feel of the contact between the rollers and the flight idle stop detents as the levers are retarded.

Ergonomic issues

Considering the behaviour of one lever in isolation, correct positioning at the flight idle angle allows the latch to be lifted using the designed finger force, ie solely overcoming that created by the latch return spring. Rapid, firm movement of the lever aft to the stop, however, may result in slight flexing of both the lever and parts of the console structure which can result in movement of the cable within the conduit occurring slightly beyond the position achieved if more gentle movement occurs. This over-travel may be locked into the cable by static friction effects within the conduit and the cable/pulley system.

If the latch is then lifted, the roller must travel over a slight projection created by the curved profile of the flight idle stop. The necessary forward movement of the lever to allow this is resisted by the friction in the cable causing the fitting to which the roller pin is attached to bear firmly on the forward face of the locating slot in the power lever. Friction created by this contact adds to the spring force resisting the lifting of the latch. Active backward hand force on the lever, if present, further increases the force required to lift the latch, by way of the same geometric effect; the magnitude of the force increase being approximately in proportion to the magnitude of this backward hand force.

Should, however, the lever be inadvertently positioned slightly forward of the correct flight idle angle, the latch will be baulked by the gate plate and will be impossible to lift. If the lever is significantly further forward of this baulk position, the latch may be easily lifted up to approximately ⅔ of normal travel into a 'false detent', resisted solely by normal spring force. This 'false detent' is created by a recess in the upper edge of the track significantly forward of the flight idle position. Backward movement of the power lever from the 'false detent' to the flight idle position cannot take place without releasing the relevant latch lever(s) allowing the roller(s) to descend under spring pressure. This situation has been addressed in the manufacturer's bulletin reference SI-328-76-048 issued on 5 November 1998. For this situation to arise, the power levers must be positioned some distance forward of the flight idle position, and it is not considered that this condition occurred in this incident. Recorded flight data indicates that the engines were at flight idle several times after touchdown.

With the lever positioned even further forward, applying upward pressure on the latch imposes an aft component of force on the power lever as a result of the latch roller bearing on a sloping contact face of the cut-out, thereby reducing the normal hand force (brought about by the friction in cables, pulleys and in the cable/conduit system) necessary to retard the lever. At the same time the latch moves up against a force slightly greater than the spring force provided the power lever is moved steadily aft. Under these conditions, the latch lever will eventually move up some ⅔ of full travel and be unable to move further whilst the roller will eventually reach the false detent, under lower than normal backward hand force on the power lever and again, roller and power lever will be unable to move further aft until the latch lever is released.

Only by correctly positioning the power levers at a precise angle, ie in light contact with the flight idle stops, will the fingers be able to operate the latches solely against the spring pressure in order to move smoothly into the beta range and thence into reverse.

The stiffness of power lever movement created by the friction of the cables may cause uneven and slightly different movement of the two power levers, leading to potential for slight throttle stagger during the retarding process. This may allow one latch roller to come into firm contact with the flight idle stop whilst the other lever may be correctly positioned only in light contact with the stop, ensuring minimum latch movement force. Thus a significant difference in lifting force between the two latches would be evident to the pilot. Alternatively, with both power levers slightly further forward and staggered, one may be sufficiently far forward for the track to completely baulk upward movement of the latch roller whilst the other latch lifts freely being only constrained by its return spring. Easy upward movement of one latch accompanied by stiff operation or complete baulking of the accompanying lever may result, for the pilot, in confusion about the freedom of movement of the reverse system in general.

These difficulties may seem at first sight to be unlikely to cause an operating problem when viewed in isolation. However, immediately following an approach and touchdown, with the runway end rapidly approaching, the precision of the actions required to place both propellers in reverse at the same time makes this a more demanding task. The required sequence involves delicate, accurate movement of levers whose operation is fairly stiff, (accentuated for a pilot in the right-hand seat by the offset of the power levers positioning them further from his body) followed, often rapidly, by lifting of the latches. Anticipation of the need for the latter might result in premature latch lifting attempts or attempts made when the power levers are not precisely positioned. This possibility is assisted by ergonomic design features of the latch levers, since they fall easily beneath the fingers of a hand which is placed on the power levers and orientated in the optimum position to retard them. It could become an easy and natural process to squeeze the latch levers as the power is retarded. Failure to ensure that both levers are positioned gently against the aft flight idle stop before latch lifting is attempted can lead to stiff operation, asymmetry of latch stiffness or baulking of one or both latches.

These effects can create the perception that jamming is occurring, even when it is not, or actual jamming of one or both latches can occur as a result of a variety of these scenarios.

Alternative Design Approaches

A reverse lever and interlock arrangement is commonly found on turbo-fan powered aircraft. To enable reverse operation the pilot must retard the thrust levers fully before transferring his hand to the dedicated reverse levers. These are positioned as part of the thrust levers but cannot be reached without difficulty until the thrust levers are fully retarded. Once the thrust levers are fully aft, the reverse levers can be grasped and moved, usually to a detent position where an interlock prevents their further movement until the reversing hardware is correctly positioned for reverse operation and the interlock is released. Thrust can thus only be increased once the thrust reversing mechanisms are in place. Deliberate difficulty in attempting a continuous movement through idle thrust to reverse is created by the designed-in need to change hand position during the process.

Although the process of reverse selection in this arrangement is rendered more complicated, the chances of accidental or premature reverse selection are much lower.

Such an arrangement is uncommon on turbo-prop types. Nonetheless, a design change to achieve re-orientation, or different sizing of the latch levers to make it necessary to reposition the hand, would reduce the possibility of jamming through incorrect lever sequencing. Careful design of the position and orientation of the latch levers should enable reverse operation to be appropriately controlled once the power lever has passed into the latch release position.

Examination of other turbo-prop aircraft types

The power lever controls and reversing arrangements of two other aircraft types were examined as part of this investigation.

Both aircraft types were types powered by a pair of three spool Pratt and Whitney Canada turbo-prop engines of the PW 119/125 family, having generally similar requirements of their control systems to those of the Dornier 328 aircraft. The first type was initially certificated in North America whilst the second was initially certificated in Europe.

The first type examined had FADEC[5] and electrically controlled engine and propeller functioning, obviating the need for lengthy mechanical interconnections between power levers and the engine nacelles. Significant friction was thus not present within the operating system other than that created by the manually adjusted friction control on the console. The power levers were notably stiffer in bending than those on the Dornier 328. Operation of the levers in a retarding sense thus occurred with good tactile feel. This enabled the flight idle stops to be detected easily when the power levers were symmetrically moved aft to that position. In a similar manner to the Dornier 328, finger operated latches on each power lever could only be lifted when the power levers were correctly placed at the fully aft position of the forward range (ie flight idle).

In contrast with the arrangement on the Dornier, however, the positioning of the hand on the levers to control engine power and to retard the levers during landing, differed significantly from that required to lift the latches. The latches are positioned directly below the cylindrically shaped power lever roll grips and cannot be properly manipulated by the pilot unless the hand is repositioned. The arrangement thus ensures that any tendency to baulking created by applying simultaneous force to both the levers and the latches is minimised. There is little scope for doubt when the levers are at the flight idle position, ready for the latches to be lifted and the levers to be moved further aft into reverse.

The other aircraft examined had power lever functions connected mechanically to the fuel and propeller control units in the nacelles. Lever friction was thus high and of similar magnitude to that encountered in the Dornier 328 system. No controllable friction device was therefore necessary or fitted.

In the case of the second aircraft type, however, the in-flight power of each engine was controlled by a dedicated lever, the rearmost position of which coincided with flight idle. Low pitch operation and reversing of each propeller was achieved by use of a separate lever mounted on each power lever, in a manner somewhat similar to that found on turbofan aircraft described previously. These reversing levers were mechanically baulked at all power lever angles forward of flight idle. Operation of each reversing lever required the corresponding power lever to be moved to the aft stop, released and the hand moved physically forward to grasp the roll handles of the reverse levers. During examination on the ground one negative aspect was noted. If the reverse levers were pulled rearwards when the power lever was forward of the flight idle geometric position, although the reverse lever could not initially move, a component of the hand force created by pulling it against the baulking action reacted upon the power lever, driving it rearwards. This enabled it to reach the flight idle position at which point sustained force on the reversing lever caused it to move into the reversing range.

Both the above arrangements provide a distinct division between power lever movement and, either movement of the lever into the reverse range, or operation in that range. In doing so they provide the necessary positive safeguards against inadvertent reverse operation in flight. At the same time they also largely prevent simultaneous attempts at movement of both levers together during landing, which can lead to baulking.

The Dornier 328 differs from either of these two arrangements in having the latch levers positioned where they can readily be pulled upon during aft power lever movement.

Footnote

[5] Full Authority Digital Engine Control (FADEC).

Analysis

There have been a number of events in which pilots have experienced difficulties in selecting ground idle after landing, or other difficulties in moving Dornier 328 power levers. Actions taken as a consequence of these events have been to alter the maintenance procedure for the power levers (on the assumption that wear and/or lubrication is the cause) or to instruct pilots to alter their technique.

Pilots have also been trained to deal with such a problem after landing, with one UK operator carrying out simulator training of its crews to enable them to carry out a baulked landing (effectively, a go-around after the aircraft has touched down). This procedure acknowledges that, if the power levers are not retarded to ground idle soon after touchdown, it may not be possible to stop the aircraft. Factors giving rise to this difficulty include the relatively high thrust of the Dornier 328's powerplants, the rapid rate at which it is progressing along the runway soon after landing, and the relatively limited braking capacity required by turbopropeller aircraft in general[6]. The operator of TF-CSB had not carried out this training, but its operations manual did instruct pilots how to deal with a power lever jam.

The instructions in the operations manual, to advance and then retard the power levers in order to resolve a jam, appear, at first sight, to be reasonable. However, there is a tacit assumption that this procedure will be effective, the jam will be cleared, and there will be sufficient runway remaining on which to stop the aircraft. On a limiting runway, this may well not be the case, and if a crew find it necessary to carry out these actions (as did the crew of TF-CSB), repeatedly advancing the power levers will add energy to the aircraft on each attempt, making an overrun more likely.

The runway at Aberdeen is longer than many on which the aircraft type typically operates, yet the aircraft came to rest beyond the end of the RESA. It was fortunate that this additional area also met the requirements of a RESA, although it was not declared as such. Had the terrain or obstacles in this area been less benign, the outcome could have been very much more serious.

Following the accident in Genoa, two amendments were made to the airplane operating manual, one of which identified that it was possible to move the power levers aft, with the latches lifted, until the latch cams were in 'Location X' (Figure 3). Whilst there is no doubt that this position is achievable, it is also possible that the investigation into that accident did not identify the difficulties found in the course of this investigation, and that the difficulties experienced by pilots centre, not around placing the cams into 'Location X', but around the friction and cable forces. Thus, whilst technically accurate, the second amendment to the airplane flight manual may have been based upon a false assumption of cause. Therefore the following additional Safety Recommendation is made to the Type Certificate holder's National Airworthiness Authority, the Luftfahrt-Bundesamt (LBA), to minimise the likelihood of a further, similar, accident:

Safety Recommendation 2007-103

The Luftfahrt-Bundesamt should ensure that a training programme, fully alerting Dornier 328 crews to the potential for restricted movement and the optimum operation of the lever/latch combination, and detailing appropriate operational procedures, be developed and

Footnote

6 The Dornier 328 aircraft meets the relevant certification requirements.

mandated for all operators in Europe, and through liaison with all relevant National Aviation Authorities, make this information available to all operators of the Dornier 328 worldwide.

In the longer term, the design features which allow the fingers of an average hand to bear comfortably on the reversing latches, whilst the palm of the hand is positioned in the optimum orientation for power regulation and reduction, should be eliminated. Therefore the following Safety Recommendation is also made:

Safety Recommendation 2007-104

The European Aviation Safety Authority should require the Dornier 328 Type Certificate holder to re-design the power lever/beta/reverse latch system to improve the present arrangement.

INCIDENT

Aircraft Type and Registration:	Raytheon Hawker 800XP, CS-DRQ
No & Type of Engines:	2 TFE 731-5BR-1H turbofan engines
Year of Manufacture:	2006
Date & Time (UTC):	31 October 2006 at 0900 hrs
Location:	London City Airport
Type of Flight:	Commercial Air Transport (Non revenue)
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	37 years
Commander's Flying Experience:	12,000 hours (of which 200 were on type) Last 90 days - 123 hours Last 28 days - 18 hours
Information Source:	AAIB Field Investigation

Synopsis

This aircraft experienced significant navigation problems after taking off from London City Airport (LCY) and was unable to comply with the Standard Instrument Departure (SID). The crew were able to recover heading information after approximately 10 minutes and landed back at LCY without incident. It transpired that several similar incidents had previously occurred with other aircraft and there have been similar incidents subsequent to this one. The cause of the problem was identified as strong magnetic anomalies in the holding area for Runway 28. Six Safety Recommendations have been made.

History of the flight

The aircraft intended to depart London City Airport (LCY) on a non-scheduled flight to Brussels. Prior to departure, while stopped at holding point Mike (Hold M) (Figure 1) at LCY the pilots observed AHRS and HDG red flags on both Primary Flight Displays (PFDs), indicating that the Attitude and Heading Reference System (AHRS) had failed and that heading indications were unreliable. The pilots commented that this was a "known fault" at LCY which they thought was associated with "metal in the taxiway pilings". After lining up on Runway 28 the flags disappeared without further action. However, after departure, the pilots found that they were unable to control the aircraft in heading using the autopilot because neither of the heading selector bugs would move in response to rotation of the heading selector control. They observed a difference of 60º between the heading indicated on PFD 1 and PFD 2 and the combined standby instrument indicated a heading of 15º less than that shown on PFD 1. A red FD flag was displayed on both PFDs and both flight directors were unavailable.

In accordance with the Emergency Procedures section of the Quick Reference Handbook (QRH) the pilots selected AHRS 1 as the source for both sets of flight instruments but found that this system did not operate normally for a further 10 minutes. They decided to return to LCY and were given radar vectors in order to do so. The aircraft landed without further incident.

Previous occurrences

Following this report the AAIB was advised of previous occurrences dating from January 2000 that were the subject of Mandatory Occurrence Reports (MORs) received from operators and from ATCOs at the London Terminal Control Centre (LTCC). These involved several types operating from LCY, including Hawker 800, Cessna Citation and Fokker 50 aircraft, all of which experienced navigation problems after departure from Runway 28 at LCY. The first such occurrences, mostly to Fokker 50 aircraft, were attributed to poor compliance by pilots with assigned routings. An ATC Occurrence

Google Earth ™ mapping service/Bluesky

Figure 1

London City Airport

Report into an incident on 23 September 2003 noted that failure to follow the correct SID route was "an increasingly regular occurrence" involving aircraft departing Runway 28 at LCY.

On 16 November 2003 a Fokker 50 was reported to have deviated to the south of the intended track whilst attempting to follow the Clacton (CLN) 5T departure from Runway 28 at LCY. This brought it into potential conflict with arriving traffic. In his report to the operator the commander of the Fokker 50 reported that the aircraft's instrumentation showed that the desired 082º radial outbound from the London (LON) VOR had been intercepted correctly. He noted, however, that there was a short delay between the indication on the co-pilot's instruments that the radial had been intercepted and the same indication on his own instruments. There have been no further reports of related occurrences to Fokker 50 aircraft departing from LCY.

A series of reports beginning on 26 October 2004 were received of aircraft experiencing problems with their heading reference systems on departure from Runway 28 at LCY. A summary of these occurrences follows.

CS-DNK (Hawker 800), 26 October 2004

On departure from Runway 28 the pilots noticed a discrepancy between the commander's, co-pilot's and standby compasses. They believed that this was caused by the sole passenger having left his mobile telephone switched on. The pilots reported that they carried out "trouble shooting", informed ATC and shortly afterwards the headings returned to normal. The passenger informed the crew that he had switched off his mobile phone during the climb. The subsequent flight was operated without incident.

CS-DNX (Hawker 800), 10 March 2005

The pilots stated that on a busy departure during which they received radar vectors, there was a temporary loss of heading information. Finding that they were unable to comply with heading instructions the pilots declared a 'PAN'. Heading information was regained shortly afterwards without crew action and the 'PAN' was cancelled.

CS-DXE (Cessna C560 Citation XL), 28 February 2006

The pilots reported that while parked at Hold M all three compasses became "unserviceable". They informed ATC that they required "a couple of minutes" to clear a "technical issue" and when ATC asked if the pilots were experiencing a compass problem they replied "yes". ATC advised the pilots that several aircraft had experienced the same problem. When the aircraft lined up, the heading reference systems appeared to function normally.

In a safety report to the aircraft operator the pilots suggested that the "loop" taxiway including Hold M should not be used until the underlying problem was solved. In discussions with the aircraft operator, the airport operator commented that pilots could request to hold elsewhere in the loop containing Hold M in order to avoid the problem.

CS-DMA (Beech 400A), 6 November 2006

After what they considered a long hold at Hold M prior to takeoff from Runway 28, the pilots noticed a "compass comparator warning", whereby a yellow HDG caption presented on both PFDs indicated that the heading displayed to each pilot differed by more than 6º. Commenting that this was a "known problem" and anticipating that the condition would resolve itself, the pilots decided to take off. However, once airborne, the compasses continued to disagree by up to

30º for a further 28 minutes, during which the aircraft had difficulty following the assigned Brookmans Park (BPK) 3T (SID).

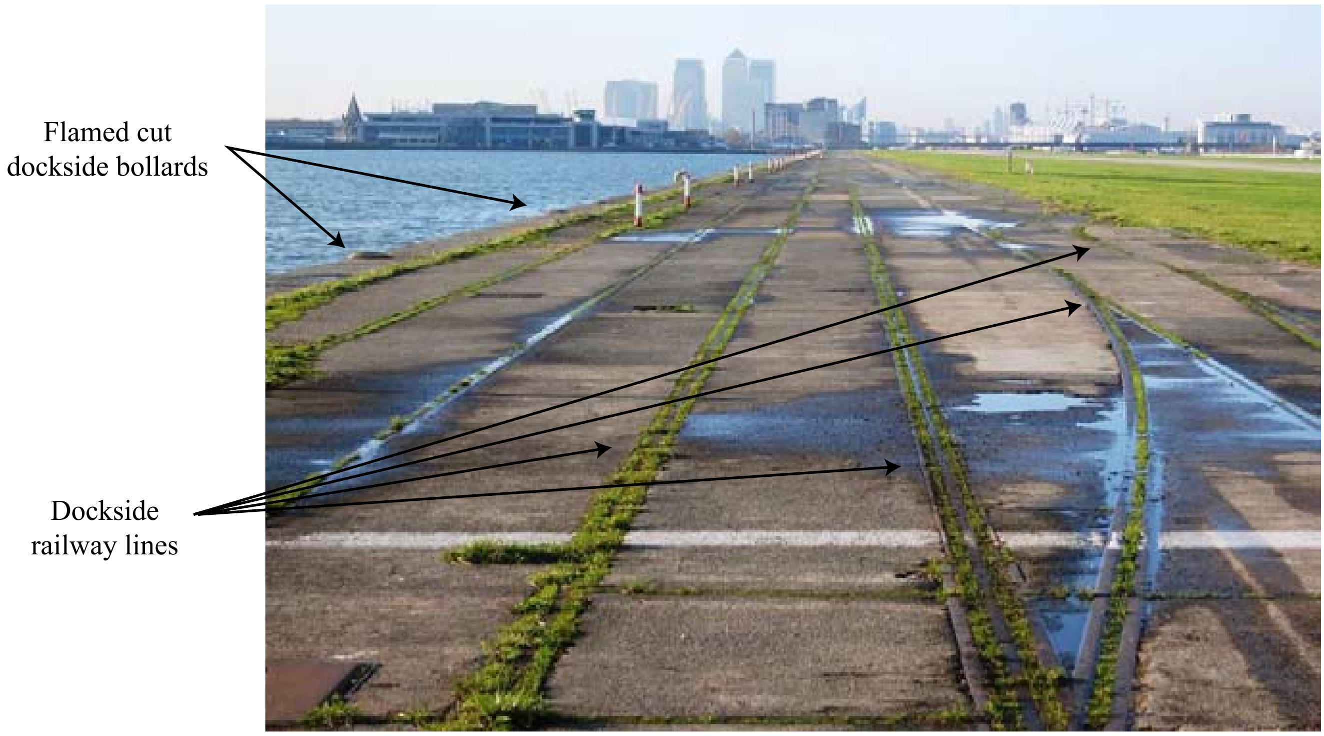
The pilots of CS-DMA reported that they consulted the abnormal and emergency checklist and attempted several times to realign the heading reference systems, without success. They advised ATC that they were experiencing navigation difficulties and were given radar headings to follow until the compasses realigned themselves.

Initial investigation by CAA

The United Kingdom Civil Aviation Authority (CAA) became aware of these events through MORs. Initially their investigation focussed on the possibility that performance of the LON VOR ground station was degraded or affected by transmissions from other sources. No such fault was found and the absence of other reports involving the LON VOR, separate from operations at LCY, indicated that the VOR was not the cause of the problem.

Airport history

The airport, opened in 1987, was built on the site of a disused ship's loading and unloading dock. Prior to being made into an airport the dock consisted of two rows of warehouses along the northern and southern sides of the dock that were accessed by a central road and railway that ran in an east-west direction down the middle of the dock (now the airport's runway). These railway lines were removed prior to the construction of the runway. Between each row of warehouses and the waters' edge ran two sets of railway lines on which ran the ship loading/unloading cranes and rail freight wagons. These railway lines were not removed when the airport was constructed and remain in place today (Figure 2).



Courtesy of QinetiQ

Figure 2

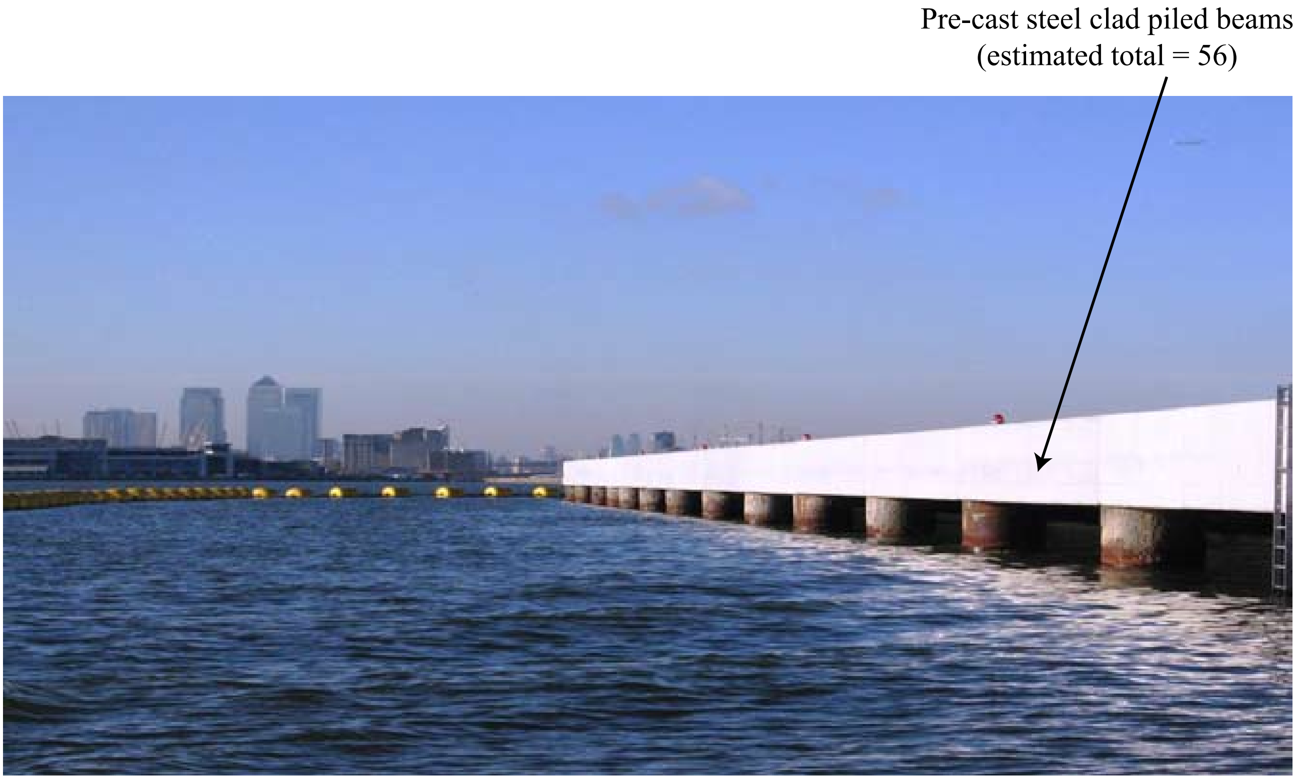
View looking west showing the railway lines and cut off dockside bollards

Along the dock walls were mounted large cast iron bollards that were used to tie up the ships. These bollards were similar to icebergs; what was visible above the dock wall was about a fifth of the size of what was below the wall. When the airport was constructed the sections of the bollards that were above the dock wall were removed using a flame cutting method (Figure 2).

