CONTENTS

SPECIAL BULLETINS

None

COMMERCIAL AIR TRANSPORT

FIXED WING

ROTORCRAFT

None

GENERAL AVIATION

FIXED WING

ROTORCRAFT

None

SPORT AVIATION / BALLOONS

CONTENTS (Continued)

ADDENDA and CORRECTIONS

(ALL TIMES IN THIS BULLETIN ARE UTC)

INCIDENT

Aircraft Type and Registration:	Boeing 767-31K, G-DAJC
No & Type of Engines:	2 General Electric Co CF6-80C2B7F turbofan engines
Year of Manufacture:	1994
Date & Time (UTC):	15 August 2010 at 0750 hrs
Location:	Gatwick Airport, West Sussex
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 11 Passengers - 324
Injuries:	Crew - None Passengers - None
Nature of Damage:	Electrical overheating of an oven controller module
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	13,650 hours (of which 8,630 were on type) Last 90 days - 155 hours Last 28 days - 34 hours
Information Source:	Aircraft Accident Report Form submitted by the aircraft commander

Synopsis

Shortly after reaching cruise altitude, an electrical short circuit occurred in the oven controller module of the forward galley's right oven. Smoke caused by the overheating circuit board dispersed around the periphery of the left and right ovens in the forward galley, causing confusion regarding its source. The oven controller's 5 amp circuit breaker tripped, preventing further damage, and the aircraft diverted successfully to London Gatwick Airport. The source of the electrical overheating was traced to the connection between the oven controller's ON-OFF switch and its printed circuit board.

History of the flight

The aircraft was operating a passenger service between Manchester Airport and Dalaman Airport, Turkey. At 0710 hrs, shortly after the aircraft had reached its cruising altitude of FL370, the cabin manager informed the commander that smoke was emanating from an oven in the forward galley. The commander instructed the cabin manager to pull the forward galley ovens' circuit breaker and to check whether the smoke had cleared. A cabin crew member pulled the ovens' circuit breaker, but as acrid smoke continued to emanate from the ovens, a second cabin crew member discharged one bromochlorodifluoromethane (BCF) extinguisher into the right oven. The commander, having been informed of the situation, isolated the utility busbar. He made a PAN call to Maastrict ATC informing them of his intention to divert to London Gatwick Airport.

Smoke continued to issue from the forward galley ovens and cabin crew members discharged five additional BCF extinguishers into the left and right ovens. This was not effective, as the smoke appeared to originate from around the exterior of the ovens. The cabin manager assessed the situation and decided not to move any passengers as she had not received any complaints regarding smoke inhalation from either passengers or cabin crew members.

Maastrict ATC transferred the aircraft to London ATC, who offered the commander a direct approach to Runway 26L at London Gatwick, rather than Runway 08R which was in use. The commander accepted Runway 26L and the aircraft landed normally at 0750 hrs.

The aircraft vacated Runway 26L via Taxiway FR and parked on Taxiway J, to await an inspection from the AFRS. Owing to the narrowness of Taxiway J, the AFRS could not use steps to gain access to the aircraft and instead entered the aircraft at door L1, using a ladder. They confirmed that no fire was present and the aircraft was towed to a remote stand.

Description of the forward galley ovens

The aircraft was equipped with eight ovens: two in the forward galley and six in the aft galley. The forward galley ovens were mounted next to each other, as a pair. Each oven is an assembly of the oven unit and an oven controller module, mounted on top of the oven unit, as shown in Figure 1. The two ovens in the forward galley are supplied with 115 volt AC electrical power and are protected by a circuit breaker, rated at 15 amps, that is accessible to the cabin crew. Each oven controller module is additionally equipped with a circuit breaker rated at 5 amps, installed on the rear of the controller. This circuit breaker is not accessible without removal of the oven from the galley.

Examination of the right oven

Following the incident, both forward galley ovens were removed from the aircraft by the operator's maintenance engineers. Whilst the left oven was undamaged, inspection of the right oven revealed that an electrical short circuit had occurred within the oven's controller module, and the controller's 5 amp circuit breaker had tripped. The controller's printed circuit board (PCB) assembly exhibited electrical overheat damage where the ON-OFF switch was mounted to the PCB, as shown in Figure 2. Localised burning of the PCB copper tracks and soldered connections at the ON-OFF switch location prevented examination of pre-existing defects in this area of the PCB.

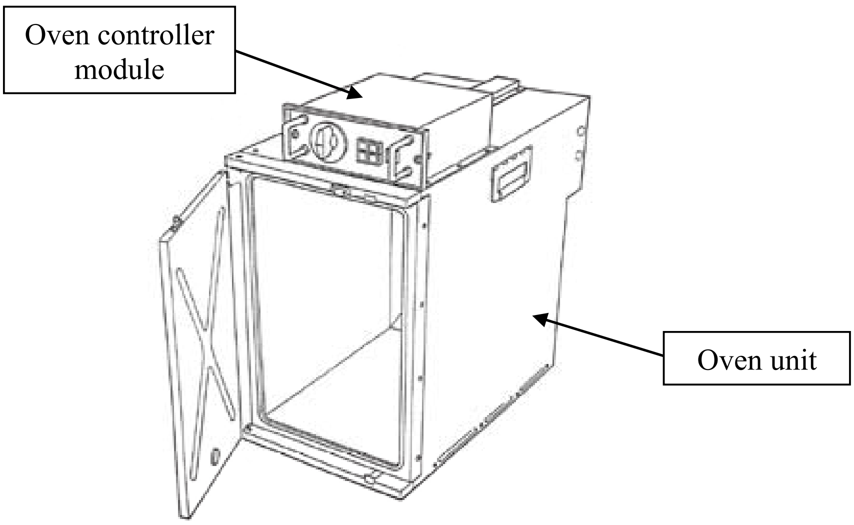

Figure 1

Oven assembly

Figure 2

Electrical overheating damage to the oven controller PCB

The oven unit was taken to an approved repair facility for testing. It was fitted with a replacement oven controller module and was functionally tested. These tests demonstrated that the oven unit was serviceable.

The oven controller's 5 amp circuit breaker was tested by a specialist agency and shown to perform within the manufacturer's specifications for current and cut-out time parameters. Tests were also performed on the oven controller's panel-mounted switches and timer switch that demonstrated the serviceability of these components.

Maintenance information

The oven had been installed in the aircraft eight days prior to the incident occurring. Following installation, the aircraft had completed 30 flight cycles and 108 flying hours. No defects relating to the oven were recorded during this period.

In May 2010, prior to installation of the oven in the aircraft, the oven was serviced by an approved repair organisation. This service included cleaning, inspection and testing of the oven controller in accordance with the oven manufacturer's component maintenance manual. The inspection report covering this testing recorded that the oven was serviceable.

Analysis

The damage to the oven controller's PCB indicates that an electrical short circuit occurred at the connection between the PCB and the oven controller's ON-OFF switch. The nature of the damage to the soldered connections and copper PCB tracks at this location prevented further investigation into the cause of the short circuit. The oven controller's 5 amp circuit breaker, which was operating within its design specification, tripped and prevented further current from flowing and intensifying the electrical overheating.

The overheating damage was limited to the oven controller's PCB and was contained within the controller enclosure. Smoke caused by the overheating circuit board escaped from the controller enclosure and circulated around the forward galley ovens, causing confusion regarding its source.

A review of the maintenance history of the oven controller module did not reveal any defects that may have contributed to the initiation of an electrical short circuit, which is the most likely cause of the electrical overheating damage to the oven controller's PCB.

INCIDENT

Aircraft Type and Registration:	DHC-8-402 Dash 8, G-FLBC
No & Type of Engines:	2 Pratt & Whitney Canada PW150A turboprop engines
Year of Manufacture:	2009
Date & Time (UTC):	10 October 2010 at 1845 hrs
Location:	Amsterdam Schiphol Airport, The Netherlands
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 4 Passengers - 54
Injuries:	Crew - None Passengers - None
Nature of Damage:	Left main landing gear, both tyres and brake assembly
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	64 years
Commander's Flying Experience:	15,000 hours (of which 4,000 were on type) Last 90 days - 250 hours Last 28 days - 80 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by AAIB

Synopsis

Shortly after arriving on stand, and just as normal passenger disembarkation was about to begin, flames were observed coming from the left hand main wheel assembly. The passengers vacated using the aircraft forward door directly into the terminal. The flames went out after a short time and the aerodrome fire and rescue service (AFRS) cooled the affected wheel and brake assemblies.

History of the flight

The aircraft was performing a scheduled passenger service from Southampton to Amsterdam Schiphol Airport. It was the third sector the aircraft and crew had operated that day and the previous two sectors had proceeded without incident. The co-pilot was the handling pilot and, after landing on Runway 06, applied moderate braking on the runway. The commander then took control of the aircraft. The commander made little use of the wheel brakes during the 14-minute taxi to the stand, where the aircraft was shut down normally. As passenger disembarkation was about to begin through the rear left exit, the ground crew alerted the crew to a fire in the left main wheel assembly. The crew halted disembarkation through the rear exit and passengers vacated the aircraft through the front left exit directly into the terminal. The fire went out after approximately two minutes although the wheel continued to emit smoke until cooled by the AFRS.

Engineering investigation

The brake units and wheel assemblies were replaced and the aircraft returned to service the following day. The aircraft operator carried out an engineering investigation of the affected brake units but this proved inconclusive. The investigation determined that the most likely cause of the fire was that the affected brake unit was not fully released whilst the aircraft was being taxied. The heat generated by the brake caused the grease in the wheel hub to melt, leak out and ignite when it came into contact with the hot brake units.