In 2003 an aircraft holding area was completed on the southern side of the eastern end of the runway (Figure 1). This holding area projected out over the water and was mounted on approximately 56 steel encased concrete piles (Figure 3). The steel casings of the concrete piles are sections from a disused oil pipeline. Neither the railway lines that run along the edge of the old dock nor the lower parts of the cast iron bollards were removed prior to this holding area being constructed.

Engineering investigation

A walk around the Runway 28 holding area with a hand-held magnetic compass by an AAIB Inspector showed that there were some large and strong magnetic anomalies that made the compass needle deviate by up to ±60º. Engineers from the magnetic survey team based at QinetiQ, Portland Bill, Dorset were contracted to conduct magnetic signature and compass deviation surveys of the Runway 28 aircraft holding area. Figure 4 shows the results of the compass deviation survey observed at various points in the holding area. The numbers annotated at each point in Figure 4 indicate the number of degrees that a magnetic compass will deviate from magnetic north when placed in that position. These readings were taken 1.4 metres above the holding area surface. The areas where readings



Courtesy of QinetiQ

Figure 3

View looking west along southern edge of Runway 28 Hold Area could not be made, marked with a cross within a circle on Figure 4, were where the magnetic field density was so strong that the compass needle pointed either up or down, preventing it rotating to provide a reading.

The following was the conclusion of the QinetiQ surveys:

> *'It is QinetiQ's considered opinion based upon the results obtained during the magnetic and compass surveys that aircraft flux gate compass deviation problems experienced at London City Airport are caused by several ferrous magnetic signature anomalies (MA), primarily emitted as a vertical component from the 68 piled beam structures situated under Runway 28 Holding Area in excess of 60,000nT[1]. The second source of MA is emitted from remains of flame cut bollards spaced a regular intervals under Runway 28 Holding Area with a magnetic signature in excess of 30,000Nt. The third source comes from the reinforced concrete in Runway 28 Holding Area, which appears to interact with the signature from both prime and second source signature emitters. The fourth source, albeit not quite so large as the previous sources, is the railway lines below Runway 28 Holding Area.'*

Occurrences at other airports

Stockholm Arlanda, Sweden

Pilots of aircraft operating at Stockholm Arlanda Airport reported compass deviations while taxiing to Runway 01/19. The Geological Survey of Sweden measured the magnetic field at a height of 2 m above the taxiway and determined that the magnetic anomalies which it identified were sufficiently severe to explain the reported compass deviations.

Refurbishment of the taxiway revealed that the original steel nets used to reinforce it were notably harder to bend than the material commonly used for this purpose and exhibited permanent magnetism. The report stated that it was very difficult to impart permanent magnetism to the standard, more spring-like, steel nets commonly used in such construction. It concluded that the use of standard steel nets as reinforcement presented no risk of interference with aircraft compasses but that permanent magnetic steel nets constituted a significant source of interference.

There have been no further reports of such occurrences at Arlanda since refurbishment of the taxiway.

Houston, Texas

The entry for Houston International Airport (IAH) in the United States Aeronautical Information Publication states:

> *'Runway 15L/33R Magnetic anomalies may affect compass heading for take-off.'*

and

> *'Taxiways WA and WB Magnetic anomalies may affect compass heading.'*

When contacted by the AAIB a representative of the airport operator commented that he thought that IAH was the only airport with this problem, and provided a history of the phenomenon. In order to remove paint and rubber from Runway 15L the airport used

Footnote

[1] nT is 10^{-9} Tesla. A Tesla is the SI unit of magnetic flux density (or magnetic induction) and defines the intensity (density) of a magnetic field. The earth's magnetic field density at LCY is approximately 48,000nT. The figures quoted in this report are those of the magnetic field density above the earth's field density.

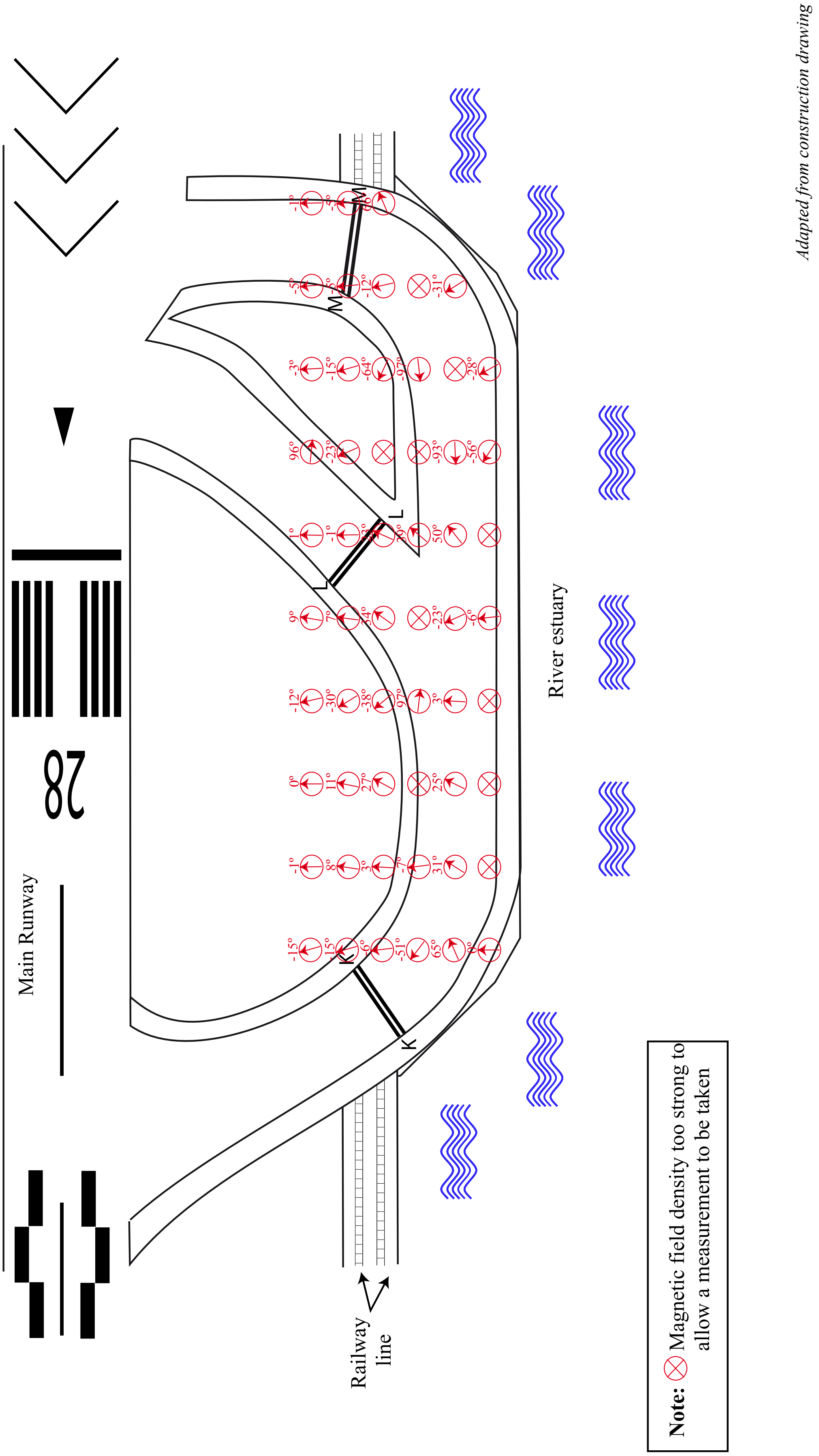


Figure 4

Results of the QinetiQ Compass Deviation Survey at the hold area for Runway 28 a process in which small steel balls were blasted against the runway surface. The balls and debris were recovered, but the impact of the steel balls with the runway surface had magnetized the steel reinforcement embedded in the concrete. Subsequently, aircraft with flux valve detectors mounted in the wing tips would experience a magnetic deviation of between 40º to 90º. Several aircraft aborted their takeoffs. Those that departed either returned to the airport or regained normal compass indications shortly afterwards. Types most affected were McDonald Douglas (Boeing) MD-80 series aircraft and some ATR-42 aircraft.

In order to mitigate the problem the airport operator attempted to degauss the runway. The process was partially successful and the magnetic anomaly was found to dissipate over time. The airport did not institute special ATC procedures to address the problem and found that pilot awareness of the potential problem reduced the incidence of related occurrences, of which there have been no further reports for "several years".

La Guardia

An article entitled "*Magnetic Mystery*" in "*Callback*", the monthly safety bulletin from the Office of the NASA Aviation Safety Reporting System referred to problems encountered at New York La Guardia Airport:

> *'Our clearance required a turn to a heading of 360 degrees after takeoff on Runway 31. Our gate is very close to the departure end of Runway 31. Start-up, checklists, and taxi involved less than 4 minutes and we were cleared for take off upon reaching the end of the departure runway. During the takeoff roll, I noted that my HSI read 350 degrees when it should be reading 310 (runway heading). The Captain's HSI and both our RMI's read the same erroneous heading.*
>
> *No flaps or instrument failure warnings were present. With some help from Departure Control we managed to get on our correct heading and subsequently re-synced the HSI's against the wet compass. All further operations were normal.*
>
> *We learned later that the gate we had parked at prior to our departure had produced gross compass swings in the past on some aircraft. Evidently some magnetic anomaly is present there, producing as much as 40 degrees of compass swing. A subsequent rapid departure does not give the compass system time to re-sync to the correct heading and if the crew doesn't catch it, a problem after departure can develop. Our company has since issued a NOTAM in our release papers that warns against compass swing possibility at that particular gate.'*

It was not possible to establish which aircraft type had been involved in this incident and the airport operator did not state what, if any, remedial action had been taken.

Other causes of local compass deviation

Aircraft and airport operators worldwide have reported that decommissioned arrestor systems (where anchor structures remain in or near the runway surface), hangars and other metallic structures have caused compass deviations at other airports. None has generated as great a number of such reports as London City Airport.

Subsequent occurrences at LCY

Following the series of incidents described above, the AAIB requested that the airport operator and the relevant sector of LTCC contact the AAIB immediately in the event of subsequent similar occurrences so that flight data and ATC recordings could be recovered. Several similar incidents were reported and the AAIB decided to observe a departure from LCY Runway 28 from the flight deck of a Hawker 800XP aircraft.

The observed flight departed Biggin Hill and conducted several takeoffs and landings at LCY in the course of training for a commander with no prior experience of LCY. The crew were aware of a magnetic anomaly affecting aircraft using the loop Holds K, L and M but were not otherwise briefed by the AAIB investigator.

After departure from Biggin Hill the aircraft made an uneventful approach to go around followed by an approach to land at LCY. After landing on Runway 28, the crew were instructed to exit at K and hold at M prior to departure. As the aircraft passed over Hold L a red HDG caption appeared momentarily on the right hand PFD. When the aircraft stopped at Hold M, a red HDG caption illuminated on the left PFD, accompanied by a red FD caption.

Heading indications were as follows (L – left PFD, S – standby compass, R – right hand PFD):

L	S	R	Estimated Hdg
360°	120°	057°	050°

(The heading of a PFD showing the red HDG caption defaults to 360°.)

After lining up on runway 28, the commander began to slew the heading indication on the left PFD to the runway heading of 275º. However, having been advised of landing traffic a short distance behind, he re-engaged the NORM (slaved) mode before the heading indication on the left PFD was aligned with the runway heading. At the start of the takeoff the heading indications were as follows:

L	S	R	Runway Hdg
268°	261°	277°	275°

A yellow HDG comparator caution was present on both PFDs, indicating a difference of greater than 6° between the heading on each PFD. During the initial climb, heading indications were as follows:

L	S	R	Actual Hdg
287°	271°	274°	Unknown

Shortly after takeoff the aircraft made a right turn as instructed by ATC onto a heading of 090° indicated on the left PFD. During the turn the yellow HDG caution was not present but it illuminated once again when the aircraft rolled wings level. Heading indications were as follows:

L	S	R	Actual Hdg
060°	051°	050°	Unknown

Approximately 5 minutes after takeoff and 10 minutes after the aircraft had vacated the area of Hold M, the heading indications on the left and right PFDs returned to within 6º of each other and the yellow HDG caution extinguished. During the subsequent approach with a crosswind from the south, the heading indications were as follows:

L	S	R	Runway Hdg
270°	257°	271°	275°

The landing was uneventful with no further cautions or warnings associated with the heading reference system. Two further circuits were flown. On the first of these the aircraft was again required to hold at Hold M. On this occasion a red HDG warning flag appeared on the right hand PFD. However without the pressure of landing traffic, the crew were able to realign the heading indications on both PFDs before departure. On the final departure the pilots requested a back track along the runway to the takeoff position to avoid holding at Hold M. There were no cautions or warnings associated with the heading reference system and the departure was uneventful.

Flight deck procedures

The Emergency Procedures section of the Quick Reference Handbook (QRH) for this aircraft contained the following information regarding the red FD and HDG failure flags on the PFD:

> ***'FD***
>
> *This annunciation indicates that the respective flight director has failed. If coupled to the failed flight director, the autopilot will also disengage. If only one PFD is affected, flight director and autopilot functions may be regained by transferring control to the operative side.'*

This section did not specify how this transfer should be made, although the relevant control might be familiar to pilots of this aircraft type.

> ***'HDG***
>
> *This annunciation indicates invalid heading data from the selected source. The compass rose/arc will rotate to north-up.*
>
> *Relevant AHRS reversion switch……….Select operative AHRS.'*

The Abnormal Procedures section of the QRH contained the following information regarding the yellow HDG annunciation on the PFD:

> ***'HDG***
>
> *This annunciation indicates a mismatch between the pilot's and co-pilot's displayed heading data.*
>
> *Establish airplane in straight and level, unaccelerated flight.*
>
> *Compare indictions with Electronic Standby Instrument System*
>
> *Determine if pilot's or co-pilot's heading display is in error.*
>
> *Relevant AHS Transfer switch……….REV.'*

Action by the aircraft operator

Following these incidents the operator involved in most of the occurrences to Hawker and Cessna Citation type aircraft issued to all its pilots internal memoranda specific to each type, restating or revising the techniques to be adopted to cope with magnetic anomalies at London City Airport.

The recommended procedure for the Hawker 800XP was as follows:

> *'When aligned on the runway and either the LHS or RHS indicated heading deviates from the magnetic runway heading by more than 6 degrees perform the following actions:*
>
> 1. *Select DG on applicable AHRS panel, slew the heading to runway heading and switch back to SLAVED mode. If this does not solve the problem, perform step 2.*
> 2. *Select AHRS reversion switch on the misaligned side to REV.*
>
> *When in level unaccelerated flight, select NORMAL mode on the applicable AHRS reversion switch.'*

In the case of Hawker 800XP aircraft fitted with Pro Line 21 avionics (such as CS-DRQ), the advice was as follows:

> *'Do either of the steps that follow to correct or prevent heading errors that are induced by ground operations:*
>
> > *Wait until the aircraft has either moved away from the distorted magnetic field or the distorting object has moved away and then fast slave the AHC to return it to the actual aircraft heading.*
> >
> > *Switch the AHC to the SLEW/DG mode and use the SLEW -/+ switch to slew the heading back to the actual aircraft heading. When the aircraft is clear of the distorted magnetic field, return the AHC to the NORM mode.'*

Each memorandum contained the statement:

> *'No take-off shall be initiated unless: both heading indicators show the correct heading and the Heading Miscompare Warning is not present.'*

Training to operate at London City

All aircraft operators wishing to use LCY require approval from the airport operator, which must be satisfied that pilots of aircraft using the airport have received adequate training to do so. In particular, pilots are assessed on their ability to conduct the steep approaches required by the confined location of the airfield. Currently there is no requirement for pilots to be assessed on their ability to recognise and deal with the effects of magnetic anomalies.

Aircraft operators provide special briefings for their pilots, known as Category C briefings, for airports with unusual or challenging characteristics such as steep approaches, significant terrain or unusual operating requirements. All operators using LCY issue a Category C briefing to their pilots but the AAIB is not aware of any which contain information regarding magnetic anomalies.

Detection of magnetic north by the aircraft system

All modern commercial aircraft have magnetic flux detector correction systems that detect the earth's magnetic field and, using electrical signals, correct the aircraft's compass gyros. Part of this system are magnetic flux valves (also known as gates) which are usually mounted one under each wing tip to ensure that they are as free as possible from any magnetic influences from the aircraft systems and structure. This system corrects the aircraft compass gyros at a slow rate of heading change, which is generally set at 3º per minute.

Attenuation of the affect on the earth's magnetic field by airport infrastructure

There are four possible methods of removing or attenuating the affect of airport infrastructure on the earth's magnetic field.

1. Each magnetic anomaly be individually demagnetised making it magnetically neutral. This is a short term solution as over a period of a few years, the magnetic anomaly will return.

2. Each individual magnetic anomaly have a permanent demagnetising system installed with an individual magnetic field sensor to monitor the change in the magnetic effect of the anomaly over time and the demagnetising system adjusted accordingly.

3. A sheet of magnetically opaque material eg Mu-metal, being placed over the area of the magnetic anomalies.

4. Removal of the items that cause the magnetic anomalies.

Aerodrome regulatory background

National and international standards for aerodromes are contained respectively in CAA publication CAP 168 – *Licensing of aerodromes* and ICAO Annex 14 – *Aerodrome design and operations'*. Neither contains guidance regarding interference with the Earth's magnetic field by airport infrastructure.

CAP 729 – *'Guidance on Aerodrome Development Procedures'* concerns the effect of plant, equipment and cranes on electronic equipment, approach aids and aerodrome surfaces and CAP 738 – *'Safeguarding of Aerodromes'* refers to development outside the control of the airport operator. Both refer to the development process rather than prevailing or resulting long term characteristics and neither considers the existence of magnetic anomalies in the construction of aerodromes.

Dangerous Cargo Regulations

The ICAO Technical Instructions for the safe Transport of Dangerous Goods by Air specifies that magnetised material, which can include large masses of ferro-magnetic metals such as automobiles, are classified as Miscellaneous Dangerous Substances and Articles since they may affect aircraft instruments, particularly the compasses. Magnetised material will only be accepted when the magnetic field strength at a distance of 4.6 m from any point on the surface of the assembled consignment does not exceed 0.418 A/m[2] or produce a magnetic compass deflection of 2 degrees or less. Magnetised material must not be loaded in such a position that it will have a significant effect on the direct-reading magnetic compasses or on the master compass detector units.

Footnote

[2] 1 Ampere turn per meter (A/m) equals $1 \times 4\pi \times 10^{-7}$ Tesla.

Analysis

Crew procedures exist to address the effects of magnetic anomalies on aircraft heading reference systems. However, the available evidence suggests that the heading reference systems of some aircraft suffer a temporary residual deviation which continues to affect aircraft operation. In most cases, if the correct procedure is completed, the residual deviation may be sufficient to generate a heading comparator caution but would not seriously affect the ability of the aircraft to follow an assigned route. In cases where deviations from the assigned route became problematic for pilots and ATC, it is likely that the condition was exacerbated by the manner in which the crew dealt with the anomaly. For example, in the case of the flights observed by the AAIB, the crew did not complete the procedure before takeoff, with the result that the heading reference system was not in a mode which could provide meaningful heading information. On that occasion the pilots knew that they had not completed the procedure but, advised of landing traffic a short distance from touchdown, decided to take off anyway. It is possible that the pilots of aircraft involved in the most serious deviations from the assigned route perceived similar pressure.

The effect of the magnetic anomalies on the earth's magnetic field in the areas of the K, L and M Holds at London City Airport is severe and in some areas, where measurements could be made, altered the earth's magnetic field by 97º. Most aircraft have magnetic flux valves fitted on the undersides of the wingtips. These flux valves sense the earth's magnetic field and, by electrical/electronic circuitry, realign the aircraft's compass systems. An electrical limiter is installed into the flux valve system that limits the rate of realignment of the aircraft's compasses to, generally, 3º a minute. This allows aircraft to transit areas of magnetic anomalies at airports without any significant realignment input into the compass systems. However, if an aircraft is stationary in an area of magnetic anomaly, then the amount of compass realignment is directly proportional to the length of time that the aircraft is stationary and the strength and orientation of the magnetic anomaly in that area. When the aircraft taxies to a magnetically neutral area the compass system will realign itself back to magnetic north, but at a rate of 3º a minute. At London City Airport an aircraft that is stationary at Hold M for 10 minutes could have both compasses realigned by up to 30º, the P1's 30º to the left and the P2's 30º to the right. Once the aircraft leaves the hold and enters the runway for departure it could take up to 10 minutes for the compasses to realign to magnetic north.

Although the events at London City Airport and similar occurrences worldwide were almost certainly initiated by local magnetic anomalies, currently there is no national or international requirement to assess or mitigate the effects of magnetic anomalies at aerodromes. Accordingly, the following two Safety Recommendations were made.

Safety Recommendation 2007-119

It is recommended that ICAO amend Annex 14 to highlight the importance of ensuring that no airport infrastructure is allowed to alter significantly the local earth's magnetic field density in areas where aircraft hold prior to departure.

Safety Recommendation 2007-120

It is recommended that the CAA amend CAP 168 to require airport operators to ensure that no airport infrastructure is allowed to alter significantly the local earth's magnetic field density in areas where aircraft hold prior to departure.

At present EASA does not oversee aerodrome standards in member states. However, EASA Notice of Proposed Amendment (NPA) 06/2006 – *'Basic principals and essential requirements for the safety and interoperability regulation of aerodromes'*, noted that the organisation "is set to become by 2010, the European authority with extended powers covering all aspects of civil aviation safety", including the safety of aerodrome operations. Therefore, the following Safety Recommendation was made.

Safety Recommendation 2007-121

It is recommended that EASA require airport operators to ensure that no airport infrastructure is allowed to alter significantly the local earth's magnetic field density in areas where aircraft hold prior to departure.

Safety action by airport operator

The airport operator issued the following NOTAM, valid from 19 January 2007 until 7 July 2007, intended to increase awareness of the magnetic anomaly in the area of the Runway 28 hold:

'When using Runway 28 hold some aircraft types may experience magnetic disturbances affecting the heading reference system. Pilots should ensure that when positioned for take off from Runway 28, the aircraft heading reference is checked against the runway alignment. Flight crew noticing a compass anomaly on departure should notify ATC.'

This NOTAM, designated C0248/07, was reissued on 27 June 2007.

NOTAMs may, where appropriate, be permanent. However, Chapter 9, section 4 of CAP 410 – '*Manual of Flight Information Services*' entitled *'NOTAM'* states:

> *'…operational information not covered by AIP Amendment or AIP Supplement will be issued as a NOTAM… …including changes of operational significance (permanent or temporary) which need to be introduced at short notice. Such changes will be superseded, as soon as possible, by AIP Amendment or AIP Supplement as necessary.'*

Accordingly, the following Safety Recommendation was made.

Safety Recommendation 2007-122

It is recommended that the Civil Aviation Authority (CAA) should ensure that NOTAM C0248/07, relating to magnetic anomalies at London City Airport, is superseded by an appropriate amendment to the AIP in the form of a 'Warning' within the 'Local Traffic Regulations' section of the entry for London City Airport.

Safety action by aircraft operator

There were no further reports of such occurrences for several months after the aircraft operator issued advice to its pilots regarding the magnetic anomalies in the loop hold at LCY. However, two recent events indicate that the problem persists and that adequate remedial action is not always taken by pilots of affected aircraft.

Therefore, in order to maintain awareness of this phenomenon and the correct remedial action, the following Safety Recommendation was made:

Safety Recommendation 2007-123

It is recommended that the CAA should require each operator approved to operate at London City to include in its Category C brief for that airport an entry highlighting the presence of the magnetic anomaly and procedures for mitigating its effects.

Although operator awareness and the correct application of remedial procedures will help to mitigate the affects of the magnetic anomaly, the continued incidence of related occurrences suggests that the problem will persist until the anomaly itself is removed. Accordingly, the following Safety Recommendation was made:

Safety Recommendation 2007-124

It is recommended that the CAA should require London City Airport Ltd to mitigate the effects of the magnetic anomaly in the loop hold so that it no longer affects the normal operation of aircraft.