SERIOUS INCIDENT

Aircraft Type and Registration:	Dornier 328-100, D-CIRT
No & Type of Engines:	2 Pratt & Whitney Canada PW119B turboprop engines
Year of Manufacture:	1997
Date & Time (UTC):	23 September 2009 at 1410 hrs
Location:	Dundee, Fife
Type of Flight:	Commercial Air Transport (Non-Revenue)
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to air-switching valve in both engines
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	45 years
Commander's Flying Experience:	8,100 hours (of which 400 were on type) Last 90 days - 120 hours Last 28 days - 42 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft had not been in regular use for almost two years and was being repositioned from Dundee to a maintenance facility in Germany, in preparation for sale. The crew experienced a variety of system malfunctions during the takeoff and initial climb, followed by a loss of oil pressure on the left engine. The crew declared an emergency with Leuchars ATC and were receiving radar vectors to return to Dundee when the oil pressure on the right engine also began to fluctuate. The crew advised ATC that they were experiencing problems with both engines and manoeuvred the aircraft to land at RAF Leuchars, an airfield with which they were not familiar.

After landing there was no external evidence of an oil leak, but the left and right engines had lost approximately seven and four quarts of oil respectively. The subsequent engineering investigation revealed that in both engines the air-switching valve had seized due to the presence of corrosion, which allowed the oil system to become over pressurised and caused oil to be vented overboard.

One Safety Recommendation is made.

History of the flight

The aircraft was to fly from Dundee to Oberpfaffenhofen, Germany, on a Permit to Fly, where further maintenance would be carried out to make the aircraft serviceable for a potential sale.

The two pilots, native Russian speakers, worked for a German company that had been contracted by the aircraft owners to reposition the aircraft. The pilots travelled to Dundee the evening before the flight and the maintenance organisation collected them from their hotel at 0800 hrs.

The aircraft had not flown for some time, and so the pre-flight procedures included an extensive inspection of the aircraft documentation, an external inspection, during which the commander noted that both engines oil levels were just below full, and a ground run. After the ground run, a paperwork issue was resolved and at approximately 1330 hrs the crew declared that they were ready to fly the aircraft to Germany. The weather conditions were good, with scattered clouds around 3,000 ft agl and a strong south-westerly wind.

The start-up and taxi were described by the crew as normal, and at 1406 hrs D-CIRT commenced its takeoff from Runway 27. Shortly after getting airborne the commander saw an amber caution warning light illuminate, but it then disappeared. The co-pilot believed this was the ELEVATOR DISC LOAD HIGH caption, but as it self-extinguished no action was required. At 1,500 ft the aircraft was accelerated to 'clean' airspeed, the flaps were retracted and the propeller rpm and torque were adjusted to the climb settings. Passing 3,000 ft, the RH ALT caption illuminated (referring to the alternator on the right-hand engine), along with associated messages on the EICAS. The crew completed their 'after takeoff' checks and were about to commence the abnormal checklist for the RH ALT caption when the commander noticed the left engine oil pressure was fluctuating. While the crew were discussing the fluctuating oil pressure the red left engine oil pressure warning illuminated with the associated audio attention-getter. The crew initially levelled the aircraft at FL 60, advised Leuchars Radar that they would like to return to Dundee and, after a prompt from ATC, declared an emergency.

ATC at Dundee observed the takeoff, and noticed some grey smoke coming from both engines, but as the aircraft had not flown since December they thought that it was probably not unusual. An engineer from the maintenance organisation, who had been working with the crew, observed the takeoff, and saw what he described as a trail of white smoke from the left engine. He considered that this was not normal and when the aircraft had disappeared from view he decided to call ATC to ask them to advise the crew. On his way to a phone he turned on a radio that monitored VHF ATC frequencies and heard the aircraft report it was returning to Dundee with an emergency.

The commander considered the implications of shutting down the left engine with a right engine alternator failure, and the implications of the associated loss of electrically-driven hydraulics, and decided that he would shut down the left engine, in accordance with the QRH drills for low engine oil pressure. The co-pilot had identified the left power lever, and was about to retard it, in accordance with the drill, when the commander noticed the right engine oil pressure start to fluctuate. The crew stopped the left engine shutdown drills and the commander asked the co-pilot to request radar vectors to the nearest suitable airfield. The co-pilot thought that he had communicated this to ATC when he said, "WE ARE HAVING PROBLEMS WITH TWO ENGINES RT AND IT'S THE SHORTEST WAY TO THE FIELD." As the aircraft had already requested a return back to Dundee, ATC understood that the aircraft was asking for vectors direct to Dundee.

The commander was now concerned that at any time either engine, or both, might stop without further warning and so he manoeuvred the aircraft to remain in visual conditions whilst following the general direction of the ATC vectors. The crew saw an airfield, which they believed was the one to which ATC were vectoring them, and called visual with the field. ATC advised them that the field they were visual with was Leuchars and that they still had 10 miles to run to Dundee; they then asked the crew if they required to land at Leuchars. The crew were not familiar with Leuchars and thought the controller was offering them an alternative to the airfield that was ahead of them, and so replied *"NEGATIVE"*.

The crew completed their landing checks and positioned the aircraft onto finals for Runway 28 at Leuchars; with the engines at low power the oil pressure fluctuations had reduced in severity. ATC again advised the crew that they were flying towards Leuchars, not Dundee, to which the crew replied "ROGER". The Leuchars controller judged from the position and attitude of the aircraft that it was the crew's intention to land at Leuchars, and so cleared the runway. He then confirmed that the landing gear was down, and gave D-CIRT clearance to land.

D-CIRT landed safely at 1418 hrs and vacated the runway. ATC advised the crew that they were on the ground at RAF Leuchars, and the crew then realised where Leuchars was. The airfield was not in the aircraft's FMC database, nor did the crew carry its approach plates.

Maintenance history

The aircraft had previously been operated by City Star Airlines, which had ceased trading in January 2008, and the aircraft had latterly been used as a source of serviceable spares to support the airline's other aircraft. The aircraft remained in open storage at Aberdeen until it was purchased by an aircraft asset management company who had the aircraft made serviceable and had it flown to Dundee, in December 2008, where it was once again placed in storage. During its time at Dundee, maintenance was carried out in accordance with the aircraft manufacturer's storage programme, which included routine low power (idle) engine runs, by an approved engineering organisation. In September 2009, the owners contracted the engineering organisation to carry out a package of work, in order to allow the aircraft to undertake a ferry flight to Oberpfaffnhofen. This included the rectification of outstanding defects, power assurance runs on both engines and a review of the status of the aircraft's compliance with current mandatory requirements. The results of this activity were passed to the Luftfahrt Bundesamt (LBA) who, after review, issued the aircraft with an EASA 'Permit to Fly'.

Flight Recorders and Maintenance Computer

The aircraft was fitted with a 25-hour Flight Data Recorder (FDR) and 2-hour Cockpit Voice Recorder (CVR). These were both removed from the aircraft following the serious incident to be downloaded and then analysed by the AAIB.

The CVR recording did not include the incident as it had been recorded over with recent information while engine tests were carried out on the aircraft post-incident. A time history of salient parameters from the FDR for the incident flight is shown at Figure 1. The engine parameters recorded on the FDR were engine torque and propeller speed However, many more engine parameters were recorded by the maintenance computer during any out-of-limit condition of engine parameters, plus 10 seconds of data prior to the out-of-limit condition being detected. A number of these conditions were detected and recorded for the oil

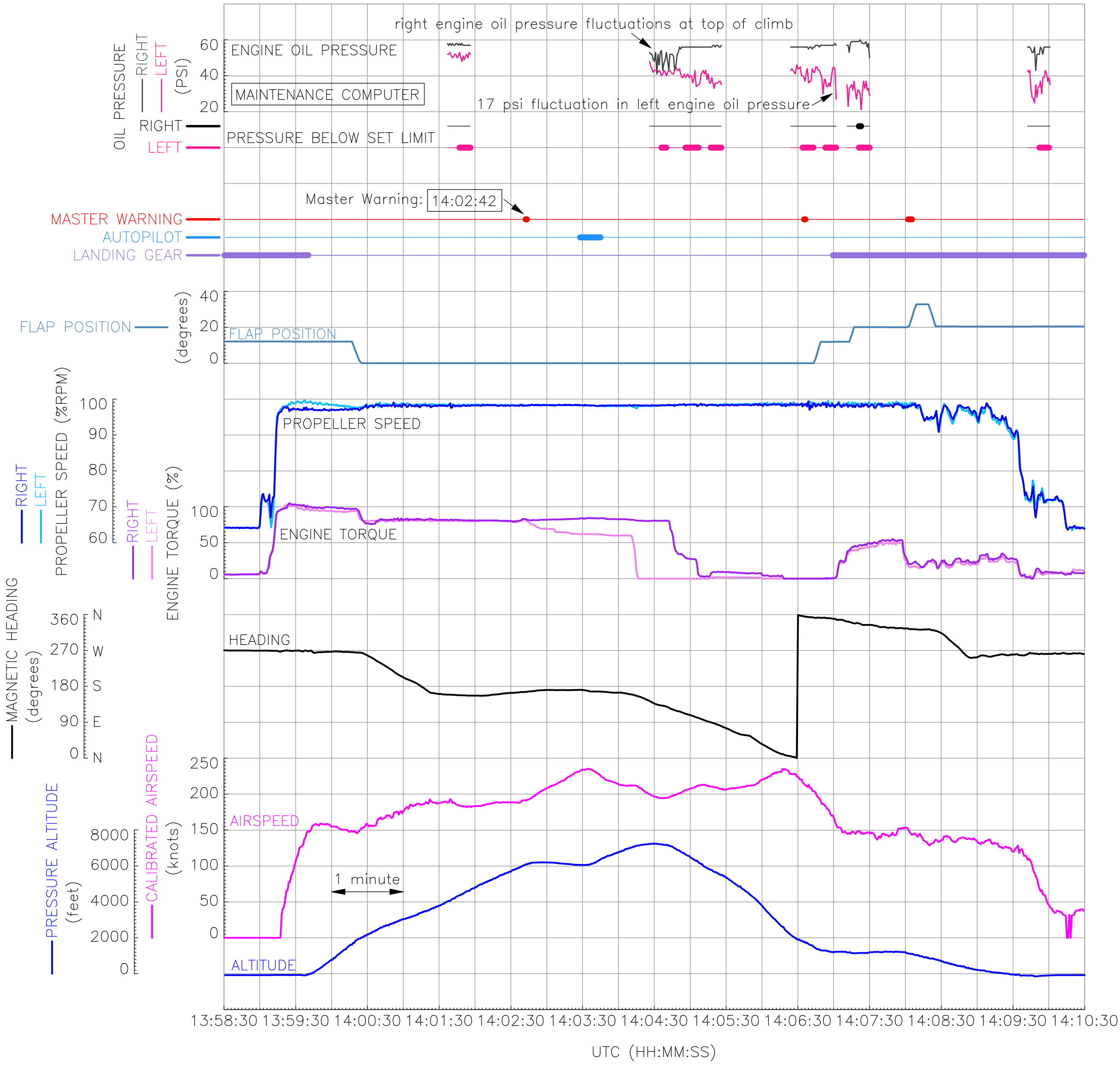

Figure 1

Salient FDR parameters and maintenance computer recordings for the serious incident to D-CIRT

pressure of both engines during the incident flight: these are also presented in Figure 1.

The figure shows that the maintenance computer detected an oil pressure 'below-limit' state for the left engine during the climb, lasting 10 seconds as the aircraft passed through 4,500 ft pressure altitude. A nominal difference of about 6 psi in oil pressure was recorded between the left and right engines (left engine lower, at around 52 psi) for similar levels in engine torque and propeller speed. As the aircraft levelled off at approximately FL60, there was a master warning associated with the left engine oil pressure[1]

Footnote

[1] The FDR records when the master warning is active but does not record the reason for the warning. In this case, however, the crew reported that the left-engine oil pressure warning light also came on.

(time 14:02:42). This was followed by a reduction in engine torque on the left engine (as the crew started to shut it down), reducing from 84% to 62% before the shutdown was cancelled. The autopilot was then engaged for about 20 seconds, during which the aircraft started to climb again.

The 'top of climb' was at just above FL70 before the torque on the left engine was reduced to near zero, followed by a stepped reduction in torque on the right engine for the descent. From top of climb, throughout the descent and landing, the maintenance computer detected a further 13 left engine oil pressure 'below-limit' conditions and one on the right engine. The associated extracts of engine oil pressures recorded by the computer show that the oil pressure difference between the engines grew as the left engine pressure fell to about 30 psi (ie a 50% reduction), although it fluctuated as much as 17 psi. Fluctuations were also recorded in the right engine oil pressure at top of climb, but stopped once the torque was reduced for the descent.

The master warning also alerted a further three times during the flight but, these were coincident with changes in aircraft configuration for landing.

Initial investigation of the engines

Due to a delay in the notification of this event to the AAIB, some troubleshooting of the reported defects had been carried out before the aircraft was inspected. A review of the post-incident maintenance actions confirmed that no abnormalities had been found with either of the engines' oil systems and that there was no evidence of external oil leaks, although the left engine had lost approximately seven quarts of oil and the right engine had lost approximately four quarts. Borescope inspection of the engines did not identify any obstruction of the bearing oil vents or any evidence of damage to the high pressure and power turbines. However, a small amount of oil splatter was observed on the left engine power turbine.

After replenishing the oil systems, both engines were operated at idle power for 20 minutes, with no observed oil pressure fluctuations. The power of the right engine was increased to 100% torque for five minutes with no observed abnormalities. The power of the left engine was then increased to 85% torque for several minutes without any observed defects, but when the torque was increased further the engine oil pressure began to fluctuate wildly. After reducing the torque to below 85% the oil pressure stabilised again. After shutdown, the right engine had consumed one and a half quarts of oil and the left engine three quarts, with no evidence of an external oil leak or of 'venting'.

This aircraft's equipment included a fault reporting system which, on detecting a parameter exceedence, records the event as well as ten seconds of data preceding and ten seconds after the exceedence, into the aircraft's Central Alerting System (CAS) to aid troubleshooting by maintenance personnel. A download of the CAS showed that there were 11 'low oil pressure' events recorded for the left engine between 14:01 and 14:14. The lowest recorded pressure was 21 psi. For the right engine the system recorded only one event at 14:04, when the engine oil pressure decreased to 41 psi. After discussion with the engine manufacturer, the decision was made to remove both engines for detailed inspection at an engine overhaul facility.

Engine oil system - description

The turbo-machinery of the PW119 engine is supported by seven bearings which are located in four separate sumps or cavities. Each cavity is provided with a pressurised supply of oil from the lubrication system. The oil is contained within these sumps by the use of labyrinth seals which require a flow of air passing from the outer face of the seal into the cavity to be effective. The air in each cavity is then vented overboard through a breather in the accessory gearbox.

At low power, below 40% Nh (high pressure impeller/turbine speed), sealing air is provided by air bled from the output of the high pressure impeller (P3). Above 40% Nh the pressure and temperature of the P3 air is too high and air bled from immediately upstream of the high pressure impeller (P2.5) is used for seal pressurisation. The source of bleed air is controlled by the air-switching valve, which is spring-loaded to supply P3 bleed air. As engine rpm increases beyond 40% Nh, the increase in P2.5 allows the valve piston to move against the spring force, blocking the supply of P3 air and allowing P2.5 air to flow to the bearing cavities. This should change before the engine reaches its stable ground idle speed of 66% Nh. Failure of the air-switching valve to move from the P3 bleed air position to the P2.5 position, as the engine speed increases, will cause the engine oil cavities and gearboxes to become over-pressurised, forcing oil into the breather system before it is discharged overboard.

Further investigation

The engines were removed in March 2010 and dispatched to an approved overhaul facility for further investigation under the supervision of the Bundesstelle für Flugunfalluntersuchung (BFU), the German Federal Bureau of Aircraft Accident Investigation.

Both engines were subject to an 'as received' test to determine whether the cause of the abnormal engine behaviour observed by the flight crew could be identified prior to disassembly. During the tests, when operating above idle speed, both engines exhibited high oil consumption with vapour observed venting from the oil system breather. Both engines exhibited oil pressures in the reduction and accessory gearboxes that were at or above the maximum allowable pressure, together with oil vent pressures greater than the P2.5 bleed pressure.

The P2.5/P3 air-switching valves were replaced with new units and the runs repeated, with no abnormalities observed on either engine. The P2.5/P3 air-switching valves were partially disassembled and both valves were found to be seized in their housings. They were then dispatched to the engine manufacturer for further investigation, which showed that the pistons of both air-switching valves were seized in their respective housings and a hydraulic press had to be used to remove them. After removal it was found that both pistons, the piston rings and the inner surface of the valve housings were corroded.

Analysis

The high oil consumption on both engines experienced by the flight crew was entirely consistent with the failure of the engine air-switching valves to operate correctly as power was increased. The storage of the aircraft at both Aberdeen and Dundee, where it was exposed to the effects of saline moisture, would have increased the rate of formation of corrosion products within the valves. However, although the air-switching valves should have operated before the engines reached stable ground idle speed, the increased oil consumption, resulting from the over-pressurisation of the oil system was not apparent prior to dispatch of the aircraft. Therefore:

Safety Recommendation 2010-094

It is recommended that Pratt and Whitney Canada amend the maintenance requirements for the PW100 series of engines, to ensure the continued serviceability of the air-switching valve on engines installed on aircraft in storage.

The engine manufacturer has subsequently confirmed that they will review the de-preservation requirements for these engines and amend them as necessary. Transport Canada has confirmed that they will monitor this activity.

Conclusion

The cause of this serious incident was the failure of both engine air-switching valves to operate normally. This resulted in the over-pressurisation of the engine oil cavities and the purging of oil overboard through the engine vent system. The presence of corrosion on the pistons, piston rings and the inner bore of the valves, caused as a result of the prolonged storage of the aircraft, prevented the valves from operating normally.

The crew were faced with a series of malfunctions resulting in their decision to land at the nearest suitable airfield. However, these intentions were not communicated effectively to ATC and it was the decisive action of the Leuchars controllers which prevented an escalation of an already difficult situation.

ACCIDENT

Aircraft Type and Registration:	ERJ 170-100 STD Embraer 170, G-LCYF
No & Type of Engines:	2 General Electric CF34-8E5A1 turbofan engines
Year of Manufacture:	2009
Date & Time (UTC):	25 July 2010 at 1710 hrs
Location:	Edinburgh Airport, Scotland
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 4 Passengers - 68
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to APU intake on underside of tail
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	38 years
Commander's Flying Experience:	6,500 hours (of which 450 were on type) Last 90 days - 160 hours Last 28 days - 40 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent AAIB enquiries

Synopsis

During pushback for departure, the underside of the aircraft's tail struck a blast fence. Investigations by the organisations involved identified a number of factors which contributed to the event, and contained recommendations to prevent recurrence.

History of the flight

During pushback from Stand 34, the aircraft's tail was pushed over, and then impacted, a blast fence behind the stand. The ground crew halted the pushback, pulled the aircraft slightly forward, and informed the flight crew. The flight crew aborted the engine starts and shut down the APU. A set of mobile steps were brought to the aircraft and the passengers disembarked normally.

Investigations conducted by the organisations involved

Investigations into the accident were carried out by both the aircraft operator and the ground handling company which carried out the pushback. Both companies identified a number of factors relevant to the accident, including the fact that Stand 34 is the only stand at the airport requiring a 'dog-leg' pushback.

An engineer who attended stated that most of the damage to the aircraft was done when it was pulled forward after impact, rather than in the initial collision with the blast fence. The aircraft operator found that ground handling companies should be reminded not to move an aircraft which has sustained damage until it has been inspected by an engineer.