ACCIDENT

Aircraft Type and Registration:	Aquila AT01, G-UILA
No & Type of Engines:	1 Rotax 912-S3 piston engine
Year of Manufacture:	2007
Date & Time (UTC):	23 September 2007 at 1140 hrs
Location:	Lasham Aerodrome, Hampshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to nose landing gear and propeller. Heavy landing and engine shock-loading checks to be carried out
Commander's Licence:	Private Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	213 hours (of which 50 were on type) Last 90 days - 43 hours Last 28 days - 13 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

During the final approach to land the pilot raised the nose of the aircraft to extend the approach and avoid undershooting the grass runway. The aircraft stalled, landed on its nose leg, which collapsed, and the propeller struck the ground. Neither of the occupants of the aircraft were injured and there was no fire.

History of the flight

The aircraft was landing on the grass central area to the west of Runway 23 bounded by Runway 09/27 and the two unused Runways 05/23 and 16/34. Before departing on the flight from Headcorn Aerodrome, the pilot had obtained an update on the weather conditions at Lasham Aerodrome from the resident tug pilot. The surface wind was forecast to be from 190º at up to 10 kt, with broken cloud at 2,500 ft and 20 km visibility.

The final approach was commenced at 500 ft and the pilot reported that the actual weather conditions were as forecast, although she commented that the windsock indicated little wind at the surface. During the latter part of the approach the pilot assessed that G-UILA would land short of the grass landing area and, with full flap selected, she raised the nose of the aircraft to extend the approach. The aircraft stalled at a height of about 15 ft, landed on the grass runway on its nose landing gear, which collapsed, and the propeller struck the ground: the pilot could not recall whether she added power.

Neither the pilot nor her passenger were injured and they exited the aircraft normally after it had been shut down. There was no fire and no assistance was required from the Airfield Fire and Rescue Service. The pilot noted that there seemed to be more wind than had been indicated during the approach and that it was gusty. In a candid account, she concluded that the accident was the result of insufficient speed on final approach.

At the time of this report, heavy landing and engine shock-loading checks were due to be carried out.

Lasham Aerodrome is operated by the Lasham Gliding Society. The society's Airfield Manual includes a section on *VISITING LASHAM BY AIR*. It states:

'Runway 05/23 is the Medium Runway and runs north-east/south-west. It stands out well from the air but the surface is rough and is not used for take-off or landing. Visiting light aircraft will land in the grass centre triangle formed by the crossing of the hard runways…. If landing on the south-westerly run or taking off to the north-east, turbulence can be expected due to the line of trees that you cross on landing /take-off.

Visiting glider pilots should note that there is a great risk from undershooting in both directions and should therefore aim to land well up the airfield in this wind direction. If this runway is in use, the wind is likely to be strong and so there will be a wind gradient and turbulence.'

ACCIDENT

Aircraft Type and Registration:	Cessna 152, G-BGIB
No & Type of Engines:	1 Lycoming O-235-L2C piston engine
Year of Manufacture:	1979
Date & Time (UTC):	19 September 2007 at 1547 hrs
Location:	Redhill Airfield, Surrey
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nosewheel fork detached from gear leg; damage to nose gear leg and surrounding structure; engine shock-loaded and propeller bent
Commander's Licence:	Student
Commander's Age:	48
Commander's Flying Experience:	111 hours (of which 111 were on type) Last 90 days - 36 hours Last 28 days - 21 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

A student pilot, with only seven hours of solo experience was attempting to land in gusty conditions. The aircraft bounced twice, and the nose gear fork and nosewheel became detached.

History of the flight

The student pilot had completed seven hours of solo training. He arrived at the airfield and, after discussing with his instructor, he waited until the 1450 hrs Automatic Terminal Information System broadcast before using that information to decide whether or not the conditions were too gusty to fly. The instructor's brief to the student included dealing with the gusty conditions, and how to deal with bouncing during landing.

The pilot decided he would fly, but if the conditions proved too difficult he would land after the first circuit. The pilot proceeded to complete six 'touch-and-goes' without incident. The seventh approach was normal; the aircraft was lined up for Runway 26R, two stages of flap were selected and the speed was 65 kt as the aircraft crossed the airfield boundary. During the flare the aircraft lost height and bounced twice on the runway, and the nose fork became detached before the pilot could apply power. The nose gear leg dug into the grass and the aircraft came to a stop on the runway ahead of the intersection with Runway 18/36. The pilot was unhurt, and he vacated the aircraft normally.

Weather

The actual weather at the time of the accident agreed with the forecast. Visibility was good, it was dry, and the wind was from 240º at 15 kt. However, the wind was variable in strength, and the direction was varying from 190º to 270º.

Discussion

The pilot was briefed about the gusty conditions, however it appears that the aircraft encountered a gust too severe for his level of experience.

INCIDENT

Aircraft Type and Registration:	Cessna F172M Skyhawk, G-BEMB
No & Type of Engines:	1 Lycoming O-320-E2D piston engine
Year of Manufacture:	1976
Date & Time (UTC):	30 October 2007 at 1000 hrs
Location:	South of Shoreham Airport
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Private Pilot's Licence
Commander's Age:	64 years
Commander's Flying Experience:	385 hours (of which 290 were on type) Last 90 days - 12 hours Last 28 days - 0 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The pilot diverted and undertook a precautionary landing after experiencing an aileron control restriction in flight. It is believed that the restriction was caused by the engagement of the autopilot.

History of the flight

The pilot and his passenger departed Goodwood for a flight to Lydd. Shortly after informing Shoreham Approach that he was south of Shoreham at 3,100 feet, the pilot began to experience a problem with the ailerons, which he described as freezing and trying to fight back. He had to use increasing amounts of right rudder and had to apply considerable pressure to the yoke to keep it from moving to the left. At this stage the pilot believed that a loose object was partially jamming the controls. He informed Shoreham Approach of his problem and the controller suggested a descent and right base join for Runway 02. The pilot did not want to fly over Shoreham town and therefore declared a 'MAYDAY' and told the controller that he had severe control problems and was unable to land on Runway 02. The controller therefore cleared him for an approach for Runway 20, which would entail a downwind landing. The aircraft made an uneventful landing and during the taxi to the parking area the pilot noted that when he relaxed his grip on the yoke it moved fully to the left. After the aircraft was shut down and the electrical power turned off, the ailerons operated normally.

Engineering investigation

Two days after the incident, an engineering organisation based at Shoreham was asked to inspect the aircraft and an engineer carried out a functional check of the controls, which operated satisfactorily. The aircraft was equipped with a basic autopilot that had wing levelling and heading facilities that were activated by two separate rocker switches. The engineer engaged the wing levelling function and reproduced the symptoms which the pilot experienced on the ground. Because the engineer was unable to verify the integrity of the autopilot, he pulled and gagged the autopilot circuit breaker. The aircraft has since flown satisfactorily with the system inhibited.

Comment

The pilot's and engineer's reports indicate that at some point during the flight the autopilot wing levelling function became engaged. The engineer informed the AAIB that unless there is a fault in the autopilot, it de-latches when power is turned off and is turned on by moving the rocker switches after the electrical power is turned on. The pilot said that he visually checked that the autopilot was switched off during his pre-flight check and that neither he nor his passenger touched the autopilot controls during the flight.

ACCIDENT

Aircraft Type and Registration:	(i) DH82a Tiger Moth, G-ANJA (ii) DR 400/140B Robin, G-GGJK (parked)
No & Type of Engines:	1 De Havilland Gipsy Major I piston engine
Year of Manufacture:	1939
Date & Time (UTC):	28 August 2007 at 1210 hrs
Location:	Headcorn Airfield, Kent
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	(i) G-ANJA - damage to lower left mainplane and gear (ii) G-GGJK - damage to left mainplane and flap
Commander's Licence:	Private Pilot's Licence
Commander's Age:	70 years
Commander's Flying Experience:	2,254 hours (of which 234 were on type) Last 90 days - 7 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Summary

The Tiger Moth was taxiing out and collided with a parked Robin DR400.

History of the flight

The handling pilot was being checked out on the type. He had 12,500 hours experience, including both military and commercial flying, and held a valid Airline Transport Pilot's Licence. He had previously satisfactorily completed a check on the PA-18, and had flown 169 hours in the last 90 days, of which 19 hours were in the last 28 days.

The commander reported that the handling pilot was taxiing slowly towards the runway and commenced a turn. At about this time the commander's attention was distracted by an intermittent headset microphone problem. Both the handling pilot and the commander considered that there was sufficient clearance to avoid a parked Robin, however the Tiger Moth struck the Robin, damaging both aircraft. Nobody was injured.

The commander considered that the distraction caused by the intermittent headset was a factor, but accepted that it should not have been allowed to affect his airmanship.

ACCIDENT

Aircraft Type and Registration:	Jodel D120A Paris-Nice, G-BMLB
No & Type of Engines:	1 Continental Motors Corp C90-14F piston engine
Year of Manufacture:	1965
Date & Time (UTC):	21 October 2007 at 1330 hrs
Location:	Lydd Airport, Kent
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to left landing gear, left wing and airbrake
Commander's Licence:	Private Pilot's Licence
Commander's Age:	59 years
Commander's Flying Experience:	174 hours (of which 29 were on type) Last 90 days - 0 hours Last 28 days - 0 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

During landing the aircraft ground looped, resulting in a partial landing gear collapse.

History of the flight

The pilot was using Runway 21 at Lydd for landing from a short local flight. The asphalt runway was dry with a surface wind of 190º/3 kt. On touchdown G-BMLB began to oscillate in yaw. The pilot was unable to regain control and the aircraft ground looped. During the ground loop the left landing gear collapsed resulting in damage to the wing and airbrake. The pilot, who was wearing a full harness, was uninjured and able to vacate the aircraft normally.

The pilot commented that he had not flown the aircraft for three months and that most of his recent flying had been on aircraft with nose gear. He considered that a refresher flight with an instructor prior to flying a tailwheel equipped aircraft would have been beneficial.

ACCIDENT

Aircraft Type and Registration:	Miles M65 Gemini 1A, G-AKHP
No & Type of Engines:	2 Blackburn Cirrus Minor II piston engines
Year of Manufacture:	1947
Date & Time (UTC):	30 July 2007 at 1703 hrs
Location:	Shoreham Airfield, Sussex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to rudder of adjacent aircraft
Commander's Licence:	Private Pilot's Licence
Commander's Age:	N/K
Commander's Flying Experience:	2,000 hours (of which 0 were on type) Last 90 days - Nil Last 28 days - Nil
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional AAIB inquiries

Synopsis

Whilst taxiing away from the fuel pumps, the wheel brakes became ineffective. In an attempt to stop the aircraft using the parking brake lever, the lever failed. Despite shutting down both engines, the aircraft rolled forward and collided with the tail of a parked Tiger Moth, causing damage to its rudder.

Circumstances of the accident

The aircraft had recently been acquired by the owner. His intention was to conduct a familiarisation flight from Shoreham to Little Staughton with a passenger, who had approximately 20 hours experience on type.

After starting the engines the aircraft was taxied to the fuel pumps. Brake operation was normal during the taxi and held the aircraft with the engines running whilst waiting for another aircraft to complete refuelling. It then pulled forward and the engines were shut down as the aircraft was parked by the fuel pumps.

After refuelling, the engines were restarted, the brakes were released and the aircraft started to roll forward. At this point the pilot attempted to turn the aircraft to the right but found that it would not respond either to differential braking inputs or to the parking brake lever on the instrument panel. In the attempt to stop the aircraft, the lever fractured at its base and bent backwards. The pilot stopped the engines by switching off both magnetos, but the aircraft continued to roll at a slow walking pace until it struck the tail of a Tiger Moth aircraft that was parked close to the taxiway. The Gemini was undamaged, but minor damage was caused to the Tiger Moth's rudder.

The Gemini aircraft is equipped with cable operated drum brakes; pulling the ratcheted parking brake lever applies the brakes to both main wheels, but via a mixing unit that also enables the brakes to be applied differentially using the rudder pedals. The owner of the aircraft initiated an investigation of the braking system after the incident but found no failed component other than the operating lever. However, he considered that this failed as a result of excessive force applied during his increasingly frantic efforts to halt the aircraft.

The brake system rigging procedure is somewhat complex and the nature of the design is such, in the opinion of the owner, that a small rigging error can result in a disproportionate loss of braking effectiveness. After re-rigging the system, the brakes operated satisfactorily.

ACCIDENT

Aircraft Type and Registration:	Piper L21B Super Cub, G-SCUB
No & Type of Engines:	1 Lycoming O-290-D2 piston engine
Year of Manufacture:	1954
Date & Time (UTC):	6 October 2007 at 1653 hrs
Location:	Anwick, near Sleaford, Lincolnshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Serious) Passengers - 1 (Serious)
Nature of Damage:	Aircraft extensively damaged, power cables damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	39 years
Commander's Flying Experience:	46 hours (45 were on type) Last 90 days - 8 hours Last 28 days - 0 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

Whilst making a precautionary overflight of the airstrip prior to landing, the aircraft was inadvertently allowed to descend. The right wheel snagged a set of power cables, which spun the aircraft round, before it struck the ground. Recent cultivation of the land resulted in a low visual contrast between the cables and the background, making them hard for the pilot to see.

History of the flight

After a 30 minute local flight, the pilot returned to the farm strip from which he had taken off. On departure, he noticed that there were birds in the fields adjacent to the strip and considered it prudent to make an inspection pass prior to landing. He positioned the aircraft to overfly the strip diagonally from east to west, with the intention of landing on grass Runway 07. Whilst looking out to check that the runway and approach path were clear, he inadvertently allowed the aircraft to develop an excessive sink rate, causing its right wheel to snag on 11 kVA power cables at the eastern end of the strip. The aircraft spun round and struck the ground, out of control, coming to rest a short distance from the cables. The pilot and passenger, who were wearing four-point harnesses, were seriously injured. Despite his injuries, the pilot was able to exit the aircraft unaided and call the emergency services, who arrived quickly at the scene.

The pilot assessment of the cause of the accident was that the rate of descent developed because he was concentrating on the instruments and his lookout, and the lack of contrast between the power cables and the background, made them hard to see.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28-181 Cherokee Archer III, G-LKTB
No & Type of Engines:	1 Lycoming O-360-A4M piston engine
Year of Manufacture:	2001
Date & Time (UTC):	19 July 2007 at 1115 hrs
Location:	Otherton Airfield, Staffordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nosewheel collapse
Commander's Licence:	Private Pilot's Licence
Commander's Age:	39 years
Commander's Flying Experience:	108 hours (of which 107 were on type) Last 90 days - 2 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and AAIB enquiries

Synopsis

Following a loss of electrical power and an apparent loss of engine power, the pilot made a precautionary landing at Otherton Airfield. The aircraft ran off the end of the runway and into a recently ploughed field where the nose landing gear collapsed.

History of the flight

The pilot reported that he planned to fly from Manchester International Airport to Halfpenny Green, via Congleton. The aircraft was equipped with a GPS receiver, two VHF radios and a transponder all fitted with digital displays. Approximately 5 nm south of Stoke-on-Trent, and 30 to 35 minutes into the flight, the radio and GPS displays started to flicker and eventually failed. The pilot was still able to communicate with Shawbury Radar, who were providing him with a Flight Information Service, and he advised them of his position and informed them that he was experiencing radio problems. He then lost contact with Shawbury Radio but his subsequent radio calls were "unexpectedly" answered by London Information. Shortly after he passed his details to London Information the radio failed completely. In order to verify his position the pilot started to orbit, set the carburettor heat to HOT and also descended to his last reported height of 2,800 feet. As the aircraft reached 2,800 feet he opened the engine throttle to maintain height and speed, but the engine did not immediately respond and sounded, and felt, as if it was running rough. The pilot believed that he had both an electrical and an engine fault and, as he was near Otherton Airfield, he decided to make a precautionary landing.

The aircraft arrived in the overhead at approximately 2,000 feet and the pilot selected Runway 25 as the longest and best option to land on. He said he was conscious that the grass runway might not be long enough to stop on, but he could see a suitable field at the end of the runway which he could run into. He made a normal powered approach and configured the aircraft for a short field landing. However, on base leg the engine again appeared to be slow to respond to the throttle being opened. The pilot said that the aircraft touched down at the threshold, but halfway along the runway he realised that he was landing downhill and would not be able to stop on the runway. He said that he considered going around, but with the M6 motorway approximately 1 nm directly ahead, and the poor engine acceleration, decided to continue with the landing. The aircraft travelled approximately 20 to 30 feet into the recently ploughed field at the end of the runway when the nose leg collapsed and the aircraft came to a halt.

Description of the electrical system

The aircraft was equipped with a 28 volt direct current electrical system. A 75 amp alternator and a 24 volt battery were connected to a busbar which provided power to all the electrical equipment with the exception of the starter motor. The battery and alternator were controlled by the Battery Master and Alternator switches, which were rocker type switches mounted on the overhead panel. Alternator and Low Voltage warning lights were contained in the annunciation panel, positioned in front of the pilot near the top of the instrument panel. The Alternator light illuminates when there is no electrical current from the alternator and the Low Voltage light illuminates when the alternator output is lost and the electrical system is drawing power from the battery alone. A digital ammeter, mounted on the instrument panel, also provides a visual indication of the current produced by the alternator.

Engineering investigation

Following the repair of the aircraft, the maintenance organisation carried out engine ground runs and tests of the electrical generation system with the same engine and electrical components that had been fitted to the aircraft during the accident flight. The engine, electrical and warning systems all performed satisfactorily.

Comment

The pilot gave a very honest account of the accident and, even though he could not recall the warning lights being illuminated, he felt that during the pre-start checks he might not have selected the alternator switch to ON. The consequence of such an action is that the aircraft electrical equipment would run directly from the battery, which would become discharged after approximately 30 minutes. Such a scenario is consistent with the loss of the GPS and radio after 30 to 35 minutes into the flight. The unexpected response from London Information may have been because the radio was pre-set to 124.75 MHz, the frequency for London Information. It is likely that with the battery voltage decreasing there was insufficient power to operate all the electrical equipment and the radio therefore stopped working. However as other electrical equipment shut down it is possible that the battery power was then sufficient to power up the radio again, which then defaulted to the pre-set frequency.

The pilot commented that after the accident he remembered that the engine was slow to respond when the throttle was moved quickly during stall recovery exercises. Carburettor heat set at HOT enriches the fuel/air mixture, causes a reduction in engine power and can adversely affect the acceleration of the engine as the pilot advances the throttle. This negative effect would be compounded if the pilot were to rapidly advance the throttle such that the accelerator pump in the carburettor provides even more fuel to an already over-rich mixture. The result would be an engine that would be slow to accelerate and might also run roughly.

ACCIDENT

Aircraft Type and Registration:	Pitts S-1C Special, G-BRVL
No & Type of Engines:	1 Lycoming IO-320-B1A piston engine
Year of Manufacture:	1981
Date & Time (UTC):	11 August 2007 at 1230 hrs
Location:	Fishburn, Co Durham
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Two wing tips damaged; spats broken
Commander's Licence:	Private Pilot's Licence
Commander's Age:	37 years
Commander's Flying Experience:	2,219 hours (of which 165 were on type) Last 90 days - 98 hours Last 28 days - 37 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft landed normally, then swung gently to the left and entered a wheat field where it came to a halt on its nose and a wing-tip.

Pilot report

The pilot reported that following an uneventful flight from Leeming, he carried out an overhead join followed by an 800 ft circuit. A side-slipped approach, with the right wing down was carried out at 100 mph. The aircraft was flared, the wings were levelled and a tail-wheel first landing carried out touching down just beyond the threshold. The aircraft soon settled on the main wheels although it became airborne again briefly as a consequence of a bump in the grass surface. The aircraft then drifted left and the pilot made a moderate correction with right rudder. The throttle remained closed from the touchdown, with the stick held fully back. The left lower wing then contacted long grass at the runway edge causing the aircraft to swing further to the left and enter a wheat field, despite full right rudder application.

On entering the crops, the pilot centred the rudder and ailerons and the aircraft ran straight whilst quickly decelerating. The right lower wing touched the ground and the aircraft came to rest on its spinner, the spats and the left upper wing-tip.

The pilot concluded that although he flew a right wing down side-slipped approach, normal for the Pitts, the unfamiliar narrow grass runway and the lack of visibility of the left side of the strip, coupled with a local surface camber to the left, influenced his ground run.

ACCIDENT

Aircraft Type and Registration:	Reims Cessna F152, G-BHCP
No & Type of Engines:	1 Lycoming O-235-L2C piston engine
Year of Manufacture:	1979
Date & Time (UTC):	28 January 2006 at 1430 hrs
Location:	Meden Vale, Nottinghamshire
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nose landing gear damaged and lower engine cowling distorted
Commander's Licence:	Commercial Pilot's Licence with Instrument and Instructor Ratings
Commander's Flying Experience:	1,500 hours (of which 700 were on type) Last 90 days - 100 hours Last 28 days - 25 hours
Information Source:	AAIB Field Investigation

Synopsis

After approximately 20 minutes of flight the engine rpm started to decrease, with the engine running unevenly and producing severe vibration prior to stopping. The pilot successfully landed the aircraft in a field, with no injury to the occupants. An engineering examination revealed that the No 4 cylinder had separated from the engine due to a fatigue crack that had originated from an external surface corrosion pit. A search of the Civil Aviation Authority's Mandatory Occurrence Reporting database revealed 23 similar events. The Bureau D'Enquetes et D'Analyses Pour La Securite De L'Aviation Civile (BEA) has reports of 34 similar events occurring in France. This AAIB report carries seven Safety Recommendations.

History of the flight

Approximately 20 minutes into the flight the instructor applied full power to initiate a climb. About 5 to 10 seconds after the application of power the rpm reduced and the engine began to run unevenly. The instructor applied carburettor heat and found that the engine rpm became erratic, accompanied by severe vibration. With the carburettor heat remaining applied he trimmed the aircraft for the best glide speed, transmitted a 'PAN' call on the departure airfield's frequency and started to look for a suitable field for an emergency landing when the propeller and vibration suddenly stopped. The instructor carried out the forced landing checks, which included briefing the student and transmitting a 'MAYDAY' call. The aircraft was successfully landed in a field about half a mile to the south-east of the village of Meden Vale, causing damage to the nose landing gear and distortion of the lower engine cowling. Both the instructor and student, who were not injured, evacuated the aircraft safely.

Engineering and metallurgical examination

Inspection by the maintenance organisation revealed that the No 4 cylinder had completely separated from the engine in the area between the cooling fins and the cylinder-to-crankcase mounting flange (Figure 1). The pieces of the cylinder were sent to AAIB for detailed metallurgical examination. The metallurgical examination showed that corrosion had occurred on the outer surface of the cylinder which, over a period of time, had reduced the wall thickness and produced corrosion pits. These corrosion pits acted as stress raisers which, combined with the reduced cylinder wall thickness, allowed fatigue initiation and propagation. A fatigue crack initiated and propagated around approximately 36% of the cylinder's circumference prior to the final overload failure.