Several recommendations were made by the companies conducting these investigations, focussing on:

- Risk assessment of push-back operations
- Design of push-back procedures
- Promulgation of clear instructions to staff
- Training of ground handling staff
- The design and marking of Stand 34
- 'Near-miss' reporting within the ground handling company

Discussion

Ground handling of aircraft is not regulated to the same degree as aircraft operations. The investigations carried out by the organisations involved identified opportunities for improvement in several areas and produced recommendations that, if implemented, may reduce the likelihood of a recurrence.

INCIDENT

Aircraft Type and Registration:	Piper PA-23-250 Aztec, G-BATN
No & Type of Engines:	2 Lycoming IO-540-C4B5 piston engines
Year of Manufacture:	1973
Date & Time (UTC):	6 July 2010 at 1259 hrs
Location:	Cambridge Airport, Cambridgeshire
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Propellers bent, nose cone and nose landing gear doors abraded
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	7,146 hours (of which 79 were on type) Last 90 days - 39 hours Last 28 days - 14 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

Synopsis

On the third of three planned landings the nose landing gear collapsed and the aircraft slid to a halt on its nose. The investigation revealed that a lack of lubrication on the link plate attachments that secure the downlock actuator to the downlock link is likely to have caused a restriction and prevented the complete engagement of the downlock. The pilot was unaware that the downlock had not engaged completely.

History of the flight

The purpose of the flight was for the pilot to perform three landings to maintain currency to fly with passengers. The first two landings were performed successfully and the pilot confirmed that, on each occasion, all gears were down and locked with three green indicator lights showing. The third circuit was flown as a practice low-level bad weather circuit with the pilot confirming that the gear was down and locked at approximately 200 ft on final approach. The pilot considered the approach and touchdown to be normal but as the nose was lowered, it continued beyond the normal landing pitch attitude and made contact with the runway. The propellers also contacted the runway, the engines stopped and the aircraft slid to a halt.

Figure 1

G-BATN on Runway 23

The pilot, who was wearing a lap and diagonal harness, escaped uninjured. The Airport Fire Service attended the scene, reported a small fuel leak from the left wing and laid down foam as a precaution.

Aircraft description

The aircraft has a hydraulically-actuated, retractable tricycle landing gear system with the nose landing gear extending forwards. When the landing gear lever is selected DOWN, hydraulic pressure causes the nose gear actuator to extend a drag link until the link reaches an over-centre position. The final movement of the actuator causes the downlock link to pivot about a link plate to engage the downlock pawl and activate a downlock microswitch. Once the full travel of the actuator has been achieved, hydraulic pressure within the system rises and, at a preset pressure, the selector lever returns to the neutral position. Springs attached to the landing gear downlock pawls hold them in place in the event of loss of hydraulic pressure.

The landing gear status is indicated to the pilot using four lights on the centre pedestal in the cockpit. Engagement of each landing gear downlock microswitch illuminates a green light, indicating that the respective gear is down and locked. Illumination of an amber light indicates all landing gears are up. A gear unsafe warning horn will sound when power from both engines is reduced to below 10-12 inches of manifold pressure and any landing gear is not locked down.

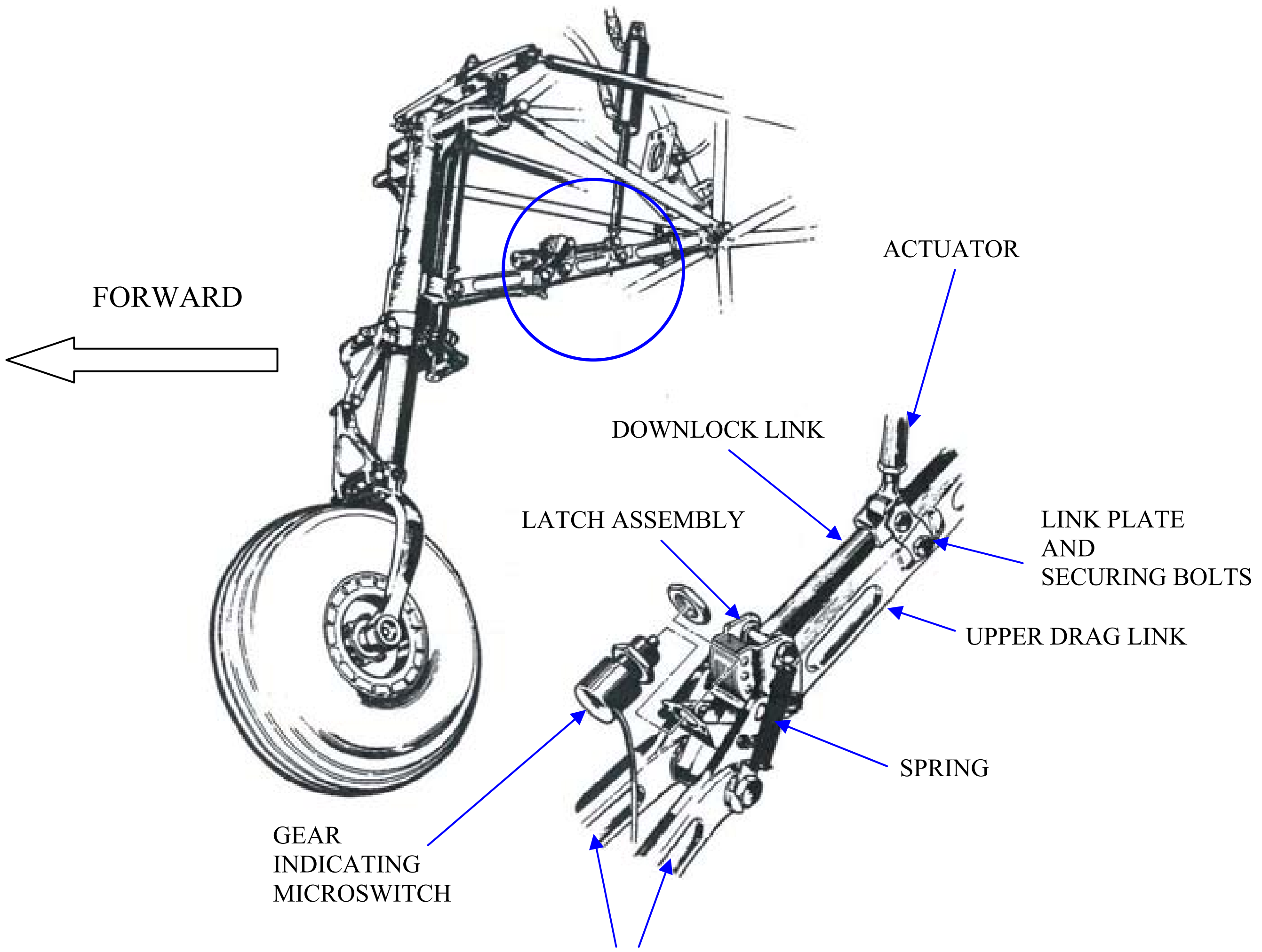

Figure 2

Nose gear leg assembly

Aircraft examination

The aircraft was not examined by the AAIB and the aircraft operator contracted an external assessor to investigate the nose landing gear collapse. Initial tests performed after the incident confirmed that lowering the nose landing gear by hand would not achieve full downlock, and the cockpit nose landing gear green light did not illuminate. In this case, with the throttle levers at idle, the gear unsafe horn also sounded.

Functional tests of the landing gear system were then performed. When the lever was selected to DOWN, both main landing gears downlocked illuminating their associated green light, but the nose landing gear downlock did not engage fully, and the associated green light remained OFF. Repeated cycling of the landing gear resulted in the same outcome.

The nose landing gear was inspected and the link plate attaching the actuator to the downlock link was found to be damaged. The bolts securing this link plate were removed and were reported to be:

> *'dry of lubricant and had visible surface rust on the bolt shank.'*

After straightening the link plate and reinstalling the bolts, using engine oil to lubricate the bolt shanks, further extension and retraction functional tests were performed. These were successful and the nose landing gear downlock pawl engaged successfully each time and the cockpit nose gear green light illuminated.

Maintenance activity

Between 2006 and the incident landing, G-BATN had been inspected on a number of occasions for nose landing gear down indication problems. The service manual landing gear troubleshooting pages state that, in the event of no green light indication with the landing gear down, the cause is likely to be electrical. As the gear remained downlocked for landing in all previously reported cases, the cause was considered to be an intermittent electrical problem and, during the annual inspection in April 2010, the microswitch was replaced. Maintenance action following these reports did not identify a restriction at the link plate that could have prevented complete downlock engagement. All cases of cycling the landing gear during maintenance prior to the incident landing had resulted in successful downlock and indication.

The manual also states that the nose landing gear downlock link plate attachments require lubrication every 100 hours of operation using a general purpose, low temperature lubricating oil to MIL-PRF-7870C specification. However, it was noted that the lubrication procedure does not require the removal of the downlock link plate bolts. Without removal of the bolts it would not be possible to determine whether or not the lubrication had successfully penetrated through to the bolt shank. The operator confirmed that the correct lubrication schedule had been followed.

Discussion

The nose landing gear retracted on landing because it was not fully locked down. It was considered that a lack of lubrication on the shanks of the downlock link plate bolts caused sufficient restriction to prevent the complete engagement of the downlock. For reasons for which could not be established the pilot was unaware that the gear was not locked down and he stated that it would be "very unlikely" that the green light was not illuminated at touchdown and the gear unsafe horn was sounding but that he had failed to notice.

The aircraft manufacturer commented that since 1995 there had been no reported events with the same symptoms. However, since this event the operator is considering introducing an additional maintenance activity for the periodic removal and inspection of the bolts to ensure that lubrication has successfully penetrated to the bolt shank and that no corrosion has developed.

ACCIDENT

Aircraft Type and Registration:	Cassutt Racer IIIM, G-BNJZ
No & Type of Engines:	1 Continental Motors Corp O-200-A piston engine
Year of Manufacture:	1989
Date & Time (UTC):	17 October 2010 at 1440 hrs
Location:	Hinton-in-the-Hedges Airfield, Northamptonshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to left wingtip, leading edge, propeller, engine, and cowlings
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	72 years
Commander's Flying Experience:	22,570 hours (of which 1 was on type) Last 90 days - 71 hours Last 28 days - 21 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent AAIB enquiries

A prospective purchaser had arranged for a pilot with previous experience on similar types to fly the tail wheeled aircraft and assess it for him. The weather conditions were "clear and bright" with light north-north westerly winds estimated at three or four knots. The owner briefed the pilot about the aircraft, emphasising that as the propeller was relatively coarse, the pilot should lift the tail promptly before accelerating.

There was some difficulty starting the engine, but once it was started the pilot taxied to the grass Runway 06 and began a takeoff. Witnesses stated that the grass was damp and that the tail wheel did not lift. The pilot perceived that the aircraft would not become airborne, and aborted the takeoff attempt; the aircraft came to rest in a hedge, sustaining damage. The pilot evacuated the aircraft without difficulty. Those involved subsequently commented that the accident may have arisen from the takeoff technique used, the length of the grass, or the engine not producing sufficient power.

ACCIDENT

Aircraft Type and Registration:	Cessna 152, G-BSZI
No & Type of Engines:	1 Lycoming O-235-N2C piston engine
Year of Manufacture:	1984
Date & Time (UTC):	26 August 2010 at 1730 hrs
Location:	City of Derry Airport, Londonderry, Northern Ireland
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to nose landing gear leg, propeller and engine
Commander's Licence:	Student
Commander's Age:	43 years
Commander's Flying Experience:	37 hours (of which 23 were on type) Last 90 days - 7 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The aircraft was returning to Londonderry after a solo cross-country exercise. On final approach to Runway 08, the student pilot reported that he flared too high, the aircraft touched down and bounced back into the air. On the second touchdown, the nose landing gear partially collapsed, the aircraft veered to the right and ran off the side of the runway onto the grass. The pilot vacated the aircraft normally with only minor cuts and bruises.

The student's instructor was in the flying club at the time and did not witness the accident. Although the pilot believed that the nosewheel collapsed due to it "digging in" on the grass, debris on the paved surface, and damage to the propeller, indicated that nose gear collapse had occurred on the second touchdown.

ACCIDENT

Aircraft Type and Registration:	Cessna 172s Skyhawk, G-GEHL
No & Type of Engines:	1 Lycoming IO-360-L2A piston engine
Year of Manufacture:	1999
Date & Time (UTC):	8 August 2010 at 1420 hrs
Location:	White Waltham Airfield, Berkshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Fuselage floor area
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	53 years
Commander's Flying Experience:	160 hours (of which 13 were on type) Last 90 days - 8 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

After an overhead join, the aircraft began an approach to Runway 03 in reported winds of between 020º and 030º at 10 kt. During the flare, the pilot reported encountering a "sudden updraft / windshear" and a subsequent rapid roll to the right. The pilot corrected the roll but the aircraft touched down heavily at the intersection of Runway 03 and Runway 29 and then bounced two further times before being brought under control. The pilot, who was wearing a lap and diagonal harness, was uninjured.

The pilot stated that a subsequent inspection of the area at the intersection of Runway 03 and Runway 29 identified that the grass area was "very, very bumpy and firm".

ACCIDENT

Aircraft Type and Registration:	Cessna R172K Hawk XP, G-FANL
No & Type of Engines:	1 Continental Motors Corp IO-360-KB piston engine
Year of Manufacture:	1978
Date & Time (UTC):	2 October 2010 at 0840 hrs
Location:	Haverfordwest Airport, Pembrokeshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to the propeller, lower fuselage and firewall
Commander's Licence:	Private Pilot's Licence
Commander's Age:	59 years
Commander's Flying Experience:	149 hours (of which 59 were on type) Last 90 days - 7 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot was flying circuits at Haverfordwest Airfield, Pembrokeshire. The weather conditions were good, with a 15 kt southerly wind, and Runway 21 was in use. The first circuit was normal, although the pilot noted some light wind sheer and turbulence on final approach. During the landing flare after the second circuit, in mild turbulence, a greater sink rate than normal was experienced and the aircraft bounced. Full power was applied but the aircraft pitched nose down, rolled right and landed heavily on its nosewheel, with the propeller striking the ground. The pilot realised that the landing was heavy, so he closed the throttle and taxied back to the parking apron where he shut the aircraft down. A visual inspection revealed damage to the propeller and the geometry of the nose landing gear.

The pilot considered that the accident was caused by the starboard wing stalling, after the aircraft had bounced, resulting in the aircraft not remaining airborne when he applied full power.

ACCIDENT

Aircraft Type and Registration:	Culver LCA Cadet, G-CDET
No & Type of Engines:	1 Continental Motors Corp O-200-A piston engine
Year of Manufacture:	1940
Date & Time (UTC):	5 September 2010 at 1630 hrs
Location:	Eshott Airfield, Northumberland
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Damage to fuselage, gascolator, engine cowl, wing, cockpit and propeller
Commander's Licence:	Private Pilot's Licence
Commander's Age:	63 years
Commander's Flying Experience:	207 hours (of which 47 were on type) Last 90 days - 11 hours Last 28 days - 7 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent AAIB enquiries

The pilot stated that on approach to Eshott the aircraft encountered "extreme turbulence". He had difficulty extending the landing gear, which required both hands to operate, but believed that it was locked down. Following a normal landing the landing gear collapsed and the aircraft skidded to a halt on its underside. During the skid, the gascolator, mounted on the bottom of the aircraft forward of the firewall, sustained damage releasing fuel, and a fire broke out. Although flames entered the cockpit, the pilot vacated the aircraft with only a minor injury, and used the aircraft's fire extinguisher to tackle the fire. The extinguisher ran out before extinguishing the fire, which was put out by members of the flying club who attended promptly with other extinguishers.

The pilot stated that lack of experience in turbulent conditions and the absence of a system to indicate that the gear was not locked down both contributed to the accident. In rebuilding the aircraft, the pilot plans to install a landing gear warning system and to reposition the gascolator to protect it better during any future gear-up landing.

ACCIDENT

Aircraft Type and Registration:	Czaw SportCruiser, G-CFPA
No & Type of Engines:	1 Rotax 912 ULS piston engine
Year of Manufacture:	2008
Date & Time (UTC):	2 October 2010 at 1115 hrs
Location:	East Fortune Airfield, Scotland
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to leading edge of right wing, aileron and flap, propeller and wheel spat
Commander's Licence:	Private Pilot's Licence
Commander's Age:	33 years
Commander's Flying Experience:	245 hours (of which 86 were on type) Last 90 days - 22 hours Last 28 days - 9 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

Due to the prevailing winds, the pilot decided to land the aircraft on a grass area adjacent to the two published runways. The grass area was wet and approximately 190 m in length. During the landing roll he was unable to the stop the aircraft before striking a wire fence. The pilot was uninjured and vacated the aircraft. He had previously landed a flex-wing microlight on the same area, but not G-CFPA. There were no published dimensions of the grass area. The pilot considered that he should have aborted the landing and waited for the wind to reduce before landing on Runway 29, which was 450 m in length and of part-concrete construction. The Pilot's Operating Handbook (POH) stated that the landing distance from 50 ft on grass was 170 m and 180 m on concrete. An airtest conducted in support of the permit to fly detailed the landing distance from 50 ft as 327 m on a tarmac runway. The Light Aircraft Association (LAA) advised that it plans to review the POH with regards to landing distance performance. The airfield operator advised that it would review the publication of additional airfield information.

History of the flight

The pilot had flown from Plockton Airfield to East Fortune Airfield (see Figure 1). East Fortune Airfield has two unlicensed runways. Runway 07/25 is a grass runway of 250 m in length and Runway 11/29 is 450 m in length, with the first 350 m of Runway 29 being

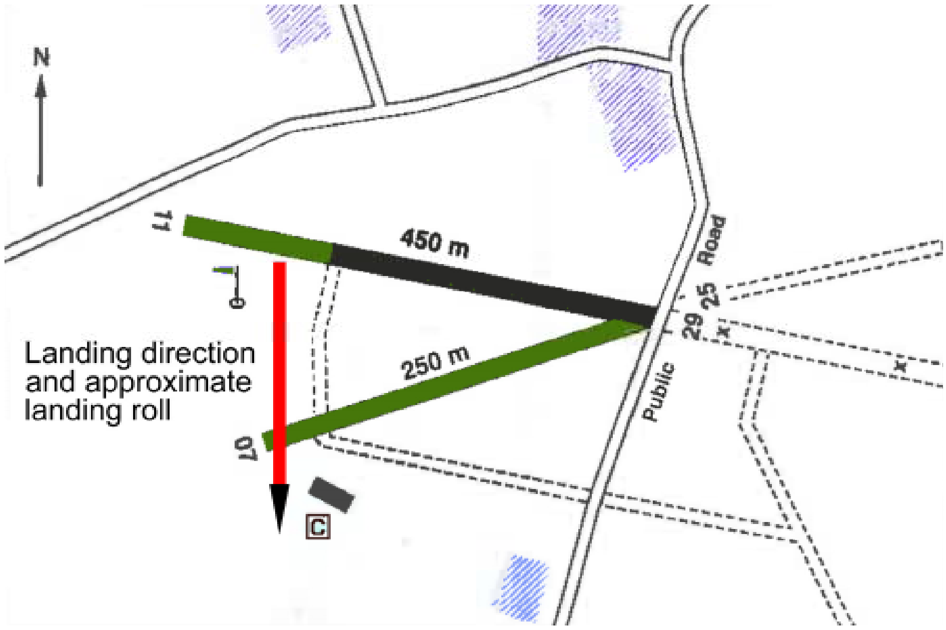

Figure 1

G-CFPA Landing direction and approximate landing roll

of concrete construction and the remaining 100 m grass. Near to the threshold of Runway 07 and 11 is a concrete taxiway running almost north-south, adjacent to which is a mown grass area of approximately 20 m in width and 190 m in length. At the southern end of the grass area, near the threshold of Runway 07, was an area of light vegetation bounded by a wire fence. The pilot had previously flown flex-wing microlights at the airfield and, when operating with strong northerly or southerly winds, he and other flex-wing microlights had occasionally used the grass area for landing. He had also previously landed G-CFPA at East Fortune, but not on the north-south grass area. The airfield operator advised that it was aware that the area was occasionally used for landing, but had not published information on it.