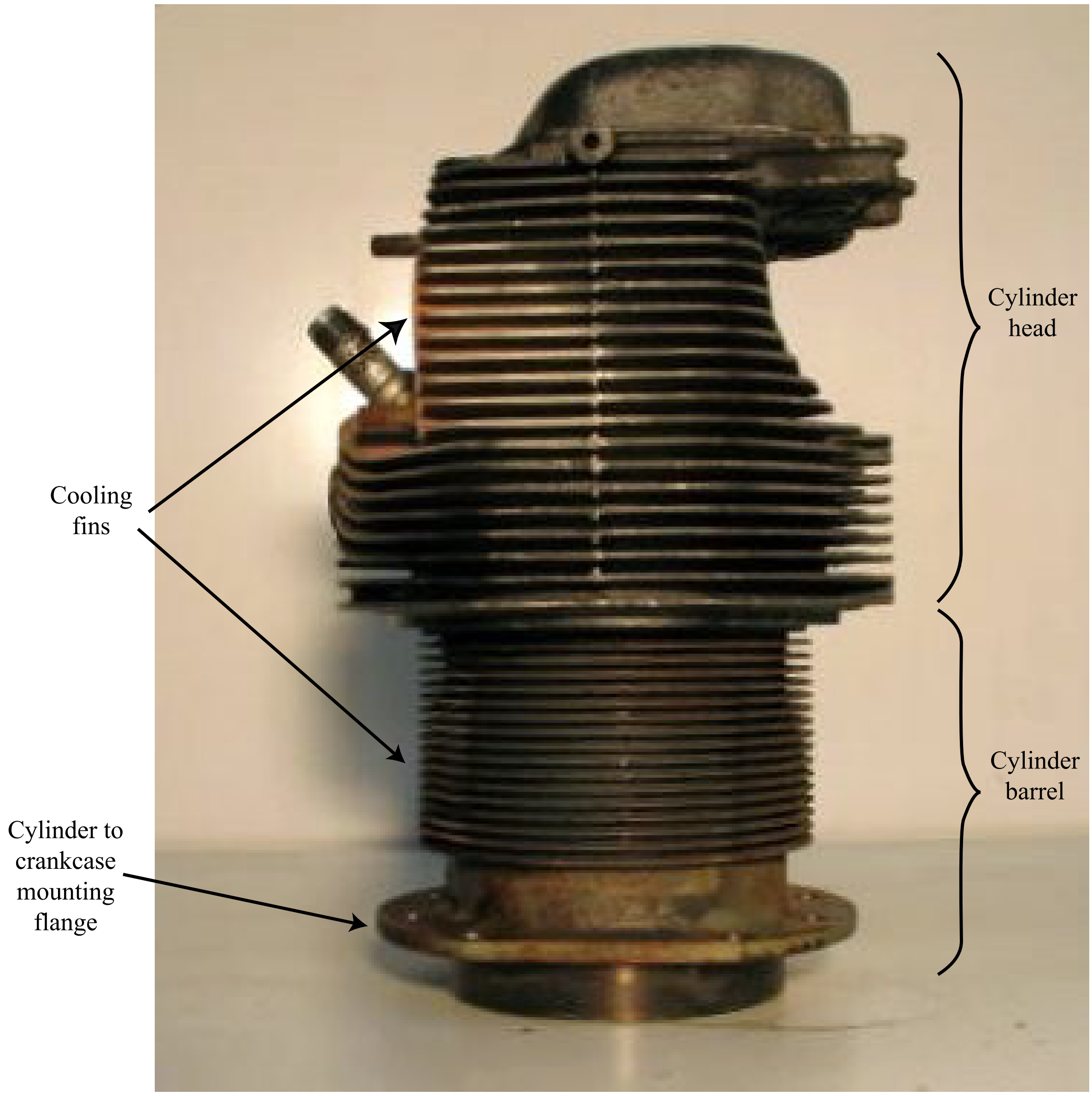


Figure 1

Lycoming 0-235 Series Engine Cylinder

Aircraft history

The aircraft had been on the UK register since it was manufactured and had been owned and operated by a number of individuals and flight training organisations. The previous owner/operator ceased operations in April 1998 and went into receivership. The aircraft was purchased at auction from the Official Receiver by the current owner at the beginning of 2005. It is understood that between April 1998 and January 2005 the aircraft was normally stored in the open but occasionally, for short periods, in a hangar. During this period the engine was occasionally ground run, although there is no written record of this. Only the current airframe and engine log books were with the aircraft when it was purchased by the individual who still owned it at the time of the accident. The previous owner/operator was no longer involved in aviation and his whereabouts, together with the missing log books, could not be established.

Engine history

The engine was manufactured in 1978 but it is not known if the failed No 4 cylinder was installed at that time as there were no records kept of the serial numbers of the cylinders fitted to the engine at manufacture. It is not known when the cylinder was manufactured as records were not kept of the cylinder serial numbers by the engine manufacturer.

In 1997 the engine was overhauled and given a new log book that started at 'zero hours'. It also contained an entry by the JAR 145-approved overhaul organisation which referred to one of their internal files, for the detail of the work that they had carried out. There was also a copy of the JAA Form One, the Authorised Release Certificate, which also referenced the overhaul organisation's internal file. The overhaul organisation had destroyed all their documentation relating to the overhaul in 1997, as allowed in JAR (EASA) 145.55 paragraph (c) (Appendix 1). None of the overhaul documentation had been supplied to the aircraft owner or operator by the approved overhaul organisation. It was noted that it is common practice for EASA/JAR Part-145 organisations to retain detailed worksheets and not to provide the originals or copies to aircraft owners or operators.

There was no indication in the new log book of the hours that the engine had run since it was manufactured in 1978 and no engine log books prior to the overhaul in 1997 were available. At the time of the accident the engine had completed 162 hours since the overhaul.

In August 2005, 80 hours since overhaul, the engine was found to have a low rpm at full power. As part of the remedial work carried out, all the cylinders were removed and honed, the valves removed, re-lapped and leak checked, and new piston rings fitted. In December 2005, 151 hours since overhaul, an oil leak was found around the base of the No 4 cylinder. The leak was traced to a split cylinder base seal, which was replaced.

Other cases of Lycoming O-235 series engine cylinder failures

The CAA Mandatory Occurrence Reporting (MOR) and AAIB Accident databases were searched for similar occurrences involving the failure of a cylinder from a Lycoming O-235 series engine. The CAA database revealed 24 occurrences (Table 1) (which includes the one that is the subject of this report), seven of which have been the subject of an investigation by an accident investigation organisation (six by the AAIB and one by the BFU, the German equivalent of the AAIB). The 17 occurrences that were not investigated by an accident investigation organisation either resulted in a safe landing or were found during maintenance. Seven of the cylinders

Date	Aircraft Type	Type of flight	Incident/ Accident	Cylinder No	Cylinder part no	Location and type of failure	Metallurgical examination	Comments
Jun-77	Robin 400	Private	Accident	No 4	N/K	Circumferencial crack between 3rd and 4th cooling fins	N/K	AAIB investigation Bulletin 8/77 - file destroyed
Mar-82	Cessna 152	N/A	On maintenance	No 1	LW 11633	Circumferencial crack approximately halfway down the cylinder barrel	No	MOR
Oct-84	Cessna 152	Training with instructor	Incident	No 4	N/K	Not known	No	MOR missing from CAA archives
Apr-85	Cessna 152	N/K	Incident	N/K	N/K	Cracked cylinder to crankcase flange	No	MOR missing from CAA archives
Oct-88	Cessna 152	N/K	Incident	N/K	N/K	Radial failure of the cylinder barrel adjacent to the bottom cooling fin	No	MOR unreadable on CAA microfich
Mar-89	Cessna 152	Training with instructor	Incident	No 4	LW 11633	Circumferential crack between 2nd and 3rd cooling fins	No	MOR
May-89	Cessna 152	Training with instructor	Incident	No 3	LW 11633	Circumferential crack near the top of the cylinder barrel	No	MOR
Apr-90	Slingsby T67	Training with instructor	Incident	No 4	N/K	Circumferential crack at the mid section of the cylinder barrel originating from a corrosion pit	Yes	MOR. AAIB metallurgical examination file destroyed
Jun-90	Cessna 152	Training with instructor	Accident	No 4	N/K	Circumferential crack at the mid section of the cylinder barrel originating from a corrosion pit	Yes	AAIB investigation Bulletin 12/91 - file destroyed
Sep-90	Jodel DR 220	Private	Incident	No 3	N/K	The cylinder head had separated in the area of the combustion point	No	MOR
Aug-91	Cessna 152	Private	Accident	No 1	N/K	Circumferential fatigue failure in the cylinder to crankcase flange area	No	German accident investigation
Jan-92	Cessna 152	Training with instructor	Incident	No 4	N/K	Circumferential crack in cylinder barrel in the area of the cylinder head barrel joint	No	MOR
Mar-92	Cessna 152	Private	Incident	No 1	LW 11633	N/K	No	MOR
May-92	Cessna 152	N/K	Incident	No 1	N/K	Crack in the area of the cooling fins of the cylinder barrel	No	No MOR submitted
Aug-92	Cessna 152	Training with instructor	Incident	No 4	N/K	Cylinder detached - nothing further known	No	MOR
Mar-95	Cessna 152	Training with instructor	Incident	No 3	N/K	Circumferential crack in the area of the lower cooling fins	No	MOR
Aug-95	Pipe PA-38	Training with instructor	Incident	No 1	N/K	Cylinder failure in the area of the head to barrel joint	No	MOR
Sep-95	Robin 2112	Private	Incident	No 4	LW 11633	Cylinder head failure in the area of the lower cooling fins	No	MOR

Table 1

UK incidents/accidents that have resulted from
a cylinder failure on a Lycoming 0-235 series engine

Sep-97	Robin 400	Training with instructor	Incident	No 4	N/K	Cylinder barrel cracked between the mounting flange and the cooling fins	No	MOR
Jul-01	Robin 200	Training solo	Accident	No 4	LW 16703	Circumferential fatigue crack originating from a corrosion pit in the area between the cylinder to crankcase flange and the cooling fins	Yes	AAIB investigation Bulletin 4/02
Oct-02	Cessna 152	Training	Incident	No 3	LW 11633	Circumferential fatigue crack originating from a corrosion pit in the area between the cylinder to crankcase flange and the cooling fins	No	MOR
Jan-03	Piper PA-38	Training with instructor	Incident	No 4	LW 11633	Circumferential fatigue crack originating from a corrosion pit in the area between the cylinder to crankcase flange and the cooling fins	No	MOR
Apr-05	Cessna 152	Training with instructor	Accident	No 4	LW 16703	Circumferential fatigue crack originating from a corrosion pit in the area between the cylinder to crankcase flange and the cooling fins	Yes	AAIB investigation Bulletin 7/05
Jan-06	Cessna 152	Training with instructor	Accident	No 4	LW 16703	Circumferential fatigue crack originating from a corrosion pit in the area between the cylinder to crankcase flange and the cooling fins	Yes	AAIB investigation

Table 1 (Cont)

UK incidents/accidents that have resulted from
a cylinder failure on a Lycoming 0-235 series engine

were part number LW 11633 and three were part number LW 16703; for the remaining 14, the part numbers are not known. The difference between the two cylinders is that part number LW 16703 has a shot-peened outer surface whereas part number LW 11633 has not. Unfortunately the reports on some of these 'non-investigated' occurrences omitted a number of relevant facts, which included the engine hours, the cylinder part number, the origin, type and exact location of the cylinder failure and the type of flight being undertaken.

On 19 April 2005 a Cessna 152, registration G BHFC, was involved in an accident due to an engine failure near Hardwick Airfield in Norfolk (AAIB Bulletin 7/05). The report concluded that the most likely cause of the Lycoming O-235-L2C engine stoppage was the failure of the No 4 cylinder due to fatigue cracking around the base of the cylinder, which initiated from corrosion pitting. This allowed the upper part of the cylinder to break free. As part of this investigation into the accident to G-BHCP, the failed cylinder parts from G-BHFC were subjected to a detailed metallurgical examination. This examination confirmed that the failure was by a fatigue crack mechanism that had originated from an area of corrosion that was located in the area between the barrel cooling fins and the cylinder to crankcase mounting flange (Figure 1). The fatigue crack had propagated around approximately 30% of the cylinder's circumference prior to the final overload failure.

Up to October 1998, 15 cases of cylinder failure on Lycoming O-235 series engines had been reported to the Direction Generale De L'Aviation Civile (DGAC) in France. This number of cylinder failures prompted the DGAC to issue Airworthiness Directive 1998-225(A) (see the next paragraph), with Revision 6 being issued on 27 December 2000. By November 2003 a total of 34 cases of cylinder failure had been reported (Table 2).

Service Instruction and Airworthiness Directive

During the late 1990s Lycoming, the engine manufacturer, became aware of a number of O-235 cylinder barrel failures in Europe. As a result, there was a change in the preparation and painting of cylinders and engines shipped overseas, and shot-peening was introduced for O-235 cylinders.

On 26 January 2001 Lycoming issued Service Instruction (SI) No 1504, applicable to O-235 series engines operating under the Direction Generale de l'Aviation Civile (DGAC) in France. The reason for the SI was given as follows:

> *'The French DGAC has reported a significant number (of failures) of O-235 cylinder barrels in France. These failures have initiated from corrosion pits at the base of the cylinder. For O-235 engines operated under its authority, the French DGAC has issued AD (Airworthiness directive) 1998-225(a) which requires periodic inspection of the cylinder barrels for cracks.*
>
> *Since it is not possible to determine the depth of pitting or the point at which corrosion will initiate a crack, Textron Lycoming recommends replacement of cylinders affected by AD 1998-225(a) with new cylinder assemblies which offer improved corrosion resistance. O-235 engines and cylinder kits shipped from the factory after the 1st September 2000 incorporate these new cylinder assemblies.'*

The 'improved corrosion resistance' is understood to comprise zinc chromate treatment and shot-peening, although the latter assists fatigue resistance only.

Reference to the DGAC AD 1998-225(A) suggests that the 'significant number' (20 in France up to May 2000) of cylinder failures included engines with a wide variety of calendar age and flying hours but all, generally, with failures in a similar area to that experienced by G-BHCP. The AD also inferred that the absence of significant corrosion was not a guarantee that cracks were not present and thus required that all new, or overhauled, engines should be subjected to a technique of applying white developer spray to the cylinder barrels, with the cooling baffles removed, and then running the engine in this condition. The purpose was to highlight any oil leakage through a cracked cylinder. Various further steps were detailed should such leakage be detected or suspected and the procedure was to be repeated every 50 flying hours. On overhauled engines, an additional visual inspection for oil leaks, with baffles installed, was required to be performed at 20-hour intervals.

With the formation of EASA in 2003 this DGAC AD was withdrawn and has not been re-issued by the EASA.

Requirements for maintenance record entry and retention - UK ANO & EASA Part 145

In the United Kingdom, the Air Navigation Order (ANO) 2005 Section 1, Part 3 paragraph 22, Part 7 paragraph 91 and Schedule 6 specify the requirements for maintenance records, maintenance entries and their retention.

Section 1 Part 3 paragraph 22 requires that any document which is incorporated by reference in a Log Book shall be deemed to be part of the Log Book and requires that every Log Book shall be preserved by the operator of an aircraft until a date two years after the aircraft or component has been destroyed, or has been permanently withdrawn from use.

Section 1 Part 7 paragraph 91 requires that an operator of an aircraft preserves any document or record, and that if they cease to be the operator of the aircraft shall continue to preserve the document or record as if they had not ceased to be the operator. In the event of the operator's death the duty to preserve the document or record shall fall upon their personal representative.

CAA Airworthiness Notice No.12 Appendix 61 ('Appendix 2' to this AAIB report), titled 'Retention of Records - Post Incident and Accident Investigation' summarises the requirement for the retention of records.

The treatment under EASA is slightly different. EASA Part-145 details the requirements for the approval of aircraft maintenance organisations. Part-145.A.55 (Appendix 1) states that approved maintenance organisations must record all details of work carried out in an acceptable form and that they must provide a copy of Certificates of Release to Service and a copy of any data used for work carried out. It also states that these organisations must retain a copy of all detailed maintenance records and any associated data for two years from the date the aircraft or component to which the work relates was released from the organisation. There is, however, no requirement to keep documents that are referenced in a Log Book to be deemed to be part of that Log Book and required to be preserved by the operator of an aircraft until a date two years after the aircraft or component has been destroyed, or has been permanently withdrawn from use.

Requirements for maintenance record entry and retention - EASA Part M Section M.A.305

From September 2008 all aircraft, except those specified in Annex II to Regulation (EC) No. 1592/200, not involved in commercial air transport will be required to comply with EASA Part M Section M.A.305 (Appendix 3).

Date	Aircraft Type	Type of flight	Incident/ Accident	Cylinder No	Cylinder part no	Location and type of failure	Metallurgical examination	Comments
08/11/1995	GROB 115	N/K	Incident	3	N/K	N/K	?	
01/09/1996	DR400	Private	Accident	1	LW 18289	N/K	?	Sent to Lycoming for investigation
10/02/1997	DR400	Ferry Positioning	Incident	N/K	LW 16704	Initiation in the blending radius of the flange on an outside corrosion pitting	Yes	29 bench marks over a 22mm length from 12mm of the origin
08/04/1997	DR300	Private	Incident	4	LW 16704	Initiation in the blending radius of the flange on an outside corrosion pitting	Yes	30 bench marks over a 20mm length from 16mm of the origin
21/06/1997	C 152	N/K	Incident	4	LW 16704	N/K	?	Sent to Lycoming for investigation
28/06/1997	DR400	Private	Incident	N/K	N/K	N/K	?	
06/07/1997	DR300	Training with Instructor	Incident	3	LW 16704	Initiation between the 11th and the 12th cooling fins	Yes	Corrosion in all the area (cylinder and fins)
09/02/1998	DR400	Training with Instructor	Accident	2	LW 16703	Initiation the flange in a very corroded area	Yes	Initiation from external corrosion pitting
28/04/1998	DR400	Private	Incident	3	LW 16703	N/K	?	Sent to Lycoming for investigation
Mar-98	DR400	N/A	Incident	2	LW 16703	Initiation the flange in a very corroded area	Yes	Maintenance
09/05/1998	DR400	N/A	Incident	4	LW 16704	N/K	?	Maintenance Initiation from external corrosion pitting
24/05/1998	DR300	Private	Incident	3	N/K	Two initiation points both located in the flange in very corroded areas	Yes	
20/06/1998	DR315	N/A	Incident	1	LW 16704	Initiation the flange in a very corroded area	Yes	Found on pre-flight
02/08/1998	GROB 115	N/K	Incident	2	N/K	N/K	?	
24/10/1998	C 152	Training with Instructor	Incident	3	LW 18289	Initiation in the blending radius of the flange on an outside corrosion pitting	Yes	Initiation from external corrosion pitting
02/03/199	DR315	N/A	Incident	3	LW 16704	Initiation from corrosion pits in mounting flange	?	Maintenance
16/04/1999	DR300	N/A	Incident	4	N/K	N/K	?	Maintenance
03/07/1999	DR400	Private	Incident	3	N/K	N/K	?	Sent to Lycoming for investigation
10/01/2000	DR400	N/A	Incident	4	LW 16703	Initiation in the flange in a very corroded area	Yes	Maintenance

Table 2

French occurrences that have resulted from a cylinder failure on a Lycoming 0-235 series engine

22/03/2000	DR400	Training with Instructor	Incident	2	LW 16703	Initiation in the flange in a very corroded area	Yes	
29/04/2000	DR400	Private	Accident	4	N/K	Initiation in the blending radius of the flange on an outside corrosion pitting	Yes	
12/05/2000	DR400	N/A	Incident	3	N/K	N/K	?	Maintenance
24/06/2000	DR400	N/K	Incident	3	N/K	N/K	?	Maintenance
30/06/2000	DR400	N/K	Incident	1	N/K	N/K	?	Maintenance
19/07/2000	DR400	Private	Incident	4	N/K	N/K	?	
27/07/2000	DR300	N/K	Incident	1	N/K	N/K	?	Maintenance
04/08/2000	DR400	N/K	Incident	4	N/K	N/K	?	
22/08/2000	DR300	N/K	Incident	2	N/K	N/K	?	
20/12/2000	DR300	N/K	Incident	4	N/K	N/K	?	
02/03/2001	DR400	Private	Incident	4	LW 16703	Initiation from corrosion pits in mounting flange area	?	
05/03/2001	DR400	N/K	Incident	2	N/K	N/K	?	
14/05/2001	DR400	N/K	Incident	4	N/K	N/K	?	
09/06/2003	N/K	N/A	Incident	N/K	N/K	N/K	?	Maintenance
17/11/2003	DR400	N/K	Incident	2	N/K	Initiation in the blending radius of the flange on an outside corrosion pitting	Yes	

Table 2 (Cont)

French occurrences that have resulted from a cylinder failure on a Lycoming 0-235 series engine

This section ('*Aircraft Continuing Airworthiness Record System'*) specifies those documents that are required to be retained, how long they have to be retained and who is responsible for retaining them. There is no statement in this section requiring that documents to which reference is made in a log book, or component record card, form part of that log book or record card and be retained until a date two years after the aircraft or component has been destroyed or permanently withdrawn from use.

Previous Safety Recommendations

In 2000, following an in-flight engine run-down on a BN2B Islander aircraft caused by a crankshaft failure, the AAIB made the following Safety Recommendation:

Safety Recommendation 2001-028

In order that maintenance records may be of enhanced use to post incident and accident investigations, it is recommended that the CAA promote amendment of JAR 145.55 to increase the minimum period for the retention of maintenance records from two to five years.

The CAA response to this safety recommendation was:-

'The CAA partially accepts this recommendation. Whilst it is accepted that JAR 145.55 requires that maintenance records be kept for a minimum of two years, the operator of an aircraft is bound by more stringent requirements of the Air Navigation Order 2000, Article 17 or JAR OPS 1.920. In this respect, the requirement is that operators keep log books/maintenance records until 24 or 12 months after the aeroplane has been permanently withdrawn from service. The CAA thus considers that current requirements adequately address the subject of maintenance record retention.

Further, to promulgate to industry its responsibility in respect of document retention, the CAA will issue an appendix to Airworthiness Notice 12. This appendix will be included in the October 2001 revision of Airworthiness Notice.' This was issued in October 2001.'

In 2001, following a fatal accident to a Hughes 269 helicopter the AAIB made the following safety recommendation:-

Safety Recommendation 2001-088

The CAA should conduct a review of JAR 145.55 with the aim of proposing to the JAA the improved harmonisation of maintenance document retention time requirements with those specified in the ANO, so that maintenance Worksheets and component Certificates of Release that are referred to in airframe, engine and propeller Log Books and component log cards are retained until the aircraft, engine, propeller or component has been destroyed or scrapped.

The CAA response to this safety recommendation was:

'The CAA does not accept this recommendation. The CAA recently published Airworthiness Notice 12 Appendix 61 (Retention of records – Post Incident and Accident Investigations) in which maintenance organisations and aircraft operators were reminded of their responsibilities in relation to the content and retention of maintenance records. The Notice makes the clear distinction between those records to be kept by a JAR 145 approved organisation maintaining aircraft used for Commercial Air transport (CAT), and the records that are required to be retained for non

commercial air transport as described in the Air Navigation Order Article 17. A copy of the records raised by the maintenance organisation should be supplied to the aircraft operator/owner, for retention as part of the aircraft record. In all cases, the operator/owner is required to retain aircraft records. In the case of aircraft operated for CAT, records must be kept until one year after the aircraft is destroyed or permanently withdrawn. In the case of aircraft operated for non-CAT, records must be kept until two years after the aircraft is destroyed or permanently withdrawn.'

Analysis

Retention requirements for maintenance documentation

During this investigation the AAIB could not obtain the records of the engine overhaul that occurred in 1997, which were referred to in the engine log book (CAP 398). They had been destroyed by the JAR (now EASA) approved overhaul organisation as allowed by the two-year rule stated in JAR (now EASA) Part 145. What is not specified in EASA Part 145 is that, where any document is incorporated 'by reference' in a log book, it shall be deemed to be part of that log book and retained for two years after the item to which the log book refers has been destroyed or has been permanently withdrawn from use. CAA Airworthiness Notice No. 12, Appendix 61, titled 'Retention of Records – Post Incident and Accident Investigations', paragraphs 4 and 6 do not make reference to the retention requirements when documents are incorporated 'by reference' in a log book, although there is a note to this effect after paragraph 5.

Operators of UK-registered aircraft are required to comply with the ANO, which requires them to keep such records for a period of two years after their aircraft have been permanently withdrawn from service, whereas maintenance organisations generally comply with the EASA Part 145.A.55 requirement, which only requires them to keep records for a minimum of two years after the aircraft, or component, has been released after maintenance work.

It was found during this, and previous, investigations to be common practice for approved maintenance and overhaul organisations to retain the detailed paperwork associated with the work carried out and referring to it by a file or job number in the associated log book or component record card. The organisation would then destroy this detailed paperwork two years after the date the work was completed.

It is important for specific maintenance records to be accessible, particularly after an incident or accident. The absence of relevant records in such investigations undermines the prime reason for requiring maintenance records to be kept at all. In view of this the following Safety Recommendations are made:

Safety Recommendation 2007-089

It is recommended that the Civil Aviation Authority amend the title of Airworthiness Notice No.12, Appendix 61 to 'Retention of Records' to reflect the requirement stated within the Notice to retain records at all times, not just after an incident or accident.

Safety Recommendation 2007-090

It is recommended that the Civil Aviation Authority amend Airworthiness Notice No.12, Appendix 61 to reflect, throughout Appendix 61, the requirement to retain maintenance and overhaul records for two years after the aircraft, engine, propeller or component has been destroyed or permanently removed from service, where reference is made to those records in the log books or component record cards.

Safety Recommendation 2007-091

It is recommended that the European Aviation Safety Agency (EASA) amend EASA Part 145 (and Part M as necessary) to require that maintenance and overhaul records that are referred to in airframe, engine and propeller log books, and component record cards, are deemed to be part of that log book or record card and are retained until the aircraft, engine, propeller or component has been destroyed or permanently removed from service.