The reported wind was from 200º at between 6 to 8 kt, gusting 14 kt. Conscious that landing on either of the two published runways would put him near to, or in excess of, the aircraft's 12 kt crosswind limit, the pilot decided to land in a southerly direction on the grass area. The final approach appeared normal, flown at about 50 kt with full flap selected, but shortly before touchdown, he noticed that the wind speed had reduced. The pilot stated that his groundspeed was higher than expected and upon touchdown he had applied heavier than normal braking. Both mainwheels subsequently locked and the aircraft skidded. The aircraft is equipped with a castering nosewheel, with main directional control on the ground accomplished by differential mainwheel braking. As the aircraft neared the end of the grass area, he attempted to turn the aircraft, but it continued straight ahead before striking the wire fence, which caused the engine to stop and the aircraft to come to a halt. The pilot was uninjured and exited unaided through the canopy door. The propeller, right wheel spat, right wing leading edge, aileron and flap were damaged.

The POH stated that, under ISA conditions at a maximum landing weight (MLW) of 600 kg, for an average pilot, the 50 ft landing distance on a grass runway was 170 m and 180 m on concrete. The POH did not advise whether any special techniques should be used, such as maximum brake application. In 2007, the Popular Flying Association (now the Light Aircraft Association) required flight tests of the SportCruiser to evaluate its suitability for issue of a UK permit to fly, which was subsequently granted. From the flight test report, at just less than MLW (598 kg) and using normal braking, the landing distance from 50 ft on a tarmac runway was recorded as 327 m. The approximate landing weight of G-CFPA was 490 kg for the accident flight. The POH did not provide landing performance data for weights of less than MLW. Following the accident, the LAA advised that it planned to review the POH with regards to landing distance performance.

The area used for landing was reported as being both wet and soft at the time of the accident. The CAA Safety Sense Leaflet 07 provides guidance on aircraft performance and recommended factors to be applied to performance data. It states:

> *'Landing on a wet surface, or snow, can result in increased ground roll, despite increased rolling resistance. Tyre friction reduces, as does the amount of braking possible. Very short wet grass with a firm subsoil will be slippery and can give a 60% distance increase (1.6 factor).'*

It also recommends that for soft ground a factor of 1.25 or more should be applied, and strongly recommends that the Public Transport factor of 1.43 be applied to non-factored data to take account, amongst other things, of less than favourable conditions or incorrect speeds or techniques. Applying CAA recommended safety factors to the POH data would have required a 50 ft landing distance in excess of the 190 m available.

The pilot considered that he should have aborted the landing and, having established that the winds were within crosswind limits, landed on Runway 29. To assist pilots in determining the suitability of the grass areas for landing, the airfield operator advised that it would review the publication of additional airfield information.

ACCIDENT

Aircraft Type and Registration:	Grob G115E Tutor, G-BYWH
No & Type of Engines:	1 Lycoming AEIO-360-B1F piston engine
Year of Manufacture:	2000
Date & Time (UTC):	12 September 2009 at 1440 hrs
Location:	RAF Leeming, North Yorkshire
Type of Flight:	Military
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to the landing gear rib and lower wing skin
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	46 years
Commander's Flying Experience:	5,500 hours (of which 600 were on type) Last 90 days - 85 hours Last 28 days - 35 hours
Information Source:	AAIB Field Investigation and RAF Unit Inquiry

Synopsis

During the rollout from a three aircraft 'stream' landing, the pilot and passenger of the rear aircraft had to apply full brake pressure to avoid a collision with the aircraft in front. Although the aircraft did not collide, the resulting loads experienced by the wing structure supporting the landing gear, caused it to fail in overload. Subsequent analysis of the failed structure identified possible manufacturing issues, which may have contributed to the failure. The accident was also subject to an RAF Unit Inquiry. Five safety recommendations have been made.

History of the flight

A formation flypast by three Tutor aircraft from the Northumbrian University Air Squadron (NUAS) was planned as part of RAF Leeming's station families' day flying programme. The normal morning meteorological brief took place at 0730 hrs, after which the pilot and passenger of the accident aircraft separately operated passenger experience flights in other Tutor aircraft, until a flypast formation at 1000 hrs. A light tailwind of 2-3 kt was forecast for Runway 16 for the duration of the families' day event. The aircraft commanders, from the three aircraft involved, attended the formation brief, which reiterated aspects of the formation flypast that had been briefed and rehearsed three days previously. The rehearsed profile consisted of a formation takeoff, to reposition for several 500 ft formation flypasts, culminating in a 'Visual Run In And Break' (VRIAB) and 'stream' landing on Runway 16. The brief highlighted that the formation would land beyond the raised arrestor cable; however, no mention was made of where the formation would exit the runway. The commander of G-BYWH was in the No 3 position in the formation; he had taken part in the rehearsal flight, but had deliberately overshot the landing to continue with a student training sortie. During the day's proposed flying programme, there was also a Royal Flight scheduled at RAF Leeming. The crews planned a flexible time slot for the Tutor flypast based around a Royal Flight noise embargo. The lead pilot conducted a standard formation 'outbrief' and authorised the flight.

The formation crews then checked in and awaited a radio call to initiate the flypast profile. The Ground controller passed the clearance to start and the Tower controller advised an amended noise embargo start time "in twenty minutes." The formation moved off the dispersal area at 1425 hrs. The new embargo time of 1445 hrs meant the formation flypast, recovery and close down had to be completed within the available 20 min slot. The formation leader decided that this was achievable and continued with the takeoff.

The formation display was uneventful and the aircraft completed a final 360° orbit before departing away from the crowd line to reposition in 'echelon right' formation for the VRIAB. The VRIAB was conducted level and at 2 second intervals, with the lead aircraft flying at approximately 110 kt. The break was successfully completed with the aircraft equally spaced throughout the downwind and final turn segments of the approach, maintaining a standard 1,000 ft minimum separation for the planned 'stream' landing on Runway 16. The commander of G-BYWH reported that, during the final stage of the flight, he was preoccupied with maintaining accurate formation spacing to ensure the display looked correct and also by the possibility of wake turbulence in the latter stages of the approach. He therefore elected to fly a slightly higher and faster approach than normal, aiming for an approach speed of 80 kt rather than the usual 70 kt. ATC informed the formation that the surface wind was from 330° at 10 kt, which was stronger than expected, though this information was either not heard or not assimilated by any of the pilots.

The lead aircraft landed on the runway centreline, just beyond the arrestor cable on Runway 16, at what the pilot described as normal touchdown airspeed (approximately 65 kt). Using a combination of aircraft attitude and then a gentle application of the brakes, he reduced the aircraft's ground speed and moved to the pre-briefed 'slow lane' on the left side of the runway. The pilot of the No 2 aircraft experienced a small amount of wake turbulence on short finals, which required a corrective input of right aileron. As a consequence, he touched down further along the runway and to the right of the centreline. The pilot estimated that he landed 2-3 kt faster than the normal landing airspeed and with at least 1,000 ft separation from the lead aircraft. Again the pilot used a combination of aircraft attitude and then gentle brake application to slow the aircraft.

The pilot of G-BYWH, in an effort to avoid the effects of wake turbulence, maintained the faster than normal approach speed and a slightly steeper than normal approach to lose the additional height. As a result of this, and due to the position of the No 2 aircraft and the turbulence experienced prior to touchdown, the pilot felt that the safety margin would be reduced if he followed the brief to land on the centreline, and so he elected to land to the left. The pilot and passenger reported that they touched down just beyond the arrestor cable. Neither could recall the touchdown airspeed, but both suggested it may have been slightly faster than normal, though not excessively so. They also considered that they had a minimum of 1,000 ft separation from the other aircraft at this stage. In order not to lose sight of the No 2 aircraft, the pilot of the No 3 aircraft (G-BYWH) selected a lower than normal nose attitude for landing and commenced braking immediately after touchdown.

By this time, the pilot of the lead aircraft assessed that he had slowed sufficiently to turn off the runway onto a taxiway. At the same time, the pilot of the No 2 aircraft initiated a move across the centreline of the runway to the 'slow lane' on the left. The faster touchdown ground speed of G-BYWH and reduced drag of its landing attitude resulted in a rapid rate of closure with the No 2 aircraft. Both the pilot and the passenger of G-BYWH now assessed there was a risk of collision with the aircraft manoeuvring in front of them and both occupants simultaneously applied the brakes as hard as possible. The aircraft started to skid and the crew reported significant nosewheel shimmy and mainwheel 'brake judder'. The pilot of G-BYWH made two radio calls to the pilot of the No 2 aircraft to stay on the right of the runway. In response, both the lead aircraft and the No 2 started to move to the right, with the lead aircraft re-entering the runway. This removed the initial risk of collision between the rear two aircraft, but resulted in the lead now blocking the path of the third aircraft. After the initial application of full braking, the crew of G-BYWH recalled hearing two loud 'cracks' and reported that he felt an increase in the 'brake judder' from the main gear, with an associated loss of stopping performance. G-BYWH eventually came to a halt alongside the other two aircraft, with approximately 2 ft wingtip separation.