Safety Recommendation 2007-092

It is recommended that the European Aviation Safety Agency (EASA) should amend EASA Part 145 (and Part M as necessary) to require that all EASA Part 145 approved organisations supply the aircraft operator with the records associated with work that they perform on an aircraft, engine, propeller or component.

Safety Recommendation 2007-093

It is recommended that, to enable aircraft operators to fulfil the requirements of the Air Navigation Order and EASA Part M, the Civil Aviation Authority review the requirements for, and monitoring of, EASA Part 145 approved organisations providing the aircraft operator with the records associated with work that they perform on an aircraft, engine, propeller or component.

Occurrences resulting from cylinder failure

As noted earlier in this report, Tables 1 and 2 list the known occurrences that have occurred in the UK and France which have been the result of a complete or partial separation of a cylinder from a Lycoming O-235 series engine caused by a fatigue crack propagating from an external corrosion pit. The majority of aircraft in the UK that are fitted with the O-235 series engine are operated in the pilot training role and all but two of the accidents since 1977 have occurred whilst being operated in that environment. In the UK there have been no recent fatal accidents resulting from a cylinder failure on a Lycoming O-235 series engine.

Cylinder inspection

Following a number of occurrences of Lycoming O-235 series engine cylinder failures in France, attributed to fatigue initiating from external corrosion pitting, the Direction Generale de l'Aviation Civile (DGAC) issued Airworthiness Directive (AD) 1998-225(A), that mandated regular inspections of these cylinders. With the formation of the European Aviation Safety Agency (EASA) in 2003 this AD was withdrawn and has not subsequently been re-issued by the EASA.

Safety Recommendation 2007-094

It is recommended that the European Aviation Safety Agency review the Airworthiness Directive 1998-225(A) R6 issued by Direction Generale de l'Aviation Civile (DGAC) in France with a view to issuing an EASA Airworthiness Directive to cover this area of concern.

Following the occurrence of cylinder failures in France, the engine manufacturer issued Service Instruction (SI) No 1504 which introduced a replacement cylinder for the O-235 series engines, with improved corrosion resistance. All new O-235 series engine cylinders delivered from the engine manufacture since 2000 are of the improved corrosion resistance type.

Safety Recommendation 2007-095

It is recommended that the Federal Aviation Administration review the continued airworthiness of cylinders manufactured prior to the year 2000 that are fitted to Lycoming O-235 series engines.

APPENDICES

145.A.55 Maintenance records

(a) The organisation shall record all details of maintenance work carried out. As a minimum, the organisation shall retain records necessary to prove that all requirements have been met for issuance of the certificate of release to service, including subcontractor's release documents.

(b) The organisation shall provide a copy of each certificate of release to service to the aircraft operator, together with a copy of any specific approved repair/modification data used for repairs/modifications carried out.

(c) The organisation shall retain a copy of all detailed maintenance records and any associated maintenance data for two years from the date the aircraft or component to which the work relates was released from the organisation.

1. Records under this paragraph shall be stored in a safe way with regard to fire, flood and theft.
2. Computer backup discs, tapes etc. shall be stored in a different location from that containing the working discs, tapes etc., in an environment that ensures they remain in good condition.
3. Where an organisation approved under this Part terminates its operation, all retained maintenance records covering the last two years shall be distributed to the last owner or customer of the respective aircraft or component or shall be stored as specified by the competent authority.

Appendix 1

EASA Part-145.A.55 Maintenance Records

Airworthiness Notice No. 12, Appendix 61

Issue 4
29 September 2006

Retention of Records - Post Incident and Accident Investigations

1 During an investigation into an engine failure resulting in an air turn back and emergency landing, the record keeping and retention of record period was found to be inadequate and incomplete. Considerable difficulty was experienced during the investigation in tracing the maintenance actions taken during the overhaul of the engine crankshaft which was identified as the cause of the engine failure.

2 Aircraft operators and maintenance organisations are reminded of their responsibility to retain adequate and complete maintenance records as specified and referenced in the following paragraphs for the periods listed.

3 The requirements for retention of maintenance records for EASA aircraft operated for Commercial Air Transport or Non-Commercial Air Transport are identified in Part M M.A. 305 and M.A. 306. For non-EASA aircraft the retention periods are those specified in the Air Navigation Order 2005 (as amended).

4 Part-145 approved maintenance organisations need only retain a copy of all detailed maintenance records for two years from the date the aircraft or aircraft component was released from the Part-145 organisation (Part 145.A.55). If contracted to keep records on behalf of the Operator then the retention period will be that required by Part M M.A. 305 and M.A. 306.

5 The requirements for retention of records for all other aircraft registered in the United Kingdom should be as defined in the Air Navigation Order 2005 (as amended) Article 22. This requires the Operator of the aircraft to keep Aircraft, Engine and Propeller Log Books. The Log Books must include particulars as specified in the ANO Schedule 6 which include:

- Paragraph 1(e). Particulars of all maintenance work carried out on the aircraft or its equipment.
- Paragraph 1(g). Particulars of any overhauls, repairs, replacements and modifications relating to the aircraft.

Also note that any document which is incorporated by reference in a log book shall be part of the log book and it is the duty of the Operator to keep the above records. Every Log Book shall be preserved by the Operator of the aircraft until 2 years after the aircraft has been destroyed or has been permanently withdrawn from use.

6 Consequently, if a Part-145 approved maintenance organisation carries out work (overhaul, inspection, repair, modification or replacements) on an aircraft NOT operated in accordance with JAR-OPS, then the record retention requirements are as required by the Air Navigation Order.

Appendix 2

CAA Airworthiness Notice No 12, Appendix 61

M.A.305 Aircraft continuing airworthiness record system

(a) At the completion of any maintenance, the associated M.A.801 certificate of release to service shall be entered in the aircraft continuing airworthiness records. Each entry shall be made as soon as practicable but in no event more than 30 days after the day of maintenance action.

(b) The aircraft continuing airworthiness records shall consist of, as appropriate, an aircraft logbook, engine logbook(s) or engine module log cards, propeller logbook(s) and log cards, for any service life limited component and the operator's technical log.

(c) The aircraft type and registration mark, the date, together with total flight time and/or flight cycles and/or landings, as appropriate, shall be entered in the aircraft logbooks.

(d) The aircraft continuing airworthiness records shall contain the current:

1. status of airworthiness directives and measures mandated by the competent authority in immediate reaction to a safety problem;
2. status of modifications and repairs;
3. status of compliance with maintenance programme;
4. status of service life limited components;
5. mass and balance report;
6. list of deferred maintenance.

(e) In addition to the authorised release document, EASA Form 1 or equivalent, the following information relevant to any component installed shall be entered in the appropriate engine or propeller logbook, engine module or service life limited component log card:

1. identification of the component, and;
2. the type, serial number and registration of the aircraft to which the particular component has been fitted, along with the reference to the installation and removal of the component, and;
3. the particular component accumulated total flight time and/or flight cycles and/or landings and/or calendar time, as appropriate, and;
4. the current paragraph (d) information applicable to the component.

(f) The person responsible for the management of continuing airworthiness tasks pursuant to M.A. Subpart B, shall control the records as detailed in this paragraph and present the records to the competent authority upon request.

(g) All entries made in the aircraft continuing airworthiness records shall be clear and accurate. When it is necessary to correct an entry, the correction shall be made in a manner that clearly shows the original entry.

(h) An owner or operator shall ensure that a system has been established to keep the following records for the periods specified:

1. all detailed maintenance records in respect of the aircraft and any life-limited component fitted thereto, at least 24 months after the aircraft or component was permanently withdrawn from service, and;
2. the total time and flight cycles as appropriate, of the aircraft and all life-limited components, at least 12 months after the aircraft or component has been permanently withdrawn from service, and;
3. the time and flight cycles as appropriate, since last scheduled maintenance of the component subjected to a service life limit, at least until the component scheduled maintenance has been superseded by another scheduled maintenance of equivalent work scope and detail, and;
4. the current status of compliance with maintenance programme such that compliance with the approved aircraft maintenance programme can be established, at least until the aircraft or component scheduled maintenance has been superseded by other scheduled maintenance of equivalent work scope and detail, and;
5. the current status of airworthiness directives applicable to the aircraft and components, at least 12 months after the aircraft or component has been permanently withdrawn from service, and;
6. details of current modifications and repairs to the aircraft, engine(s), propeller(s) and any other component vital to flight safety, at least 12 months after they have been permanently withdrawn from service.

Appendix 3

EASA Part M Section M.A.305

ACCIDENT

Aircraft Type and Registration:	Reims Cessna F182Q, G-BGFH
No & Type of Engines:	1 Continental O-470U piston engine
Year of Manufacture:	1979
Date & Time (UTC):	23 May 2007 at 1355 hrs
Location:	2.5 nm north-west of Burntisland, Fife, Scotland
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Nosewheel sheared off, propeller bent, engine cowling crushed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	66 years
Commander's Flying Experience:	529 hours (of which 430 were on type) Last 90 days - 17 hours Last 28 days - 9 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and AAIB enquiries

Synopsis

The engine stopped, possibly due to fuel starvation, and during the subsequent forced landing the aircraft touched down heavily causing the nosewheel to break and the propeller and engine to strike the ground.

History of the flight

The pilot planned to fly from Eddsfield in Yorkshire to Cumbernauld and back in the same day. He was familiar with the route and he estimated that it would take approximately 1 hour and 20 minutes to fly to Cumbernauld. The pilot filled both fuel tanks to within 20 mm of the top of the tank, which gave him approximately 300 litres of useable fuel. The aircraft departed Eddsfield at 0815 hours and routed to Cumbernauld via Boulmer and the Talla VOR beacon. For most of the route the aircraft was flown at 1,500 to 2,000 feet agl. However the weather was worse than predicted and at one point he experienced 40 kt headwinds and the cloud base lowered to 800 feet agl during the last few miles to Cumbernauld. The aircraft arrived at Cumbernauld at 1016 hours, a journey that had taken approximately 40 minutes longer than planned.

With light rain and a cloud base of 800 feet in the local area, the pilot, after checking the forecast with the CFI at Cumbernauld, decided to return south by following the coast. As this would require him to transit through the Edinburgh control zone he telephoned Edinburgh

Operations and was advised to contact Edinburgh Approach once he was airborne.

The pilot stated that once airborne, he contacted Edinburgh Approach and was instructed to route via Philipstoun, the Bridges and Dalkeith. He was also instructed to contact Edinburgh Tower when he reached the Bridges. When he contacted Edinburgh Tower he was instructed to hold and so began orbiting to the left. He said that he orbited for over 30 minutes, at a height between 1,000 and 1,400 feet and a bank angle of approximately 30°, during which at least six aircraft landed and two or three departed from Edinburgh Airport. Towards the end of this period he checked the fuel contents gauges and noted that the left gauge read ¾ full and the right gauge was in the red, which he stated he thought to be normal. Shortly afterwards the engine misfired and at the same time the controller cleared the pilot to cross Runway 24. The pilot informed the controller that he had an engine problem and after being given details of local airfields, advised the controller that he would not be able to make any of them. The pilot applied carburettor heat, which had no effect, and pumped the fuel primer three times, but could feel no resistance. He advised the controller that because of the circling, all the fuel had gone to the left tank and that he would try orbiting to the right. After turning through approximately 90 degrees to the right he realised that given his height, he had no option but to make a forced landing into a field directly ahead of the aircraft. At a height of 150 to 200 feet he realised that the aircraft was going to collide with a dry stone wall and in an attempt to clear the wall the aircraft stalled and touched down heavily on its landing gear.

The pilot and passenger were uninjured and reported that approximately two minutes after they vacated their aircraft, another aircraft arrived and began circling above the accident site. After a further five minutes a helicopter arrived, landed at the site and checked that the occupants were safe. Given the remote location of the accident site it was decided to leave the aircraft in the field until it could be recovered the next day. However, details of the accident were broadcast on the local radio and that evening vandals set it on fire. The aircraft cabin, the majority of the wings and the fuel system were totally destroyed by the fire.

Report from Edinburgh Tower Controller

The Tower Controller reported that G-BGFH had been given clearance to transit the Edinburgh CTR and was instructed to route as far as the Bridges and then transfer to Edinburgh Tower frequency for onward clearance across the Runway 24 extended centre line. The Controller said that the pilot made contact after passing the Bridges eastbound. He advised the pilot to hold at the Bridges, but the aircraft continued to fly on an easterly track in conflict with a number of aircraft on the approach to Edinburgh. On passing traffic information, the pilot of G-BGFH said he had an Airbus in sight. The controller suggested he pass behind the Airbus as there was further IFR traffic at 9 nm DME. However G-BGFH continued to fly to the east towards the traffic, so the controller instructed him to turn to the north. The controller reported that as this was the first instruction that the pilot had acted on he planned to direct G-BGFH back to the Bridges and to hold until he could clear him to cross the extended centre line.

G-BGFH was observed on radar manoeuvring towards the Bridges at an altitude varying between 1,200 and 1,900 feet. After loosely holding at the north tower of the Forth Road Bridge, G-BGFH was cleared to cross Runway 24 and report south-side. Almost immediately the pilot reported an engine problem and asked to orbit in the opposite direction as he felt that the prolonged orbit had emptied one of his fuel tanks.

The pilot then reported that the engine had failed and he was going down. The controller passed range and distance to Edinburgh and Glenrothes, but it quickly became apparent that the aircraft would not be able to make either of these airfields. The controller asked the pilot if he had anywhere visual to put down and he replied that he thought that he did. The controller passed the Edinburgh surface wind as the pilot passed altitude reports. At 300 feet the aircraft radar return disappeared and approximately one minute later the pilot reported that the aircraft was on the ground and both occupants were uninjured. During the emergency, the ATC assistant dispatched two aircraft, which were flying in the local area, to locate G-BGFH. Details of the position of the aircraft were passed to the local constabulary.

Description of fuel system

The Reims Cessna F182Q is a high-winged aircraft with an integral fuel tank mounted in each wing. Each fuel tank has a useable fuel capacity of approximately 166 litres and is equipped with its own fuel quantity transmitter and vented filler cap. A vent line is connected to each fuel tank.

Each fuel quantity transmitter is mounted on the inboard wall of its tank and the contents are measured by the use of a float. In a properly co-ordinated turn the fuel level will be the same as in straight and level flight. However if the aircraft skids in the turn then the fuel in the tanks will tend to slope in the direction of the skid with the result that the outboard tank will under read and the inboard tank will over read. If the aircraft slips in the turn then the inboard tank will under read and the outboard tank will over read.

An outlet pipe from each fuel tank is connected to a four-position selector valve that can be selected to RIGHT, BOTH, LEFT or OFF positions. The fuel flows under gravity to a mechanical fuel pump connected to the engine, which delivers fuel to the carburettor. A mechanically operated engine primer, which is mounted on the instrument panel, takes fuel directly from the fuel line between the selector valve and mechanical pump.

Warnings in the Flight Manual

G-BGFH was manufactured by Reims Aviation who held the airworthiness responsibility for the Cessna F182Q. In March 2003 Reims Aviation was dissolved and airworthiness responsibility was passed to Cessna.

The flight manual[1] for G-BGFH was issued by Reims Aviation and in the section describing the fuel system there is no mention of fuel transferring between the wing tanks in flight. In contrast, the flight manual[2] issued by Cessna for the C182Q includes the following warning:

'When the fuel selector valve handle is in the BOTH position in cruising flight, unequal fuel flow from each tank may occur if the wings are not maintained exactly level. Resulting wing heaviness can be alleviated gradually by turning the selector valve handle to the tank in the "heavy" wing.'

Discussion

The pilot was familiar with the aircraft and confident that there was 300 litres of fuel on board prior to the flight. Whilst the aircraft flight manual gave a fuel consumption of 42 litres per hour (for the conditions on the day) the pilot had previously checked the fuel consumption and as a result used a figure of 52 litres per hour. The total flight time, since the aircraft was refuelled, was approximately 2 hour 45 minutes, which

Footnote

1 Edition 3 dated October 1978.
2 Dated 1 October 1978.

means that at the time of the accident the fuel tanks should have been between 52% and 61% full. The photographs taken by the police after the aircraft had been destroyed by vandals clearly show that the aircraft had been subject to an intense fire, which indicates that there was still a considerable amount of fuel on board the aircraft after it had crashed.

The pilot always flew with the fuel selector switch at BOTH, which balanced the fuel contents in both tanks. However there are no non-return valves between the fuel selector valve and the fuel tanks and therefore it is possible for fuel to transfer from the higher to lower fuel tank if it is flown in an unco-ordinated turn. Once the down-wing tank is full, fuel will discharge out of the tank through the vent pipe. The rate of transfer is dependent on a number of variables such as the fuel contents, bank angle and the amount of imbalance in the turn. The manufacturer confirmed that during the certification of the aircraft there was no requirement to establish the rate of fuel transfer during an unco-ordinated turn.

The pilot reported that towards the end of his period orbiting, the fuel gauges indicated that the left fuel tank was ¾ full and the right tank was in the red (less than 8 litres). However there is a warning in the Flight Manual that states:

> *'The indicators cannot be relied upon for accurate readings during skids, slips, or unusual flight attitudes.'*

The manufacturer also confirmed that certification of the aircraft only requires the gauges to be accurate when the aircraft is level and the fuel tanks are empty. Unco-ordinated turns can also result in the fuel being pushed away from the fuel tank outlets which could, if the tank is nearly empty, cause fuel starvation and engine stoppage.

The pilot reported that his normal practice, once he was in the cruise, was to adjust the rudder trim and take his feet off the rudder pedals. He also felt that with the increased work load in flying across the Edinburgh control zone, and watching out for the numerous large aircraft in poor weather conditions, it is possible that during his prolonged period of orbiting he was flying out of balance.

Conclusion

The pilot's description of the engine misfiring and the lack of resistance when operating the fuel primer suggests that the engine stoppage was due to fuel starvation. The intensity of the fire indicates that there was still a considerable quantity of fuel in the aircraft; unfortunately the fuel system was destroyed by the fire and therefore it was not possible to rule out a fuel leak, blockage or contamination. The admission by the pilot that he might have been flying out of balance whilst orbiting at the Bridges raises the possibility that fuel starvation might have occurred due to a combination of fuel transferring from the right to the left fuel tank, and the remaining fuel in the right fuel tank being forced away from the tank outlet pipe.

ACCIDENT

Aircraft Type and Registration:	Tecnam P92-EM Echo (Modified), G-CBUG
No & Type of Engines:	1 Rotax 912 ULS piston engine
Year of Manufacture:	2002
Date & Time (UTC):	1 September 2007 at 1430 hrs
Location:	Oxenhope, Yorkshire
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:	66 years
Commander's Flying Experience:	1,284 hours (of which 2 were on type) Last 90 days - 9 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent AAIB enquiries

Synopsis

During the landing at Oxenhope in good weather but with a stiff breeze, directional control was lost in the flare. As the pilot began a go-around, the left main landing gear struck a bank, causing the aircraft to yaw and pitch into the ground.

History of the flight

The aircraft had received cosmetic maintenance at Branscombe and the pilot planned to fly it to Manchester Barton before continuing to its base at Oxenhope. He had not flown the type before but studied a copy of the flight manual prior to flight. No instructor or experienced pilot was available to provide tuition on the type but the pilot was told that its flying characteristics were similar to a Cessna 152. The pilot was experienced in flying into short strips such as Oxenhope.

Nearing Barton, the pilot decided that he had sufficient fuel to continue to Oxenhope and conduct an airborne inspection of the airstrip before returning to Barton. In the overhead at Oxenhope, he saw that the windsock showed a stiff breeze favouring Runway 24 (he later assessed the wind as having been approximately 270/20 kt). He made a number of orbits to assess the strip and conditions during which he saw an individual, whom he believed to be the aircraft's owner, opening the doors to a hangar; he concluded that this was to enable him to hangar the aircraft after landing.

The pilot carried out an "exploratory approach" to grass Runway 24 during which the aircraft became low on the approach and he carried out a go-around and further circuit. The second approach was flown crabbed into wind with the right wing down and the pilot assessed that it was appropriate to land from it. As he flared the aircraft, it drifted left towards a banked area beside the runway. Full power was applied to initiate a go-around but the left main landing gear struck the banked area and the aircraft yawed and pitched into the ground. It came to rest, substantially damaged, facing opposite to the direction of landing. The pilot was not injured and he carried out the shutdown checks before vacating the aircraft normally through the normal exit. There was no fire.

In a complete and frank report, the pilot assessed that the accident was caused by lack of familiarity with the aircraft type, the shifting wind, and the fact that the aircraft was lighter than those he usually flew. He acknowledged that additional pressure to land was brought about by the owner's presence and the opening of the hangar doors.

ACCIDENT

Aircraft Type and Registration:	Tecnam P2002-JF, G-NESE
No & Type of Engines:	1 Rotax 912-S2 piston engine
Year of Manufacture:	2006
Date & Time (UTC):	30 September 2007 at 1255 hrs
Location:	Lude Farm, Blair Atholl, Perthshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Substantial airframe damage
Commander's Licence:	Private Pilot's Licence
Commander's Age:	43 years
Commander's Flying Experience:	185 hours (of which 76 were on type) Last 90 days - 27 hours Last 28 days - 9 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

During the takeoff roll, the aircraft went over a bump in the grass runway and the steerable nosewheel lifted off the ground. The aircraft then veered off the runway and was substantially damaged when it went into a ditch.

History of the flight

The aircraft was the last of a group of aircraft that were departing from Lude Farm, Blair Atholl. The runway in use was Runway 15 and its grass surface was dry; the weather conditions were good and the surface wind was calm. After completing the pre-takeoff checks and selecting 15º of flap, the pilot commenced his takeoff roll by applying full power and appropriate right rudder; directional control was via the steerable nosewheel. Whilst accelerating through approximately 15 kt the aircraft went over a bump in the grass and the nosewheel left the ground. The aircraft veered to the left, the pilot reported that full application of right rudder was unable to prevent the aircraft from leaving the left side of the runway. The pilot closed the throttle, but the left main wheel had already entered the long grass at the side of the runway, which resulted in an immediate increase in the rate of turn to the left. After travelling two metres through the long grass the aircraft went into a drainage ditch at approximately 15 kt; this resulted in substantial damage to the aircraft. The pilot switched off the electrics and fuel and vacated the aircraft normally.

The pilot considered that increased forward deflection of the control column would have kept the nosewheel on the ground, allowing him to maintain directional control.

Comment

The Tecnam 2002 is a low-wing monoplane with a steerable nosewheel. Following this accident the AAIB sought information from the PFA regarding directional control authority for this type of aircraft at low speed. The PFA conducted ground trials, which concluded that there is adequate rudder authority at low speed on this type of aircraft.

However, the trial also demonstrated that on some of these aircraft it is possible to generate interference between the 'all-flying' tailplane and the rudder. With full aft control column applied the tailplane's trailing edge up is fully up, and in this position the rudder trim tab's lower trailing edge is in contact with the tailplane. This can cause a restriction in the rudder movement. The PFA have raised an Airworthiness Occurrence Report and a fleet-wide check has commenced.

Whilst there is no evidence of a rudder movement restriction in this accident this highlights the necessity for a thorough 'full and free' check of the flight controls, particularly a check of the freedom of the rudder with the control column fully aft.

ACCIDENT

Aircraft Type and Registration:	Vans RV-4, G-BULG
No & Type of Engines:	1 Lycoming O-320-E3D piston engine
Year of Manufacture:	1989
Date & Time (UTC):	4 August 2007 at 1100 hrs
Location:	Private strip, Firgrove, Wreningham, Norfolk
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to propeller, engine mount, firewall, cowling, landing gear and wing underside
Commander's Licence:	Private Pilot's Licence
Commander's Age:	62 years
Commander's Flying Experience:	980 hours (of which none were on type) Last 90 days - 0 hours Last 28 days - 0 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

Synopsis

After a normal 3-point touchdown on the grass runway, the aircraft ran over a slight ridge and lifted off in a high nose-up attitude. The pilot held the control stick aft and the aircraft descended, landing heavily, causing the main landing gear to collapse.

History of the flight

This was the pilot's first flight in a Vans RV-4, which is a tailwheel aircraft. The pilot had approximately 600 hours of tailwheel experience, much of it on Tiger Moths. His passenger was the owner of the aircraft. They departed Firgrove in good weather conditions and landed at Shipdham Airfield. After about 15 minutes they departed Shipdham to return to Firgrove. The pilot carried out an approach followed by a planned go-around and then established himself for an approach and a full stop landing on Runway 28 (grass). The wind was from 250° at 12 kt. The approach was made at 80 mph, reducing to 70 mph over the threshold. A normal 3-point touchdown was made with approximately two thirds of the 600 m runway remaining. The aircraft then ran over a slight ridge in the runway surface and lifted off in a high nose-up attitude. The aircraft then descended and landed heavily, causing the main landing gear to collapse rearwards.