Whilst repositioning the formation, the pilot of G-BYWH believed he had a burst tyre and made a radio call requesting a visual inspection from the No 2 pilot, who confirmed that all tyres were still intact. The three aircraft taxied back to the NUAS dispersal and were shut down. G-BYWH was inspected by the site engineer, who noticed that the aircraft attitude was abnormal and that both landing gear access panels were damaged. When the aircraft was taken into the hangar for a more detailed inspection with the landing gear access panels removed and significant damage to the lower wing skin was discovered.

Pilot information

The three aircraft commanders were either serving or volunteer reserve RAF Officers each with over 3,000 hrs experience and were Qualified Flying Instructors (QFI). The first two aircraft flew with NUAS Officer Cadets as passengers. The passenger in the accident aircraft was a qualified and experienced instructor on the aircraft type, but had not been involved in the briefing, planning or rehearsal process and had only volunteered to sit in the spare seat when the opportunity was offered.

Landing performance

The landing distance available from the raised arrestor cable on Runway 16 was 6,220 ft and the distance to the taxiway turnoff selected by the lead aircraft was 1,950 ft. The aircraft Flight Manual landing distance chart assumes idle throttle, flaps set at LAND, a dry paved runway and use of maximum braking. This gave a calculated landing distance required for calm conditions and a normal touchdown speed of 1,500 ft. However, the reported conditions at the time of the accident gave a tail wind of 10 kt, resulting in a calculated landing distance of 2,200 ft. As the No 2 and No 3 aircraft (G-BYWH) reportedly landed at a slightly higher than normal touchdown speed, in accordance with RAF wake turbulence procedures, the landing distance required was likely to have been in excess of this figure.

The lead pilot, who planned the flight, did not calculate the landing distance required. Instead he relied on his experience and the significant landing distance available, to assess the amount of runway required for the 'stream' landing aircraft to decelerate and exit the runway.

Landing technique

A 'stream' landing is when the aircraft land normally one behind the other along the runway centreline, maintaining a minimum 1,000 ft separation. A nominal 'fast' and 'slow' side of the runway are agreed beforehand depending on which side the taxiway turnoff is located. Once each aircraft has slowed to a safe taxi speed they move to the 'slow' side of the runway. This allows any aircraft, which encounters a problem in slowing down, to move to the 'fast' side of the runway and have a clear escape lane. According to RAF procedure, should a pilot consider the separation distance from the aircraft in front to be insufficient prior to or at the point of touchdown, they are to perform an 'overshoot'.

The actual touchdown ground speed of the accident aircraft could not be accurately established, given the lack of GPS data available and neither occupant being able to recall the airspeed. Members of the RAF Unit Inquiry flew the flight profile described by the pilot and concluded it would result in a faster than normal ground speed at touchdown. However, they also considered it would have been within the typical operating range experienced by the aircraft. The manufacturer's manuals do not specify a landing speed or rate of descent limit for the landing gear.

The Grob G115E Flight Manual states that the recommended technique for maximum braking performance on short dry runways is 'cadence' braking. The technique is described as follows:

> *'As soon as the nose-wheel is on the runway use three to four seconds of moderate braking to establish the braking system effectiveness. As the brakes "bite", pull the control column back towards the rear stop. Then pause the braking for 2 seconds and then reapply. Continue the 2 second 'off' and 2 second 'on' braking cycle until the ground speed is under control.'*

Although the manual advises against steady pedal pressure to give the best deceleration performance and prevent disc heating, there are no specific warnings or limitations in the manual to suggest that this action could result in overload of the wing structure.

Pre-flight planning

NUAS were invited to participate in the families' day flying schedule to replicate a flypast flown by them during the 2008 families' day. The RAF considers a flypast to be a routine benign event, where an aircraft transits past a crowd-line as part of a special occasion. Their procedures define a flypast as involving:

> *'Aircraft flying, either singly or in formation, past a reviewing stand or any specific point along a pre-planned route without manoeuvring, other than when necessary for safe and accurate navigation.'*

This type of flight is not intended to include any additional pressures compared to routine flying, although it is often flown in formation. Risk mitigation at the planning stage for these flights is therefore similar to that required for normal formation flying, although special approval for the flight is still required. Display flying is different from normal flying due to the number and type of manoeuvres flown within a pre-defined airspace, often at low-level and with timing pressures.

Although the officers who authorised the flight considered it was a routine flypast, with standard manoeuvres and no aerobatic content, it did contain timing and airspace restrictions, an unusual downwind takeoff, three formation changes and an unusual, downwind 'stream' landing. As such, the RAF's investigation concluded that the pilots encountered the following:

> *'…unusual takeoff procedures; formation handling and Crew Resource Management (CRM); a higher than normal workload for the lead [pilot]; higher than normal timing and spacing pressures; crowd-line pressures; unusual landing procedures and crowd-pleasing pressures. The investigation considered that the planned sortie therefore involved elements of display flying and therefore carried an increased risk, compared to a routine flypast...'*

Approval for the flight was provided from two sources. The lead pilot's position within NUAS gave him self-authorisation privileges but a senior officer in the station command structure also gave approval after watching the rehearsal flight. NUAS is part of 22 Group, which is a training organisation within the RAF, whereas the senior officer was part of 1 Group, which conducts operational flying. His approval was given based on the physical performance during the rehearsal flight and not on a specific check of the planning and preparation or confirmation of permission having been obtained from 22 Group Headquarters.

Despite being able to authorise the flight himself, the lead pilot was expected to seek permission for the flypast from his chain of command within 22 Group. He delegated this task to another member of his team, who misunderstood the requirement. Both individuals assumed that the requested task had been completed satisfactorily and the matter was not discussed further. As a consequence, 22 Group Headquarters were not aware of the flypast or the semi-display nature of the planned content. The Commanding Officer of 22 Group advised that had permission been requested, approval would either have been refused or additional risk mitigation in the form of more extensive planning and rehearsal of the flypast would have been required.

Runway ground marks

Significant tyre marks could be identified on the runway left by the accident aircraft, showing that both wheels had 'locked up' for a distance of approximately 1,280 ft. The marks were a mix of solid tyre tracks and short skip marks.

Aircraft information

The Grob G115E Tutor is a small, lightweight aircraft used by the RAF for elementary flight training (Figure 1). The accident aircraft was a Civilian Owned Military Operated (COMO) aircraft and on the UK civilian register as G-BYWH. The Grob G115 type was certified to Federal Aviation Admistration (FAA) Federal Aviation Regulations (FAR) 23 standards, with an EASA type certificate issued for the Grob G115E in 2002, following on from German Luftfahrt-Bundesamt (LBA) approval of the type. It is constructed predominantly from carbon fibre, has a tapered low wing, fixed horizontal and vertical stabilisers and conventional flight control surfaces. The aircraft is fitted with a panel mounted GPS unit, with a track memory feature. However, no recorded data was found when the unit was downloaded after the accident.

Figure 1

Photograph of an RAF operated Grob 115E Tutor aircraft

The aircraft has a fixed, tricycle landing gear with simple, hydraulically operated, single disc brakes on each mainwheel and no anti-skid system. The main landing gear leg is a single piece of sprung steel attached to the wing in two places by bolting to steel brackets, which are in turn bolted to a composite gear rib (Figure 2) and the root rib. The gear rib is a carbon structure which angles inboard, with a web bonded around its circumference. The rib/web is bonded by adhesive to the upper and lower wing skins and the main spar and root rib at each end. The wing is a sealed structure, but has a small access port around the main gear attachment fitting, which is covered by an access panel in normal operation.

Aircraft inspection

Both the mainwheel tyres were in good condition, with the exception of flat spots and areas of melting consistent with the reported wheel lock-up under heavy braking. The main landing gear legs, wheels and brakes showed no evidence of damage. Visual inspection of the wing structure in situ was limited to the outer skins, and small sections of the inner side of the gear rib and outer side of the root rib visible via the access port. This inspection identified significant cracking of the lower skin and cracks between the gear rib and the wing spar on both wings. There was also damage evident on both the access port cover panels around the rear of the cut-out for the gear leg.

The aircraft was returned to the manufacturer's facility in Germany for the damaged sections to be removed and assessed under the supervision of the German Federal Bureau of Aircraft Accident Investigation (BFU). The damaged sections were then returned to the UK for analysis by composite material specialists.

Detailed examination confirmed similar and almost symmetrical damage to both wings. The access port cover panels had fractures through the carbon fibre from

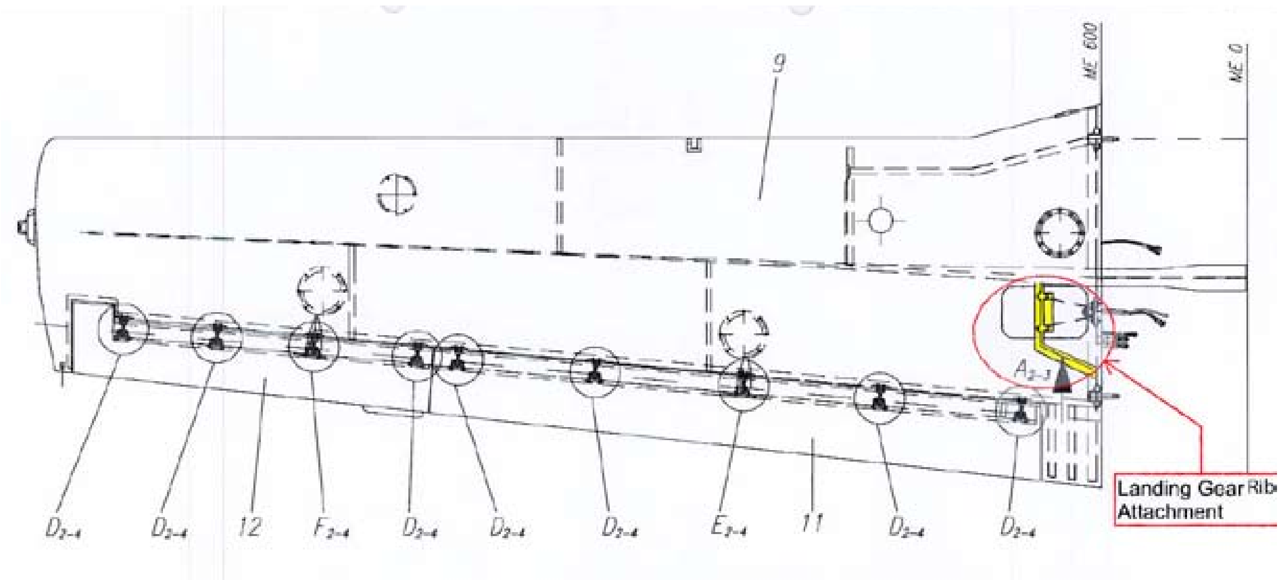

Figure 2

Diagram of Grob G115E wing structure.

the rear of the gear leg cut out of 50 mm for the left panel and 20 mm for the right panel. The orientation of the fibres and the cracking of the surface coating indicated that the panels had been pushed outwards by the gear legs. This was matched by witness marks on the paint of the gear legs. The lower wing skin was significantly cracked in the recess which formed the access port. Detailed inspection of the carbon fibres along the edges of these cracks indicated that the wing skin had been pushed upwards relative to its normal position.