Passenger's comments on the accident

The passenger, who was the owner of the aircraft, reported that the landing was normal and the pilot then brought the control stick fully aft (a normal tailwheel landing technique). G-BULG is an early model RV-4, with shorter landing gear legs, and it normally lands in a 3-point attitude above the stall speed. The passenger reported that the slight ridge in the runway normally causes the aircraft to make a slight 'hop' but, in this case, the stick was held fully aft, causing the aircraft to pitch up and it then 'mushed' back onto the ground.

Pilot's assessment of the cause

The pilot stated that he decided to hold the stick aft when the aircraft pitched up after touchdown. With hindsight, he believed he should have added some power, lowered the nose with some forward stick, and then either landed or carried out a go-around. He believed that his lack of recent flying experience probably contributed to the accident.

Recency requirements for carrying passengers

JAR-FCL 1.026[1] requires that a Pilot-in-Command carry out at least three takeoffs and three landings in the preceding 90 days in order to carry passengers.

Footnote

[1] JAR-FCL is the Joint Aviation Regulation for Flight Crew Licensing. The JAR-FCL 1.026 requirement can be found in LASORS section F.

ACCIDENT

Aircraft Type and Registration:	Vans RV-9A, G-CDMF
No & Type of Engines:	1 Lycoming O-320-E2D piston engine
Year of Manufacture:	2006
Date & Time (UTC):	2 September 2007 at 1500 hrs
Location:	Oaksey Park Airfield, Wiltshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to propeller, nose gear, canopy, left wing tip and upper fin/rudder
Commander's Licence:	Private Pilot's Licence
Commander's Age:	59 years
Commander's Flying Experience:	132 hours (of which 18 were on type) Last 90 days - 15 hours Last 28 days - 10 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

After a bounced landing, the aircraft touched down heavily on its nose gear and then flipped inverted. The variable and gusty wind conditions probably contributed to the accident.

History of the flight

The aircraft was on a return flight from St. Omer in France. The pilot overflew Oaksey Park airfield to determine the wind direction and strength from the two windsocks. He estimated the wind as variable from 270º at 10 kt with gusts to 15 kt. He then manoeuvred the aircraft for a left downwind approach to Runway 22 (grass). During final approach he reduced the airspeed to 65 mph and selected full flap. There was some turbulence and the aircraft's sink rate increased so he added some power. Close to the runway threshold the pilot noticed that the windsock was veering left and right of the centreline by about 20º. He was working hard to keep the wings level with aileron and the nose straight with rudder. After crossing the threshold he reduced the power to IDLE and started to flare. The aircraft's nose suddenly pitched up by about 10º and then the aircraft dropped suddenly, about 3 to 4 feet, and landed tail down. It bounced on its main gear back into the air and then landed heavily, nose down, on its nose landing gear. The nosewheel dug into the ground and the aircraft flipped upside down onto its back.

The pilot and his passenger were unable to exit the inverted aircraft. Shortly thereafter the airfield manager arrived with an axe and used it to cut out a section of canopy large enough for the pilot and his passenger to crawl out of the aircraft.

Pilot's assessment of the cause

The pilot reported that his landing airspeed was too low for the gusty weather conditions and that he believed wind shear near the runway threshold contributed to the accident.

ACCIDENT

Aircraft Type and Registration:	Enstrom F-28A-UK, G-BBPN
No & Type of Engines:	1 Lycoming HIO-360-C1A piston engine
Year of Manufacture:	1973
Date & Time (UTC):	12 June 2007 at 1415 hrs
Location:	Ormonde Fields Golf Course, near Codnor, Derbyshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Substantial
Commander's Licence:	Private Pilot's Licence
Commander's Age:	65 years
Commander's Flying Experience:	220 hours (of which 220 were on type) Last 90 days - 6 hours Last 28 days - 6 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The pilot carried out a go-around following an unsuccessful approach to a private landing site. During the go-around the helicopter did not climb sufficiently and sank into some trees. The pilot was not in regular flying practice until shortly before the accident and was attempting to land in a confined site in tailwind conditions.

Background to the flight

The pilot had previously held a PPL(H) for a number of years and during that period had owned his own helicopter. However, his licence had lapsed and he had not flown for about six years. He decided to restart helicopter flying and bought G-BBPN in May 2006. After he bought the helicopter it was damaged during a transit by road and was not available to fly again until 2007.

In June 2007 the pilot started training for his licence renewal on G-BBPN. On the first training flight the flight was terminated because the instructor felt the helicopter was not performing well and the collective did not have a full range of movement. A maintenance engineer conducted a thorough check of the helicopter, including the rigging, and could not find any defects. He asked the instructor if he was aware that the helicopter had long range fuel tanks fitted. The instructor responded that he had not known this because the fuel gauge fitted was of a type normally associated with standard fuel tanks.

The instructor was now satisfied that the poor performance of the helicopter was because they had been operating at above the maximum permitted weight; he was further reassured because it had been thoroughly checked. The training continued over the next few days and on the morning of the accident the pilot completed his licence skill test.

History of the flight

Having completed his skill test the pilot decided to fly the helicopter to the landing site at his home. The instructor offered to accompany him but the pilot declined the offer; he said he was familiar with the site having flown in there many times in the past.

The weather conditions recorded at East Midlands Airport (12 nm to the south) at 1420 hrs included a surface wind from 240º at 13 kt and a temperature of 21ºC.

The landing site at the pilot's house was approached from the south-west. The approach path was over an open field but the landing area was relatively confined. At a late stage of the approach the pilot felt uncomfortable and decided to go-around. The go-around was carried out straight ahead, crossing a main road and then a golf course that was situated on rising ground amidst some trees. The helicopter cleared the streetlamps on the main road, but as the pilot tried to climb away he described experiencing a loss of power and the helicopter settled into trees on the golf course; it then fell to the ground and rolled over onto its right hand side. The pilot was able to release his harness and evacuate from the helicopter unassisted.

Helicopter information

This particular helicopter was not fitted with a throttle correlator, therefore the throttle was manually operated. As delivered by the manufacturer, the helicopter was fitted with two 15 USG fuel tanks, giving a total fuel capacity of 30 USG and a maximum fuel weight of 180 lb. At some stage during its various ownerships, the aircraft had been fitted with larger, 20 USG tanks, giving a maximum fuel weight of 240 lb. This modification required simultaneous fitment of a different fuel gauge, amongst other items. The pre-modification gauge simply read 'E' and 'F' with graduations at ¼ capacity increments. The post-modification gauge had figures in lbs at the 120 and 240 lb positions. G-BBPN, despite having the increased fuel capacity, still had the pre-modification gauge fitted. However, it was reported that the gauge was still reasonably accurate, reading FULL when full and EMPTY when the unusable fuel level was reached. Neither the agent who had sold the aircraft to the owner nor, presumably, the many previous pilots and owners of the helicopter had noticed, or seen fit to comment on, the disparity. The increased capacity cannot be detected externally, and there was also no decal around the filler cap advising of the capacity.

Examination of the aircraft

The helicopter was not inspected by the AAIB until it had been recovered to the premises of the agent who had sold it to the pilot. The aircraft was now upright on its landing skids, but exhibited damage to the cockpit and tailboom consistent with an impact at low forward speed with the trees and subsequent fall to the ground. The main rotor blades had been cut off near the root by the recovery crew, all three showing distinctive upward bending along their length, characteristic of the distortion seen when blades are subject to overpitching at low rotor rpm in-flight.

Two of the three pitch control links at the top of the rotor mast had broken on impact, but one remained intact. It was therefore possible to check the range of movement of the collective lever and confirm that the rotor was able to travel through its specified range, on this blade at least. It was noted that it is possible to rig the collective lever, ostensibly to personal preference, such that the fully lowered and raised positions are different, ie the fully raised position can vary from aircraft to aircraft with a corresponding change in the fully lowered position. The total range of movement should however, remain the same.

Analysis

The go-around manoeuvre is one which requires the pilot to co-ordinate the collective pitch with the rotor/engine rpm to make best use of the power available. Overpitching of the main rotor blades or failing to ensure that the throttle is fully open will reduce the performance and may prevent the helicopter from achieving a climb.

The pilot had only just re-qualified for his licence after a break from flying of six years. Although he was familiar with the landing site he had not flown in there for a number of years and therefore was not in recent practice. He made a sensible decision to go-around when he became uncomfortable with the approach, however the missed approach path contained obstacles and was over rising ground. In the tailwind conditions and the ambient temperature the helicopter's climb gradient would have been reduced. Given these circumstances, it is possible that the power demanded by the pilot exceeded the power available; this might then cause the pilot to overpitch the main rotor, thus reducing rotor rpm and consequently climb performance. To the pilot this would appear as though a loss of power had occurred.

One other point of note is that during the refresher training neither the owner nor the instructor appeared to be aware that the helicopter was fitted with an extended range fuel tank option. This lead to the aircraft being inadvertently overloaded for that flight. As noted above, there were no cues to this available to either pilot, beyond the misleading fact that the fuel gauge was of a type fitted to aircraft with the smaller fuel capacity.

However, fuel quantity was not a factor on this flight where, with only one occupant and some fuel having been consumed during the transit, it was certainly well within its maximum gross weight.

ACCIDENT

Aircraft Type and Registration:	Easy Raider, G-CCJS
No & Type of Engines:	1 Jabiru 1600 piston engine
Year of Manufacture:	2007
Date & Time (UTC):	27 April 2007 at 1100 hrs
Location:	Near Andreas Airfield, Isle of Man
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Serious) Passengers - 1 (Serious)
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	69 years
Commander's Flying Experience:	5,000 hours (of which 10 were on type) Last 90 days - 30 hours Last 28 days - 15 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

Synopsis

The newly constructed aircraft was undertaking the second in a series of test flights for the issue of a Permit to Fly. After takeoff the aircraft's climb performance was inadequate to maintain sufficient terrain clearance with rising ground ahead and the pilot attempted to return to the airfield. During this manoeuvre the aircraft stalled at low level, impacting the ground seriously injuring the two occupants.

Background

The aircraft was undergoing flight tests to enable issue of its initial CAA Permit to Fly. It was fitted with a Jabiru 1600 engine: the first time the British Microlight Aircraft Association (BMAA) had experienced this type of engine. The aircraft type is normally fitted with the Rotax 503 engine, which has a similar power rating to the Jabiru 1600, or the Jabiru 2200, which is a more powerful derivative. BMAA inspections, during and on completion of construction, revealed no problems with the aircraft. These inspections included tests of the flying controls and appropriate control surface deflections.

The pilot had flown a single flight on the aircraft prior to the accident. This had been a solo flight, taking off from Runway 11 at Andreas Airfield on the Isle of Man. The pilot stated that the flight had been successful, although he noted that one-fifth right rudder was continuously required to maintain directional control.

The pilot intended to conduct the next flight at approximately 90% of the aircraft's maximum takeoff weight. In order to achieve this, the owner of the aircraft had been specifically approved by the BMAA to act as an observer, sitting in the rear seat during the flight. There are no controls or flying instruments associated with the seating position. The aircraft was loaded with 20 kg of fuel which gave a stated takeoff weight of 430 kg, 20 kg under the aircraft's maximum permitted takeoff weight of 450 kg.

History of the flight

The aircraft took off from Runway 05 at Andreas Airfield shortly before 1100 hrs at which time the surface wind was 060/12-15 kt. The pilot reported that the takeoff was normal but the initial climb, flown at 40 kt IAS, seemed "sluggish" with a rate of climb of no more than about 300 ft/min. Due to rising ground beyond the end of the runway the aircraft's terrain clearance did not increase significantly. The pilot recalled that at a height of about 200 ft agl, the aircraft began to sink, probably due to a downdraft caused by the effect of the wind acting on two adjacent hills in the area. During a left turn back towards the airfield, the aircraft then stalled and entered an incipient spin to the left. There was insufficient height to recover and the aircraft hit the ground in a steep nose-down attitude and banked to the left.

The pilot received serious injuries including multiple fractures to both legs and the aircraft owner suffered a broken ankle. However, the owner was able to pull the pilot clear of the aircraft. It was severely damaged in the accident and fuel was leaking from the wreckage although there was no fire.

Analysis

The pilot questioned whether the aircraft's climb performance met the standard required under the flight test schedule of being able to achieve 1,000 ft in four minutes under ISA conditions. He also commented on the need to use continuous right rudder during the first flight which he believed could probably have been resolved by the fitting of a fixed trim tab to the rudder. He stated that no adjustments had been made to the flying controls or control surfaces between the flights and that right rudder was again required to maintain direction during the second flight.

The pilot assessed the cause of the accident as a combination of the rising terrain after takeoff, poor climb performance of the aircraft and the wind conditions. In an attempt to maintain clearance from the terrain, the pilot probably maintained a steep climbing attitude with a correspondingly low airspeed. At the same time he was correcting the aircraft's constant left yaw with right rudder. In banking the aircraft left to return to the airfield it is probable that the stall speed was raised sufficiently to induce a stall with a combination of rudder input and bank angle causing the wing to drop to the left.

Conduct of BMAA test flights

The BMAA consider that the carriage of approved observers during flight tests can enhance safety by helping with such tasks as recording information and looking out for other aircraft. Normally such observers are qualified pilots and it is considered that they are therefore aware of the risks entailed by such flights. Where they are not qualified pilots, the BMAA stated that they explain such risks to them in writing as part of the observer approval process. The BMAA considers the benefits of flying with a suitably qualified observer outweighs any increased risk such test flights impose, especially as the majority of types flown already have well established flight characteristics. They also added that ballast does not necessarily replace an observer; it just allows aircraft to be loaded for performance testing.

As this accident demonstrates, however, it may be more appropriate to use ballast instead of an observer where there is no danger of the ballast itself causing potential problems and where an observer can contribute little to the safety of the flight. The BMAA currently provides no information on the use of ballast during test flights.

General advice from the BMAA on the planning, risk assessment and conduct of test flying is not currently available although it is understood that a test pilot's handbook is currently being compiled. The following Safety Recommendation is therefore made:

Safety Recommendation 2007-125

It is recommended that the British Microlight Aircraft Association provide written advice on appropriate planning, risk assessment and conduct of test flights that specifically includes use of ballast during such flights.

ACCIDENT

Aircraft Type and Registration:	Easy Raider J2.2(2), G-OEZI
No & Type of Engines:	1 Jabiru Aircraft Pty 2200A piston engine
Year of Manufacture:	2003
Date & Time (UTC):	20 October 2007 at 1030 hrs
Location:	Staindrop Airstrip, Co Durham
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Aircraft extensively damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	42 years
Commander's Flying Experience:	842 hours (of which 30 were on type) Last 90 days - 32 hours Last 28 days - 8 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft was intending to fly a 'touch-and-go', at a grass airstrip. During the ground roll, the pilot experienced a tendency for the aircraft to yaw to the left, which he overcame with right rudder. The aircraft got airborne at a lower speed than normal; it subsequently stalled and struck the ground. The aircraft was extensively damaged, but the pilot and his passenger escaped without injuries.

History of the flight

The aircraft was flying an approach with the intention of performing a 'touch-and-go' at Staindrop Airstrip, Co Durham. The takeoff weight was 426 kg against its maximum of 450 kg, and the weather conditions were good and the surface wind was calm. The aircraft touched down approximately 50 m along the 300 m long runway and the pilot applied full power for takeoff. Whilst the aircraft was on the ground the pilot recalls that the aircraft tended to yaw to the left, which required a significant application of right rudder to correct; at the time he considered that this was probably caused by an unexpected crosswind. The aircraft continued to accelerate along the runway, towards a fence at the far end. The pilot pulled back on the stick to clear the fence, and the aircraft became airborne, but at an airspeed less than the normal climb speed. The aircraft climbed to about 40 ft above the runway when the right wing stalled. The aircraft struck the ground to the right of runway, and went through two fences before coming to rest. The pilot shut the aircraft down, and he and his passenger, who were both uninjured, vacated the aircraft normally.

The pilot examined the tyre marks left on the grass strip by his aircraft. He noted that they were 175 m long, and ceased approximately 75 m before the end of the runway; presumably indicating the point at which the aircraft became airborne. The marks left by the right wheel appeared normal but there were fret lines in the runway surface where the left hub/tyre had ground along the runway. He considered that these marks were conducive with the left tyre having been flat. The tyre had been correctly inflated when he had performed his walk around, and he had noticed nothing unusual during his initial takeoff. In his opinion the tyre had deflated during the flight, and the flat tyre accounted for the yaw to the left that he had experienced. This, together with the additional drag from his application of right rudder, would have prevented the aircraft from accelerating normally along the runway, and his concern at seeing the end of the runway approaching, whilst he was still on the ground, provoked him into getting airborne before he had accelerated to his normal takeoff speed.

ACCIDENT

Aircraft Type and Registration:	Rans S6-ES Coyote II, G-CDGH
No & Type of Engines:	1 Rotax 912-UL piston engine
Year of Manufacture:	2005
Date & Time (UTC):	25 August 2007 at 1400 hrs
Location:	Broadmeadow Farm, 3 miles South of Hereford
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Broken propeller, damaged wings, cracked fibreglass cowling, damaged landing gear. Extensive damage to two parked aircraft
Commander's Licence:	Private Pilot's Licence
Commander's Age:	69 years
Commander's Flying Experience:	435 hours (of which 354 were on type) Last 90 days - 3 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form

Synopsis

A new syndicate member was making his second familiarisation flight in the aircraft, in the company of an experienced syndicate member. During takeoff, the aircraft drifted to the left of the runway and collided with two parked flex-wing microlight aircraft, causing substantial damage to all three aircraft. It was concluded by the more experienced pilot that the accident occurred because the aircraft took off with insufficient airspeed, combined with the full-throttle torque effect, which occurred in the opposite direction to that on aircraft previously flown by the new pilot. The handling pilot considered that there may have been an increase in the crosswind component that was not apparent prior to takeoff.

Background

Earlier in the day, the aircraft had departed its home airfield of Long Marston, near Stratford-upon-Avon and landed at Broadmeadow Farm, near Hereford. The aircraft was owned by a syndicate and the purpose of the flight was to familiarise a new syndicate member with the aircraft. In fact, this pilot had more hours on type than his companion, who was the syndicate trustee, but his previous experience had been with Rotax 582 engined Rans S6 aircraft, in which the propeller rotates in the opposite direction to that of the Rotax 912 engine, which powered the subject aircraft.

History of the flight

The new syndicate member occupied the right seat for the flight to Broadmeadow Farm. He carried out the takeoff, during which he noted that the aircraft had a marked tendency to swing to the left, this being the opposite direction to that of aircraft on which he had gained most of his experience. Once airborne, he handed control to the pilot-in charge in the left seat. The flight was uneventful and a landing was made on Runway 28, which had a slight downhill gradient, with a 10 mph wind from approximately 300°, thus giving a small crosswind component from the right.

For the return trip, approximately one and a half hours later, the new pilot occupied the left seat. The wind conditions were unchanged from those at the time of their landing, and the same runway was in use. During the takeoff roll, the pilot in the right seat reiterated to the new pilot of the need for "full throttle and plenty of right rudder". The nosewheel lifted at approximately 35 mph and the aircraft became airborne at 45 mph, but started to drift to the left. The right seat pilot called for the stick to be moved forward to increase airspeed and, shortly afterwards, took control. The aircraft then contacted the ground with all three wheels and veered sharply to the left, subsequently colliding with two flex-wing microlight aircraft that were parked, unattended, beyond the left side of the runway. All three aircraft sustained substantial damage but no one was injured.

In his analysis of the accident, the experienced syndicate member concluded that the aircraft took off with insufficient airspeed on rotation, which, in combination with a slight crosswind and full-throttle torque effect, caused the aircraft to drift to the left. Application of forward stick to regain adequate flying speed did not become effective in time to prevent the collision with the parked aircraft. After the accident, the handling pilot considered that there may have been an increase in the crosswind component that was not apparent prior to the takeoff.

ACCIDENT

Aircraft Type and Registration:	1) Scheibe SF27 glider, HGM 2) Schleicher ASW 19 glider, GDP
No & Type of Engines:	1) None 2) None
Year of Manufacture:	1) 1965 2) 1979
Date & Time (UTC):	2 October 2006 at 1515 hrs
Location:	Sutton Bank, North Yorkshire
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 (Fatal) Passengers - N/A
Nature of Damage:	1) Aircraft destroyed 2) Aircraft destroyed
Commander's Licence:	1) British Gliding Association (BGA) Gliding Certificate 2) British Gliding Association (BGA) Gliding Certificate
Commander's Age:	1) 50 years 2) 48 years
Commander's Flying Experience:	1) 733 hours Last 90 days - 20 hours Last 28 days - 5 hours 2) 280 hours Last 90 days - 10 hours Last 28 days - 1 hour
Information Source:	AAIB Field Investigation with assistance from the British Gliding Association (BGA)

Synopsis

Two gliders, a Scheibe SF27 and a Schleicher ASW 19B, were flying close to Sutton Bank, North Yorkshire, when they were in collision close to a bank of cloud. Both gliders lost portions of wing in the impact and were rendered incapable of flight. The pilot of the SF27 was able to escape from his aircraft and parachute to the ground: the pilot of the ASW 19 was not able to release his cockpit canopy and was killed. The engineering investigation indicated that both aircraft were serviceable until the moment of collision.

Two Safety Recommendations were made shortly after the event and a further two are made in this report.

History of the flight

The two pilots, and others, were members of a group from the Welland Gliding Club, which regularly organised expeditions to fly at the Yorkshire Gliding Club at Sutton Bank; the club hosts many such expeditions each year from clubs around Britain. The group arrived on the Saturday before the accident, intending to spend the week gliding and socialising.

The gliding club site is situated on top of a ridge, which forms around a bowl on its western side (see Figure 1). The site has two takeoff and landing 'runs', north/south and east/west. The east/west run was in use on the day of the accident, with the launch point established just south of the club building. The elevation of the site is 920 ft amsl and its geographical situation provides the opportunity for ridge soaring, whilst the presence of the Pennine hills to the west means that wave lift is also often present. Orographic cloud often forms over the site, sometimes rapidly, when a moist westerly air stream exists in the area.

On the day of the accident, the weather at Sutton Bank was changeable. Three training flights took place in the morning but a rain shower then stopped flying for a time. Once the rain shower had passed, operations recommenced, with aerotow launches. The ASW 19 (GDP) was launched at 1447 UTC and the SF27 (HGM) directly afterwards at 1458 UTC.

No evidence was available of the flight of the ASW 19 from the end of the aerotow launch until the final moments before the collision.

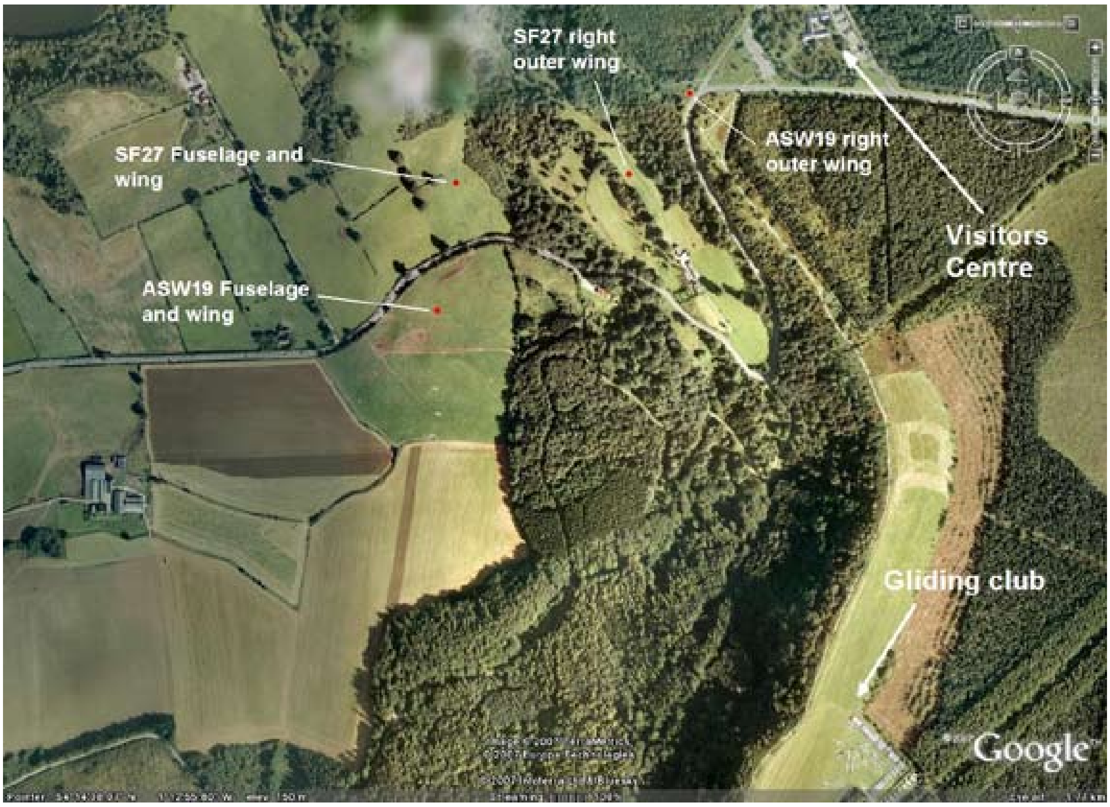


Figure 1
Accident site

The surviving (SF27) pilot recalled releasing from the aerotow at 2,000 ft above the site[1] and soaring near, and predominantly to the south of, the site, during which time he was concerned about a bank of cloud to the west-south-west of the airfield, drifting towards it. Shortly before the collision he was tracking roughly north along the ridge to the west of the site, at about 1,500 ft. Immediately prior to the collision, he recalled being in a gentle left turn, skirting around a cloud mass, the edge of which was somewhat broken and "scuddy". His intention was to manoeuvre towards the Thirsk area, where the weather was clearer. He recalled that his speed was about 45 kt and he was experiencing a little lift. He was monitoring communications on the Sutton Bank gliding frequency, 129.975 MHz, on his radio. He heard no communications which related to the ASW 19 after his launch.

The SF27 pilot suddenly saw the orange wing tip and nose of another glider at between his one and two o'clock position[2], and he realised that a collision was inevitable. Instinctively he entered a descending left turn, with the objective of preventing a cockpit-to-cockpit collision (which he thought highly probable and likely to be fatal). He recalled that the other aircraft "may have been descending out of scuddy cloud", and that it may have been flying fast and straight towards him. He ducked his head as the other aircraft's wingtip was about to impact his canopy, and immediately heard a loud bang.

The two aircraft collided almost head on, each aircraft's canopy being severely damaged by the other's wing. The wing structure of the SF27 separated from the fuselage; one wing of the ASW 19 separated approximately half way along its span.

Footnote

1 Glider pilots operating at Sutton Bank commonly refer to their vertical position as height above the site. The site is 920 ft amsl.

2 Relative position of another aircraft is frequently expressed by 'clock code': an aircraft straight ahead is at 12 o'clock, one to the right at three o'clock, directly behind at six o'clock, and to the left at nine o'clock. Other points are referred to in order.

The SF27 pilot then felt a cold rush of air, and his aircraft rolled to the right to an inverted position. He did recall operating the canopy jettison lever, but the canopy did not part from the glider. A substantial part of the canopy had been destroyed in the impact and the pilot later remembered kicking himself free of the cockpit and being momentarily delayed in locating his parachute release, before operating it. He heard the parachute canopy deploy and then looked up to check that it had deployed correctly. He made an uneventful parachute descent, landing in a wooded area. His parachute canopy caught in the trees and he found himself suspended by his canopy and harness, his toes just touching the ground. He released his harness and made his way to a clearing in the trees where he used his mobile telephone to call the club, before walking out of the wood towards a nearby road and being met by the emergency services. He sustained a broken bone in one hand, and cuts and bruises.

The ASW 19 and its pilot fell to the ground. The pilot was found close to the wreckage of his glider, his harness was found unfastened and the canopy release mechanism had been operated. He was wearing a parachute but it had not been operated. The impact with the ground was not survivable.

Staff and visitors at the club called the emergency services as soon as they heard the collision. A flying instructor, airborne in a motor glider, made a 'MAYDAY RELAY' call addressed to the Distress and Diversion cell at the London Area Control Centre, which was relayed to the cell by a commercial aircraft airborne near London. The instructor selected 7700 on his transponder[3] to assist ATC in identifying the location of the accident.

Footnote

3 The 'MAYDAY' code, which alerts air traffic controllers using secondary radar to an aircraft in distress.

Witness recollections

There was only one eyewitness to the collision. The partner of another glider pilot was standing in the car park beside the gliding club, and observed three gliders airborne: the ASW 19, the SF27, and her partner's glider. In due course, she saw two gliders "heading towards each other in thin misty cloud" and then colliding. She saw wreckage falling, and one parachute opening and descending.

Another pilot, the partner of the eyewitness, was airborne at the time. Prior to the collision, he recalled flying along the ridge, and attempting to make radio contact with the ASW 19 pilot, first on the Sutton Bank frequency 129.975 MHz and then on 130.4 MHz, the 'cloud flying' frequency. He intended to inform him of a "squall with a band of cloud" approaching the site. He recalled that he was flying at approximately 1,000 ft above the site, below "an upper, broken layer of cloud, base approximately 1,350 to 1,400 ft above the site". He also recalled that "rain was falling on the southern end of the bowl with isolated patches of scud covering the majority of the bowl area". He recalled flying along the ridge, towards the north, just past the middle of the bowl, and seeing another glider "higher, at approximately 1,400 ft above the site…", shortly after which he heard a thud. He immediately checked his flying controls, which responded normally, and then he turned to the left and saw debris falling from the sky.

A gliding instructor was at the launch point when he heard a 'crunch', which he realised was a mid-air collision. He saw "two gliders, seemingly locked together – the wreckage separated leaving one glider spinning around and the other with debris also falling from the sky". He then saw a parachute open.

Recorded data

Both gliders had a GPS receiver coupled to a glider logger. The GPS receivers and the loggers had the ability to record the track of the aircraft to memory. In all cases, a battery was required to maintain the memory. The GPS from the SF27 was never recovered; the glider logger was recovered but had failed to record the track of the accident flight due to a low battery.

The GPS from the ASW 19 was recovered but was not operational. Investigation revealed that the power circuitry had been disrupted during the accident, such that the battery powering the memory quickly depleted, losing any track information that may have been recorded. However, the glider logger had sufficient battery power to maintain its memory but was too damaged for a normal download of the unit. The memory was extracted with the assistance of the Bureau d'Enquetes et d'Analyses (BEA - equivalent to the AAIB in France) and decoded with the assistance of the logger manufacturer and one of the original design team members. It was established that the last logged flight was on the previous day.

Radar data from the Claxby and Great Dun Fell radar heads were analysed. The only steady tracks recorded were secondary radar tracks relating to aircraft that had ATC transponders switched on. Neither glider was equipped with a transponder and primary radar was not able to track targets in the area at the altitudes involved.

At 1516 hrs a secondary radar detected a transponder transmitting the emergency 7700 squawk in the area of the accident. Previously, secondary radar had not detected this aircraft, suggesting that the aircraft's transponder was switched on at 1516 hrs specifically to transmit the emergency code. Subsequently, radar tracked the transponder staying close to the accident site.

In summary, neither the radar data nor the data from the onboard equipment yielded evidence useful in this investigation.

Meteorology

The Met Office provided an aftercast which showed low pressure centered over the North Sea feeding a moderate west-north-westerly airflow over Yorkshire on the day of the accident. The weather was partly cloudy with some showers in the area. Surface visibility was assessed as 30 to 40 km but locally 10 to 15 km in showers. The cloud was one or two octas of cumulus, base 2,500 ft, becoming three to seven octas of cumulus base 2,000 to 2,500 ft in showers. There were three to seven octas of strato-cumulus with a base between 5,000 and 8,000 ft. The report also stated that:

> *'it is possible that stratus cloud was forming on west-facing ridges base between 1,500 and 2,000 ft.'*

The wind at the surface was assessed to have been from 250° at 15 kt, with isolated gusts up to 25 kt. The wind at 1,000 ft was from 270° at 20 kt, and at 2,000 ft from 280° at 20 to 25 kt.

Communications

Both gliders were fitted with VHF aeronautical radios. In the Yorkshire Gliding Club Standard Operating Procedures (SOPs), the following instruction was given regarding radio communications:

> *'The club frequency is 129.975 MHz'*
>
> *'The frequency shall be used for all communications with the gliding club and within 10 nm of site.'*

The radio fitted in the ASW 19 was found with frequency 130.4 MHz selected. Neither 129.975 nor 130.4 MHz is recorded, and no witnesses recalled hearing transmissions from the aircraft on the day of the accident.

The BGA's *'Laws and Rules'* list the frequencies to be used for glider operations in the *Recommended Practices'* section as follows:

> *'130.4 MHz Cloud flying and relaying cross-country messages only.*
>
> *129.975 MHz As a control frequency within a 10 NM radius and up to a height of 3,000ft. above certain approved airfields. (CGFF – Common Glider Field Frequency).'*

There is no advice about frequency use when cloud flying in the vicinity of *'approved airfields'* such as Sutton Bank.

The SF27 pilot

The SF27 pilot had begun gliding in 1989, and had flown regularly since then. He gained a basic instructor qualification in 1996 and an assistant category instructor qualification in 1997. He was a BGA airframe inspector. He first flew at Sutton Bank in 1996, and then in 1997, and each year afterwards.

The SF27 pilot was in the habit of practising emergency procedures regularly, including self-briefing on how to abandon his aircraft, and practising the required actions. He told AAIB investigators that he considered this was a significant factor in his successful abandonment of his aircraft.

He was an assistant category instructor at the Welland Gliding Club. As an instructor, and taking his age into account, he was required to renew his medical declaration every five years. His last medical declaration was on

1 May 1996. To ensure continuity of qualification this declaration should have been renewed by the end of April 2001 and then again by the end of April 2006. The club's instructor records for 2003, 2004, and 2005 showed this renewal date, but the club management had not identified that his medical declaration had lapsed.

After the accident, the SF27 pilot underwent an eye examination with a CAA optometrist, who found that his uncorrected eyesight was well within the standards required for the medical declaration. He did not wear corrective lenses.

The ASW 19 pilot

The ASW 19 pilot learnt to glide in 1998-99, and flew regularly thereafter, purchasing the ASW 19 in 2002. He made regular annual trips to Sutton Bank with other members of his gliding club. He held a BGA Silver Certificate and a valid medical declaration to Group 1 standard.

A post-mortem examination carried out on the pilot revealed no pre-existing medical conditions and the toxicological report was negative.

Oversight of gliding activity in the UK

Gliding in the UK is not formally regulated, but the British Gliding Association (BGA) offers a system of voluntary oversight including the publication of Laws and Rules for glider pilots, instructors, and examiners, and a system of accreditation of flying ability with certificates for heights gained, distances flown, and durations of flight. Almost all gliding clubs in the UK are members of the BGA and have agreed to be bound by its procedures.

BGA Laws and Rules and other information

Only two BGA Rules apply specifically to flight in or near cloud:

> *'6.12 No glider shall enter cloud within a radius of 5 nautical miles of a gliding site, except from at least 200 feet from below the lowest part of the cloud.*
>
> *6.13 No glider shall enter cloud unless all its occupants are wearing parachutes and have been instructed in their use.'*

The Rules of the Air Regulations permit gliders in the UK to operate under VFR or IFR in Class F or G airspace. No training syllabus has been published and there is no requirement for training relating to cloud flying under IFR. There is no minimum experience level, and no minimum aircraft equipment requirement for glider flight under IFR.

AAIB investigators met with members of the BGA executive who provided a copy of a publication entitled *'Bronze and Beyond'*[4], which is frequently read by glider pilots seeking guidance on, and amplification of, the Laws and Rules. In the section *'Flying in cloud – procedures'*, the book states:

> *'You should use your radio to announce on 130.4 MHz that you are entering cloud. You should give your callsign, height and position, and say that you are entering cloud…*
>
> *When you leave the cloud, announce your callsign and the fact that you are now clear of cloud.'*

Footnote

[4] 'Bronze and Beyond' by John McCullagh, ISBN 0-9548742-0-X.

Previous mid-air collisions involving gliders in the UK

The BGA provided information (an internal report) on previous mid-air collisions between gliders in the UK. The report identified a total of 37 mid-air collisions, and a breakdown of the types of collision is given in the tables below.

33 of the 37 collisions were in the glider circuit or the vicinity of the gliding site ('vicinity' was not formally defined) see Table 2. Weather had been deemed to be a factor in only one other event (AAIB report EW/C2004/04/03). In that event, two gliders collided in conditions of decreased visibility below cloud near Lasham airfield. The investigation determined that late sighting by the pilots of each others' aircraft meant that there was insufficient time for effective avoiding action to be taken.

Collision avoidance in glider operations

Glider flying is usually conducted without the intervention of air traffic control; indeed imposition of effective control upon aircraft which rely upon atmospheric lift for sustained flight would be practically difficult. On occasions, gliders do enter or cross controlled airspace, but this accident occurred in Class G airspace.

Glider pilots, therefore, are responsible for using the 'see and avoid' principle to prevent collisions with other aircraft and must maintain an effective lookout.

Mid-air collisions involving gliders 1987 - 2006			
Aircraft involved	*Collisions*	*Fatal collisions*	*Fatalities*
Glider/Glider	27	10	17
Glider/Tug aircraft	7	2	3
Glider/Light aircraft	2	1	1
Glider/Parachutist	1	1	2
Totals	37	14	23

Table 1

Mid-air collisions involving gliders (and tugs) by flight regime	
Flight regime	*Collisions*
In or joining thermal	13
Airfield circuit	13
Ridge soaring near airfield	3
Thermal soaring near airfield	3
Following close behind	2
Total	34
Note: this table excludes the three collisions between gliders and light aircraft/parachutist	

Table 2

Flight in or near cloud

AAIB investigators discussed the practice of flying in or near cloud with the BGA executive. The BGA put forward the perspective that very little such flying occurred in relation to the total amount of glider flying, and that much of this flying was done by glider pilots who were professional pilots and therefore likely to be competent at instrument flight and well aware of the hazards inherent in flight in restricted visibility.

Further information - collision avoidance systems

The nature of gliding, particularly at hill soaring sites, is such that there may be numerous gliders flying in relatively close proximity and pilots must keep a good visual look out to avoid potential collisions. In order to assist in collision avoidance several electronic systems have been developed to provide early warning of potential collision to glider pilots. One such system makes use of a low-powered radio transceiver, linked to a GPS system, which transmits and receives location, speed and direction information. A processor within the unit identifies any potential conflicts and then alerts the pilot to the direction and relative level of danger. This system is not, however, compatible with the collision avoidance systems used by general and commercial aviation. The system has been adopted in some areas within Europe, such as the Alps, but as yet has not seen widespread use in the UK. Several trials are currently being undertaken by the British Gliding Association to determine the system's effectiveness and training requirements. Neither glider involved in this accident had the equipment fitted.

Engineering examinations

Wreckage distribution and examination

The remains of the gliders occupied four separate sites. The fuselage and majority of the wing structure of the SF27 had landed in a field at the bottom of Sutton Bank, approximately 150 meters north of the A170 road. A section of the SF27's right wing, together with the remains of the aircraft's canopy, were found part way up the slope of the Bank, 200 metres east of the rest of the glider. The ASW 19 was at the bottom of the Bank in a field immediately to the south of the A170. Numerous fragments of both gliders' wings and canopies, the SF27's wing/fuselage fairing and a 2.9 metre long section of the ASW 19's right wing were found on the A170 and the visitors centre car park at the top of the Bank. The distribution of the wreckage is illustrated in Figure 1.

The fuselage of the SF27 was substantially complete and continuity of the aircraft's controls within the fuselage was confirmed on site. The wing structure had suffered from significant break up.

The ASW 19 appeared to have impacted the ground at a very steep angle and was found inverted, the pilot probably being thrown from the cockpit during the ground impact. The right wing of the glider had been severely damaged in the region of the right air brake and was missing approximately 3.5 metres of its outboard section including the right aileron. The continuity of the controls was confirmed to the tail, left wing and up to the break in the right wing.

Fragments of the cockpit canopy frame and glazing, together with the remains of a PDA (palmtop computer) and GPS were recovered from the area immediately around the glider; one item of specific interest recovered from the field was the 'D' ring from the pilot's parachute, which had become detached from the parachute deployment lanyard. The pilot's parachute had not deployed and the swaged 'ball' used to retain the 'D' ring had been pulled off the end of the deployment lanyard. A fingertip search of the area around the glider failed to locate the 'ball'. When the glider had been 'righted' the seat harness was found unfastened and apparently undamaged. The forward section of the cockpit canopy, which included the canopy jettison latch, was found in the cockpit - the latch was in the 'jettison' position but the canopy had remained attached to the glider by several electrical cables which had been secured by a cable tie.

The remains of both gliders were recovered to the AAIB for further detailed examination.

Detailed examination

The log books for the gliders confirmed that they both possessed valid British Gliding Association (BGA) Certificates of Airworthiness and had been maintained in accordance with the BGA Glider Maintenance Schedule. The records for the ASW 19 confirmed that it had a 'fixed' instrument panel; a modification had been issued by the manufacturer which allows the instrument panel to hinge upwards with the canopy to allow easier access to the cockpit.

Schiebe SF27

Examination of the control circuits within the fuselage showed no evidence of pre-impact damage or disconnection and, despite the fragmentation of the wing, all of the wing control circuits were identified and no evidence was found of pre-impact damage or disconnection.

The rear structure of the cockpit, including the pilot's headrest, had been significantly damaged and the wing mounting structure immediately behind the cockpit had been severely disrupted on the right side. The damage to the cockpit canopy matched the damage to the fuselage, which confirmed that the canopy was in position when the damage occurred and was consistent with an impact from an object passing over the SF27 from nose to tail. Fragments of the wing/fuselage fairing were found to have orange paint transferred, probably from the airbrakes of the ASW 19.

The wing structure consisted of three major sections. The right wing was intact for 2.6 metres outboard of the right wing root but then a section of the wing structure, approximately 1.8 metres long, had been fragmented. This damage was consistent with the airborne collision.

Schleicher ASW 19

Examination of the ASW 19 showed that the right wing had failed 2.9 metres from the wing tip, in the region of the right wing airbrake, and the section of wing released by the failure included the right aileron. A fragment of wing skin, identified as being from the underside of the wing in the region of the failure, was found to have black paint smeared onto its surface which was only found on the tubular frames of the SF27's fuselage structure. The angle of the smearing indicated that a portion of the SF27 had hit the leading edge of the wing between 2.9 and 4 metres from the wing root whilst moving under the wing at an angle of 25°, from left to right, relative to the ASW 19.

The flight instrumentation fitted to the glider had been significantly damaged. However it was possible to determine, after disassembly that the gyroscope within the artificial horizon had been rotating with some speed at the time of impact with the ground.

Examination of the cockpit confirmed that the seat harness was undamaged and did not exhibit any 'hardening' of the belt webs at the harness mounting points which is normally seen when such material is subjected to impact loads. The harness locking mechanism functioned correctly and showed no evidence of being subject to excessive force.

ASW 19 cockpit canopy

The ASW 19 cockpit canopy is secured to a hinged arm at its forward edge by a 'toggle' latch, which allows it to be lifted forwards and upwards for entry and exit. The canopy is locked closed by two 'latch pins', in the rear canopy frame, which protrude into holes in the fuselage structure. In an emergency the canopy can be jettisoned by pulling a knob which releases the forward 'toggle' latch and allows the canopy to swing upwards and rearwards in the airflow; given sufficient airspeed the canopy will jettison with the rear locking pins still engaged. However; at low speed or in unstable flight, it may be necessary for the pilot to release the two rear pins to allow separation of the canopy.

The mounting plate (for the cockpit canopy) on the forward hinge arm was examined and found free from damage or witness marks from the forward canopy latch. The cockpit canopy frame had broken into several pieces but both rear latch pins were secure in their respective frame sections and the position and damage to the pins confirmed that they were extended in the 'locked' position when the glider struck the ground.

Two mounting brackets, one to hold a PDA and the other to hold a GPS unit, were found attached to the canopy frame. The cables, 'cable-tied' to the forward section of the canopy frame, were confirmed as being used to provide power to units fitted in these mounts. One of the cables was a multi-core coiled cable which was securely attached to the metal frame used to mount instrumentation and electrical connectors in the cockpit. The mounting plate on the canopy hinge arm was examined in detail, particularly in the area where the canopy jettison latch would engage, and found to be free from any damage or distortion.

Examination of a similar ASW 19 showed that, in the seated position, the pilot's knees are raised above the hips and the lower legs project under the instrument panel to a point just below the knees, with little space available for movement of the lower legs. During informal trials on the ground, it was found to take five to six seconds for a person to extricate himself from the cockpit.

The parachute worn by the pilot of the ASW 19 was a Thomas Sports Equipment TSE28 parachute. The data card in the parachute confirmed that it had been inspected and repacked by the manufacturer in October 2005. The manufacturer confirmed that the 'D' ring retaining ball is 'pull' tested with a 300 lb load before installing the rip cord in a parachute, that the minimum height required to obtain a full deployment of the parachute is 500 ft and that the recommended method used to operate this type of parachute is to grasp the 'D' ring in both hands and pull it downwards and across the body.

The parachute's deployment lanyard, consisting of a multi-strand cable, had 'unwound' and its end was bent, indicating the application of a significant side load. The 'D' ring was compared to that of a sample TSE28 and found to be deformed, see Figure 2. Tests carried out on a sample parachute showed that this damage was consistent with a high side load applied in the ground impact and, when pulled using the recommended method, the sample parachute and the parachute from the ASW 19 deployed with a steady force of about 6 kg .

Figure 2
'D' ring distortion

Analysis of impact and escape issues

The paint transfer seen on the SF27 overwing fairing, and the fragment of the lower surface of the right wing from the ASW 19, confirmed that initial impact was between the right wing of the ASW 19, approximately 3 metres outboard of the wing root, and the cockpit canopy and right wing root of the SF27, see Figure 3. The forces involved in such a collision would have been sufficient to disrupt the wing-to-fuselage mountings of the SF27 and cause the separation of the outboard section of the ASW 19 wing. The loss of such a large portion of the wing, including the aileron, would have made the ASW 19 uncontrollable and caused it to roll right as it descended. The fact that fragments of both glider's canopies were found at the top of Sutton Bank, and that a 3 metre section of the right outboard wing of the SF27 was found 200 metres away from the main wreckage, confirmed that there were additional impacts between the two gliders but there was insufficient evidence to determine the sequence of these additional impacts. At some point after the initial impact the outboard right wing of the SF27 failed, approximately 4.5 metres from the wing root, which would have made this glider incapable of flight.

The pilot of the SF27 stated that the collision occurred at approximately 1,500 ft above Sutton Bank. Calculations by the AAIB indicated that the time taken for both gliders to descend to the ground would have been approximately 14 seconds and they would have descended below the minimum height (500 ft) for a full parachute deployment within about 10 seconds. The evidence at the site indicated clearly that the pilot of the ASW 19 had managed to unfasten his seat harness but had not managed to leave the cockpit of the glider before it hit the ground; the damage to the parachute 'D' ring was further indication of this.

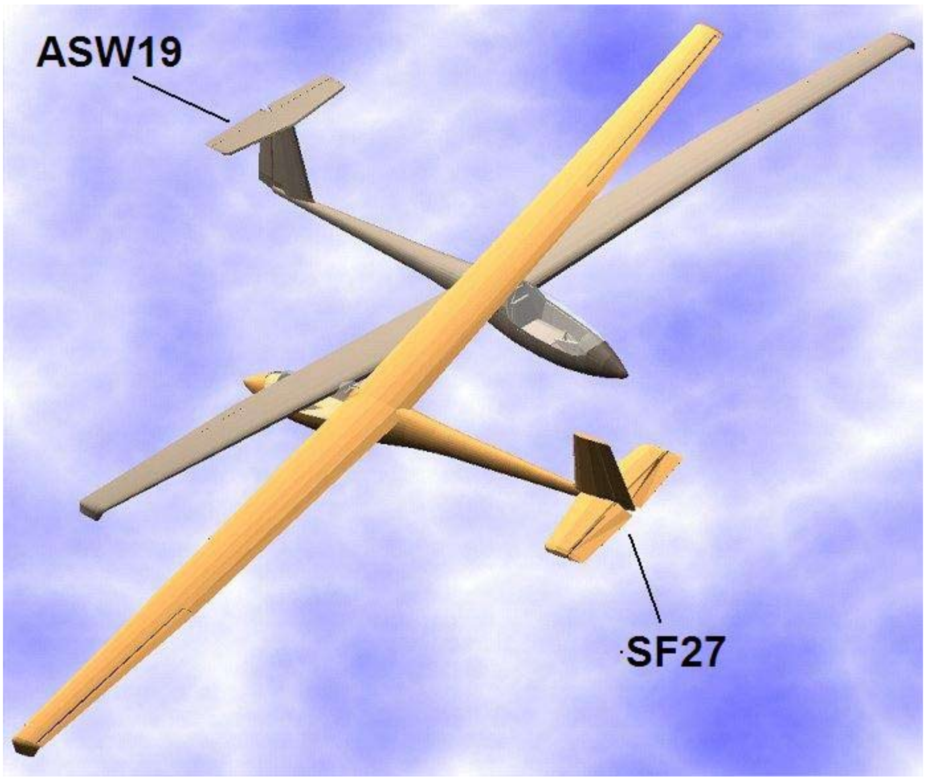


Figure 3
Collision reconstruction

Three factors appear to have acted against the ability of the pilot of the ASW 19 to escape successfully in the limited time available. First, and most significantly, was the presence of the cables attached to the front of the canopy frame. Despite the severity of the impact with the ground, and the break up of the canopy frame, the forward section of the frame had remained attached to the gliders fuselage by the PDA and GPS cables; it is therefore considered that, even had the jettison sequence been completed, the cables would have prevented a successful separation of the cockpit canopy. This factor was identified early in the investigation and was the subject of two AAIB Safety Recommendations, published in AAIB Special Bulletin S8/2006.

Second, the canopy jettison sequence in the ASW 19 had not been completed. Although the lack of distortion or witness marks to the forward canopy hinge plate, where the canopy jettison latch locates, indicated that the leading edge of the canopy had been released, the distortion to the rear canopy locking pins confirmed that they had remained in the locked position. Given the uncontrolled nature of the glider's descent, and the significant loss of airspeed during the collision, it is likely that there would have been insufficient airflow over the canopy for it to separate without disengaging the two rear locking pins.

The third factor was the configuration of the ASW 19 cockpit. The layout of the SF27 cockpit is relatively 'open' with little or no restriction to leg movement, whereas the 'fixed' instrument panel in the ASW 19 would have presented a restriction to the pilot attempting to bail out. The uncontrolled gyrations of the ASW 19 after the collision would have aggravated this situation.

In summary, no technical defects were identified which would have contributed to the mid-air collision and the damage sustained by both gliders was sufficient to render them both incapable of flight immediately after the collision. The relatively low altitude of the mid-air collision gave both pilots very little time to abandon their gliders successfully. The restrictive nature of the ASW 19 cockpit and the uncontrolled nature of the glider's descent would have significantly increased the time required to 'bail out' of the glider. The pilot of the ASW 19 had begun attempts to abandon his glider but did not complete them before it hit the ground.

Safety actions and recommendations on escape

AAIB discussion with experienced glider pilots and members of the BGA, on the subject of cockpit cables, suggested that similar modifications may have been made to other gliders. Therefore, the following Safety Recommendations were made in AAIB Special Bulletin 8/06, in December 2006:

Safety Recommendation 2006-127

The BGA should advise glider pilots to incorporate into their pre-flight checks a check to ensure that no modifications have been made which would prevent the canopy being jettisoned in emergency.

Safety Recommendation 2006-128

The British Gliding Association should remind its inspectors of the provisions of BGA Glider Maintenance Schedule Task 8, specifically with regard to ensuring that any canopy may be fully jettisoned without restriction.

The BGA has accepted these recommendations. In addition, on a number of occasions the BGA has reminded pilots of the need to ensure that nothing interferes with the correct operation of canopy jettison systems. This has included technical documentation and an article in the BGA 's own '*Sailplane and Gliding*' magazine.

Analysis of the collision

The engineering investigation indicated that both aircraft were serviceable until the moment of collision.

Both pilots were experienced and reasonably current, and both had previous experience of flying from the Sutton Bank site. Although the SF27 pilot's medical declaration was out of date, the examination carried out by the CAA provided reassurance that his eyesight met the relevant standards.

The history of mid-air collisions involving gliders in the UK from 1986 to 2006 does not demonstrate that flight in or near cloud is a frequent factor in mid-air collisions; only one similar accident was recorded.

The absence of any record of the flight of the ASW 19 deprived the investigation of important information. However, the eyewitness account of the two aircraft colliding close to cloud, and the SF27 pilot's recollection of seeing the other aircraft coming towards him, perhaps descending out of cloud, suggest that the pilot of the ASW 19 may have been descending from within cloud or flying on the edge of cloud. The engineering investigation also found that his artificial horizon was operating at the time of the accident. His radio, tuned to the cloud flying frequency, suggested that he had either been flying in cloud, or had considered doing so. Therefore, it seems probable that the collision occurred as the ASW 19 descended out of cloud, or through 'scuddy' cloud near the main cloud base.

Glider operations rely upon the 'see and avoid' principle, and operations in or near cloud make this method of collision avoidance difficult or impossible.

This collision was essentially a consequence of misfortune. However, by choosing to fly close to or in cloud, each pilot had accepted an elevated risk of encountering another aircraft with little or no time to see and avoid it. The investigation considered the general practice of flying gliders in cloud and identified that little guidance exists, and no formal training is available to glider pilots who wish to learn to fly in cloud. It is considered that further action on the part of the BGA would assist pilots in making good decisions relevant to the risks inherent in flight in or near cloud, and therefore, the following Safety Recommendation is made:

Safety Recommendation 2007-096

It is recommended that the British Gliding Association should remind glider pilots of its operational regulation 6.12 and provide reference material for its clubs, instructors, and pilots, that identifies the risks associated with flying gliders close to cloud or in marginal visual flying conditions.

There was a safety mechanism which could have given the pilots of the two aircraft the opportunity to be aware of each others' proximity, and perhaps have assisted in avoiding collision, namely the use of their VHF radios[5]. Although the BGA had promulgated procedures under which glider pilots could make radio calls announcing their intentions to fly in cloud, and provided a specific frequency for this purpose (130.4 MHz), similar guidance (and the standard operating procedure at Sutton Bank) suggested that pilots flying in the vicinity of the airfield should use and monitor another frequency (129.975 MHz). Thus, while pilots engaged in cloud flying would be aware of each others' presence and intentions, those not cloud flying, but flying close to the base or edge of cloud, would not be aware of the aircraft in, and possibly about to exit, the cloud. Where the cloud was widespread, and perhaps its boundaries indistinct, this would provide an opportunity for two pilots, with the best intentions of complying with the relevant guidance, to encounter each other's aircraft at close quarters without warning.

This was discussed with the BGA, and the following Safety Recommendation is made:

Safety Recommendation 2007-097

It is recommended that the British Gliding Association should provide its clubs, instructors, and pilots, with guidance to achieve the most effective use of the BGA cloud flying frequency for collision avoidance purposes. This guidance should take account of local requirements to monitor other frequencies.

Additional safety actions

In the time since the accident, the Welland Gliding Club has undertaken to introduce robust procedures to ensure that instructors have current medical declarations.

Footnote

[5] There is no regulation requiring gliders to carry radio equipment, whether cloud flying or not, but radios are very commonly fitted to gliders used for cloud flying.

ACCIDENT

Aircraft Type and Registration:	Skyranger 912(2), G-CEDZ
No & Type of Engines:	1 Rotax 912 UL piston engine
Year of Manufacture:	2006
Date & Time (UTC):	21 March 2007 at 1430 hrs
Location:	Oxenhope, West Yorkshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to propeller, nose leg and screen
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	43 years
Commander's Flying Experience:	202 hours (of which 14 were on type) Last 90 days - 4 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

During a diversion due to illness, the pilot made a fast approach in turbulent conditions resulting in a bounced landing and the microlight overturning.

History of the flight

The pilot, who had recently converted from flex-wing microlights, took off from Huddersfield with the intention of carrying out a local flight. During the flight he began to feel ill and as Oxenhope was the nearest airfield, he elected to land there. The weather conditions at Oxenhope were CAVOK but turbulent. The pilot selected an approach speed of 55 mph. During the approach the pilot found it difficult to maintain the centreline due to the turbulence and his developing stomach pain. He touched down slightly fast at the very beginning of grass Runway 29 which is 450 m long. The aircraft bounced and the pilot lowered the nose for a second landing. As it touched down, the nose leg collapsed and the spinner dug into the grass, flipping the aircraft onto its back.

The pilot, who was wearing a full harness, was uninjured and made a rapid exit through the P1 door as there was fuel leaking from the tank breathers. The pilot estimated that approximately 40 ltr of fuel leaked from the breathers by the time he evacuated the aircraft. This caused a large pool of fuel to gather and he was very concerned about the risk of fire.

Aircraft examination

The pilot conducted an inspection of G-CEDZ after the accident and determined that the nose leg had been damaged during his initial touchdown by failing along a weld at the fork. This caused the wheel rim to lock on the second touchdown collapsing the leg.

Pilot comments

The pilot commented that his developing medical condition combined with the turbulence to distract him from the landing. He also commented that he had initially touched down in the roughest part of the grass runway.

AIRCRAFT ACCIDENT REPORT No 6/2007

This report was published on 11 December 2007and is available on the AAIB Website www,aaib.gov.uk

REPORT ON THE ACCIDENT TO AIRBUS A320-211, REGISTRATION JY-JAR AT LEEDS BRADFORD AIRPORT ON 18 MAY 2005

Registered Owner and Operator:	Jordan Aviation, Hashemite Kingdom of Jordan
Aircraft Type:	Airbus A320-211
Nationality:	Jordanian
Registration:	JY-JAR
Place of Accident:	Leeds Bradford International Airport, UK
Date and Time:	18 May 2005 at 1143 hrs All times in this report are UTC unless otherwise stated

Synopsis

The accident was notified to the Air Accidents Investigation Branch (AAIB) by Air Traffic Control at Leeds Bradford International Airport at 1155 hrs on 18 May 2005. The following Inspectors participated in the investigation:

Mr J J Barnett	Investigator-in-Charge (until 30 April 2007)
Mr A P Simmons	Investigator-in-Charge (from 30 April 2007)
Mr J M Firth	Operations
Mr A N Cable	Engineering
Mr J R James	Flight Recorders

While landing on Runway 14 at Leeds Bradford Airport the aircraft touched down just beyond the end of the marked touchdown zone with low autobrake selected. Manual wheel braking commenced shortly after mainwheel touchdown. At a groundspeed of around 70 kt the brakes ceased operating, for about 17 seconds. A pronounced dip in the runway surface initially prevented the pilots from seeing the runway end. When it became apparent to the commander that it would not be possible to stop before the end of the runway, he deliberately did not select alternate braking, as this would have caused loss of nosewheel steering, but instead used nosewheel steering to turn the aircraft sharply to the right. The aircraft skidded sideways and came to a halt with its nosewheels off the runway, shortly before the end of the paved surface and the start of a steep down slope.

The cause of the braking loss could not be positively established but it was consistent with the effects of excessive noise in the electrical signals from the mainwheel tachometers used to sense groundspeed. Two of the tachometer driveshafts were found bent and it was known that this encouraged a resonant condition that could cause tachometer signal errors above the groundspeed at which they would be detected by the aircraft's monitoring systems. Should the condition affect both main landing gears simultaneously, the brake control system logic could generate an erroneous aircraft reference speed, which could activate the anti-skid system and release the brakes. Fluctuation in the signal errors would prevent the system from detecting and correcting the braking loss or providing a warning to the crew.

It was found that there were a number of other known anomalies with the brake control and monitoring system that could cause either brake failure or locking of the wheels, some of which had resulted in previous incidents and accidents. The aircraft manufacturer and the Airworthiness Authority had defined and implemented corrective actions, and redesigned tachometer driveshafts and updated software intended to correct some of the faults were available, but had not been incorporated on a substantial number of aircraft, including JY-JAR. The findings raised concerns about the aircraft manufacturer's procedures intended to ensure design quality and continued airworthiness.

The investigation identified the following causal factors:

1. Excessive wheel tachometer signal noise, caused by a bent tachometer driveshaft on each main landing gear assembly, resulted in loss of braking using the Normal system.
2. Inadequate fault tolerance within the brake control system led to the sustained loss of Normal braking during the landing ground roll.
3. There was no flight deck indication of brake system malfunction, and this delayed the crew's recognition of the loss of braking.
4. There was a lack of effective action to fully rectify brake system anomalies apparent from previous incidents and accidents.

Seven Safety Recommendations were made.

Findings

1. The operating flight crew members were properly licensed and adequately rested to operate the flight.
2. The multi-lingual constitution of the crew did not adversely effect crew communications during the accident.
3 Neither flight crew member had landed at Leeds Bradford Airport before, so they were unfamiliar with the line-of sight characteristics of Runway 14.
4. The aircraft was below the maximum landing weight appropriate for the runway in the prevailing conditions and its centre of gravity was within permitted limits.
5. The speed of the aircraft over the landing threshold was consistent with the achievement of scheduled landing performance.
6. The aircraft touched down just beyond the end of the marked touchdown zone, approximately 400 m beyond the Aiming Point and 700 m beyond the displaced runway threshold.
7. The LO autobrake setting selected for landing was inappropriate for the conditions but manual braking was commenced about 4 seconds after touchdown and should have been adequate to stop the aircraft on the runway.

8. A pronounced dip in the runway prevented the pilots from seeing the end of the paved surface until late in the ground roll.

9. The Normal braking system malfunctioned at around 70 kt groundspeed causing the loss of almost all braking effect.

10. Automatic reversion to Alternate braking did not occur.

11. There was no flight deck warning of the brake malfunction.

12. The lack of a flight deck warning probably delayed the crew's recognition of the loss of braking.

13. The FCOM procedure for LOSS OF BRAKING was not completed.

14. If, after selecting MAX reverse thrust, the commander had followed the remaining actions of the LOSS OF BRAKING procedure, it should have been possible to stop the aircraft on the runway but it would have used at least 252 m of the remaining 280 m of paved surface.

15. The commander could not have known that the aircraft might have been stopped on the paved surface if he had persisted with the LOSS OF BRAKING procedure.

16. Alternate braking was not selected because of concerns that the consequent loss of nosewheel steering and anti-skid would severely reduce the directional control capability.

17. The aircraft was steered off the side of the runway overrun area using nosewheel steering.

18. The aircraft skidded sideways and came to rest with its nosewheels on a grassed area at the side of the runway overrun area shortly before a steep down slope.

19. Aircraft damage was limited to slight distortion of the nose landing gear caused by overload while running on the grassed area.

20. The driveshafts for two of the mainwheel tachometers used to sense wheel speed were found bent. This probably caused excessive noise in the tachometer electrical signals that resulted in an error in the groundspeed determined by the computerised brake control system and consequent release of the brakes by the anti-skid system.

21. Fluctuation in the tachometer signal noise probably prevented automatic correction of the Normal brake system loss and caused failure of the flight deck warning.

22. The aircraft monitoring systems were unable to detect the excessive tachometer signal noise as this occurred at a speed above the monitored speed range.

23. There were a number of other known anomalies with the brake control and monitoring system that could cause either brake failure or locking of the wheels, some of which had resulted in previous incidents and accidents.

24. The aircraft manufacturer had acted with the intention of correcting brake system anomalies identified during previous incident and accident investigations, but the corrective actions had not been entirely successful.

25. Redesigned tachometer driveshafts and updated software intended to correct some of the faults were available but had not been incorporated on a substantial number of aircraft, including JY-JAR.

Safety Recommendations

The following Safety Recommendations were made:

Safety Recommendation 2007-012

The Jordanian Civil Aviation Authority should ensure that aircraft operators under their jurisdiction have procedures in place to ensure the continued airworthiness of mandatory flight recorders.

Safety Recommendation 2007-013

The Civil Aviation Authority should publish information within the Aeronautical Information Package relating to runways which do not comply with the provisions of CAP 168, or which have profiles that reduce the ability of pilots to assess landing performance distance remaining visually, in the form of a 'Warning'. within the 'Local Traffic Regulations' section or the 'Remarks' area of 'Runway Physical Characteristics' for all affected UK airports.

Safety Recommendation 2007-014

The International Civil Aviation Organization (ICAO) should re-assess the benefits and disadvantages to runway situational awareness of runway distance markers for any runway which has a profile that prevents the end of the paved surface from being in view continuously from the flight deck. If the re-assessment concludes that a net benefit is likely, the ICAO should encourage the installation of such markers at relevant civil airports.

Safety Recommendation 2007-015

The European Aviation Safety Agency should require the expeditious replacement of the long hollow titanium tachometer driveshaft in the braking systems of the A320 family of aircraft with a driveshaft of improved design.

Safety Recommendation 2007-016

The European Aviation Safety Agency should ensure the replacement of software Standards 7 or 9 with Standard 9.1 or a proven later version, in those remaining Airbus A319 and A320 brake and steering control units not yet so modified.

Safety Recommendation 2007-018

The European Aviation Safety Agency should consider requiring, for aircraft in the A320 family and other aircraft with similar combined Brakes and Steering Control systems, changes that allow manual selection of Alternate braking without consequent loss of nosewheel steering.

Safety Recommendation 2007-019

The European Aviation Safety Agency should require Airbus to take measures aimed at ensuring that anomalies in A318/319/320/321 aircraft braking systems that may lead to loss of Normal braking are clearly indicated to the flight crew.

AIRCRAFT ACCIDENT REPORT No 7/2007

This report was published on 19 December 2007and is available on the AAIB Website www,aaib.gov.uk

REPORT ON THE SERIOUS INCIDENT TO AIRBUS A310-304, F-OJHI ON APPROACH TO BIRMINGHAM INTERNATIONAL AIRPORT 23 FEBRUARY 2006

Registered Owner:	CIE Kerman Aviation (a subsidiary of Mahan Air)
Operator:	Mahan Air
Aircraft Type:	Airbus A310-304
Nationality:	French
Registration:	F-OJHI
Place of Incident:	During the approach to Birmingham International Airport Latitude: 52° 21' N Longitude: 000° 47' W
Date and Time:	23 February 2006 at 1212 hrs All times in this report are UTC unless otherwise stated.

Synopsis

Air Traffic Control at Birmingham International Airport notified this serious incident to the Air Accidents Investigation Branch (AAIB) at 1240 hrs on 23 February 2006. The following Inspectors participated in the investigation:

Mr R J Tydeman	Investigator in Charge
Mr P Hannant	Operations
Mr S J Hawkins	Engineering
Mr M W Ford	Flight Recorders

The aircraft was on a scheduled flight from Tehran, Iran, to Birmingham International Airport in the United Kingdom (UK). Following an uneventful flight, the aircraft was radar vectored for a Localiser/DME approach to Runway 33. The aircraft commenced a descent from 2,000 ft to the published minimum descent altitude of 740 ft whilst still 11 nm from the runway threshold. At a point 6 nm from the runway the aircraft had descended to an altitude of 660 ft, which was 164 ft agl. The radar controller noted this descent profile and, through the tower controller, issued an immediate climb instruction. However, the crew had already commenced a missed approach, which they initiated when they received a GPWS alert. The aircraft was radar vectored for a second approach during which the flight crew again initiated an early descent. On this occasion, the radar controller instructed the crew to maintain their altitude and the crew successfully completed the approach. The aircraft landed safely from the second approach.

The investigation identified the following contributory factors:

1. The primary cause of the incident was the use by the crew of the incorrect DME for the approach at Birmingham International Airport.

2. There was also a substantial breakdown in CRM, which was partly due to the presence of a third flight crew member on the flight deck. He was not present during the approach briefing nor when the navigation information displayed was selected. He attempted to support the crew in their efforts to fly the approach but inadvertently re-enforced the commander's misinterpretation of the DME indications. This occurred despite the first officer initially recognising the discrepancy between the distance to the threshold and the distance displayed on the VOR/DME, and attempting to communicate this to the other members of the flight crew.

Three Safety Recommendations have been made.

Findings

1. The flight crew were properly licensed and qualified to conduct the flight, and were well rested. Their training, including CRM training, was in accordance with the operator's requirements.

2. The aircraft was certified, equipped and maintained in accordance with existing regulations and approved procedures. At the time of the incident there were no recorded Acceptable Deferred Defects that might have contributed to the incident.

3. The defect relating to AP 1 had not been entered into the aircraft's Technical Log.

4. The ATCO at Birmingham International Airport was properly licensed and qualified.

5. The flight crew had the relevant meteorological information, and the conditions during the approach were above the required minima.

6. The glide slope element of the ILS to Runway 33 was not available due to work in progress and the flight crew had been notified correctly.

7. The flight crew were familiar with the Localiser/DME approach to Runway 33.

8. The commander and FO had briefed the approach prior to the top of descent in accordance with their SOPs.

9. The supernumerary captain joined the handling crew at some point during the initial approach phase; he had not been a party to the approach brief.

10. The FMC database did not contain the ILS/DME approach to Runway 33 at Birmingham International Airport.

11. The FMS auto-tuned the Honiley VOR/DME and this distance was displayed on the DME/RMI instrument because the crew did not put the VOR/NAV/ILS switch to the VOR position.

12. The commander and supernumerary captain used the DME/RMI distance display as the primary source to fly the procedure.

13. The aircraft was radar vectored for the Localiser/DME approach procedure and positioned on an intercept heading, but the

AFS did not track the localiser. However, the commander manually over-rode the AP, turning the aircraft to the left with up to 36º angle of bank.

14. The MDA of 740 ft was incorrectly set.

15. The crew initiated an early descent, based on the Honiley VOR/DME distance, this was 5 nm before the correct descent point.

16. The aircraft was not equipped with a TAWS as required by the UK CAA regulations.

17. No standard calls were made during the approach.

18. The radar controller identified the early descent and contacted the tower controller, who instructed the aircraft to climb immediately to 3,000 ft.

19. The GPWS 'SINK RATE' warning sounded as the aircraft descended to a minimum height of 164 ft whilst 5 nm from the runway threshold.

20. The commander disengaged the AFS and increased both the pitch attitude and the power just prior to receiving the climb instruction from the tower controller.

21. The go-around was not flown in accordance with the operator's SOP, and during this manoeuvre the aircraft descended from 1,750 ft to 1,300 ft, before eventually stabilising at 3,000 ft.

22. The flight crew did not identify the reason for the early descent during their discussions following the first approach.

23. The aircraft was radar vectored for a second Localiser/DME approach procedure and positioned on an intercept heading, but the AFS did not track the localiser. Once again, the commander had over-ridden the AP, turning the aircraft to the left and exceeding 31º angle of bank.

24. An early descent was again initiated, using the distance from the Honiley VOR/DME.

25. The Radar controller observed the early descent and instructed the crew to return to 2,000 ft.

26. The PF flew the approach without the AFS and landed the aircraft safely.

Safety Recommendations

The following Safety Recommendations were made:

Safety Recommendation 2007-109

It is recommended that Mahan Air should develop operating procedures for the presence of additional flight crew members occupying a seat on the flight deck.

Safety Recommendation 2007-110

It is recommended that Mahan Air should conduct a thorough review of its CRM training programme to ensure that it is both appropriate for their needs and produces consistent and acceptable results.

Safety Recommendation 2007-111

It is recommended that Mahan Air should expand its FMS database to include all approaches relevant to their route structure.

FORMAL AIRCRAFT ACCIDENT REPORTS ISSUED BY THE AIR ACCIDENTS INVESTIGATION BRANCH

2006

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

Published January 2006.

2/2006 Pilatus Britten-Norman BN2B-26 Islander, G-BOMG, West-north-west of Campbeltown Airport, Scotland
on 15 March 2005.

Published November 2006.

3/2006 Boeing 737-86N, G-XLAG
at Manchester Airport
on 16 July 2003.

Published December 2006.

2007

1/2007 British Aerospace ATP, G-JEMC
10 nm southeast of Isle of Man (Ronaldsway) Airport
on 23 May 2005.

Published January 2007.

2/2007 Boeing 777-236, G-YMME
on departure from
London Heathrow Airport
on 10 June 2004.

Published March 2007.

3/2007 Piper PA-23-250 Aztec, N444DA
1 nm north of South Caicos Airport, Turks and Caicos Islands, Caribbean
26 December 2005.

Published May 2007.

4/2007 Airbus A340-642, G-VATL
en-route from Hong Kong to London Heathrow
8 February 2005.

Published September 2007.

5/2007 Airbus A321-231, G-MEDG
during an approach to Khartoum Airport, Sudan
on 11 March 2005.

Published December 2007.

6/2007 Airbus A320-211, JY-JAR
at Leeds Bradford Airport
on 18 May 2005.

Published December 2007.

7/2007 Airbus A310-304, F-OJHI
on approach to Birmingham International Airport
on 23 February 2006.

Published December 2007.

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http://www.aaib.gov.uk