Inspection of the disassembled sections of the gear rib showed that the rib/web had separated from the front spar and also along the top and bottom wing skins. It was not possible to determine exactly how far down the rib length the failure extended, as this was not confirmed prior to the deliberate removal of the rib from the wing skins during the disassembly process. However, an assessment of the additional areas of damage suggests that this separation must have extended along the rib. The bond failure on the left wing rib was predominantly adhesion[1], but with approximately 8% of the bond surface failing cohesively. The right wing rib exhibited an almost 100% adhesion failure, with the adhesive layer remaining on the wing spar surface of the joint.

The adhesive which had bonded the rib/spar and rib/skin joints was an unusual white translucent colour, with only small areas of pale yellow coloured adhesive at the edges of the joints. Inspection under a microscope identified that the white colour was due to a high level of porosity within the adhesive (Figure 3). Ductile fibrils were also identified in the areas of the adhesive that had failed cohesively, suggesting a ductile rather than brittle failure. A brittle failure would normally be anticipated from the epoxy resin system specified for these joints in the manufacturer's design specification. Fourier Transform Infra Red (FTIR) spectroscopy was

Footnote

[1] Adhesion bond failures occur at the interface between the adhesive and the structure being bonded, with residual adhesive remaining on one surface only. Cohesion bond failures occur within the adhesive layer, such that adhesive remains on both the structure surfaces.

used to analyse the composition of samples of both the yellow and white coloured adhesive. Both were consistent with an epoxy resin system. Chemical analysis of the samples, with comparison to exemplar samples at various stages in the cure cycle, confirmed that there were variations in the degree to which the adhesive had cured. Differential Scanning Calorimeter (DSC) tests were completed on the white adhesive to determine if the ductility was due to incomplete cure of the adhesive. Due to the porosity of the sample these tests proved inconclusive.

Also noted in the adhesive joints were large void areas. An example observed in the joint between the rib and the rib web measured 30 mm by 50 mm. The thickness of the layer of adhesive forming the bondline was noted to exceed the manufacturer's design specification (and industry production standard) of 0.5 to 2.0 mm in many areas. A large section of the web joint had failed in an interlaminar manner. The resulting fracture surface exhibited features consistent with a shear failure, with relative movement between the rib and the web in the vertical and longitudinal planes (rib moving forward and down/web moving up and back). The ductile properties of the adhesive masked the fracture features on the other surfaces, preventing further analysis.

The rib web had also failed in the corner of the gear rib where it angled inwards towards the root rib. Both ribs had fractured diagonally across the rib web and

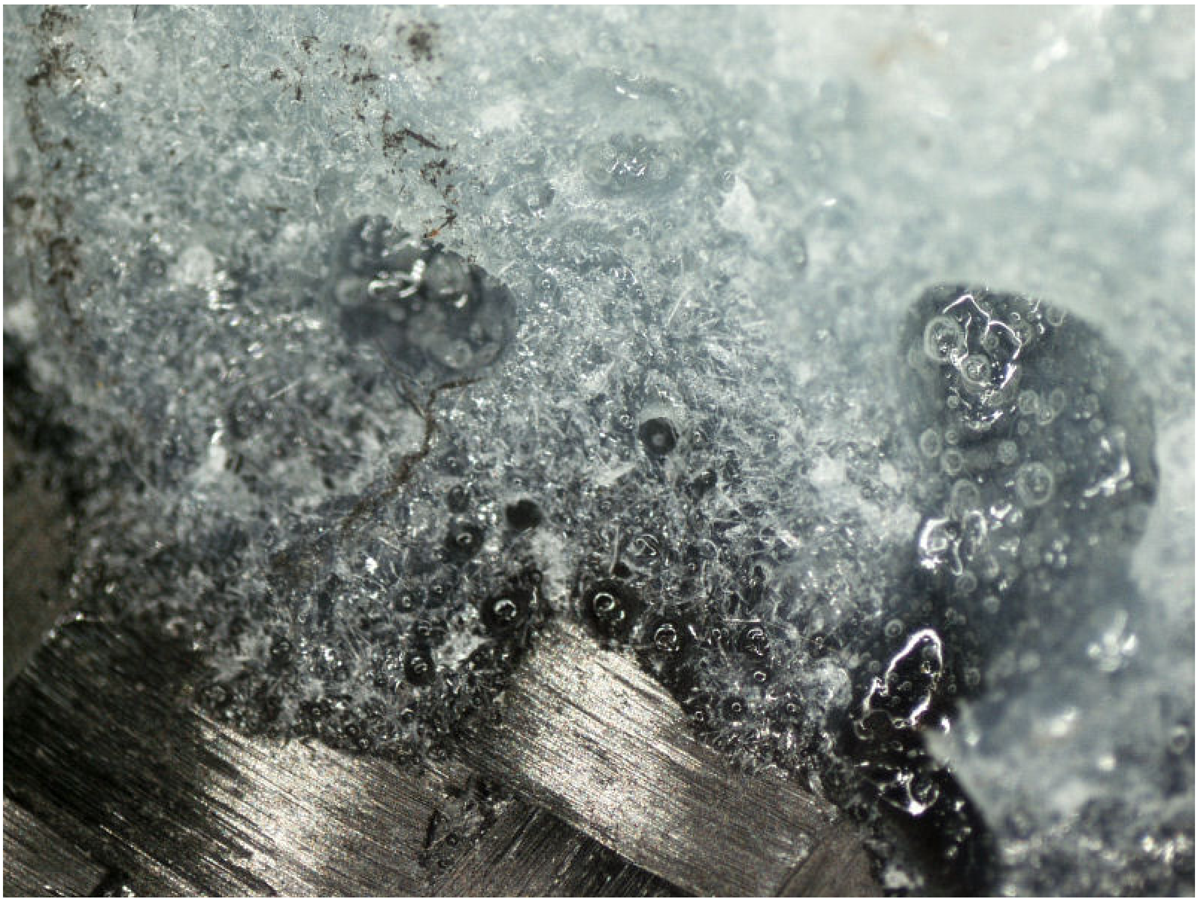

Figure 3

Magnified image of the white adhesive showing porosity down into the rib structure. The carbon fibres along the crack showed that the failure was tensile, with the front section of the rib being pulled outboard away from the wing root effectively 'straightening out' the angle. The rearward part of the metal gear leg attachment back plate was bent away from the composite rib by 1.5 mm on the left rib and 3 mm on the right rib, with associated separation of the composite straps used to secure it. This was also indicative of the forward section of the ribs having flexed outboard. The back face of the gear leg attachment plate showed fretting marks around the bolt-holes which were reflected by wear marks on the rib face, indicative of relative movement between the plate and the rib structure.

Manufacturing issues

During the detailed component inspection, a number of features were identified which indicated that the assembly process had not followed accepted industry best practice. In many cases these features were outside the manufacturer's design specification limits. These included:

- Significant interlaminar pores/voids within thick laminate sections
- Inconsistent fibre alignment and surface 'wrinkling' on composite sections
- Foreign object inclusion within a thick laminate section
- High levels of adhesive porosity
- Significant pores/voids within the adhesive at joints
- Excessive application of adhesive at joints, with resin flow-off not being removed and adhesive being used to secure non-structural items
- Excessive and inconsistent adhesive bondline thicknesses
- Fibre breakout at machined holes in the carbon fibre structures resulting in galvanic corrosion of metallic fasteners and delamination of the composite
- Low quality welding of metallic parts resulting in cracking and corrosion at the joints

Manufacturer's investigation findings

The manufacturer assessed the structural failures during the disassembly process, prior to the components being sent back to the UK. They issued an interim report confirming that the damaged areas had not been subject to a previous repair and were not the result of pre-existing damage. They stated that the structure had been certified against FAA FAR Part 23, which did not include any dynamic load test requirements and the majority of the compliance demonstration was based on similarity to previous Grob 115 models. They also advised that there had been no previous failures of this nature on any Grob 115 model in over 600,000 flying hours. Based on discussions with their Chief Test Pilot they considered the most plausible explanation for the damage was:

> *'Dynamic loads in the form of heavy vibrations'*

They expand this further by stating:

> *'Unfortunate combinations of tyre grip level, gear load at touchdown and speed may result in severe vibration of the landing gear rod. To avoid eventual vibration rising to a destructive level and for other good reasons, it is common sense to brake an aircraft sequentially instead of maintaining full brake pressure.'*

They also stated that as the failure was caused as a result of an 'emergency condition' and as such no further action was planned.

Previous occurrences

Review of operator and CAA records showed that a Mandatory Occurrence Report (MOR) was raised by the same operator following the discovery of almost identical damage to another aircraft in their fleet in 2004 during an Approved Maintenance Schedule (AMS) periodic inspection of the mounting bracket. At the time, the damage was attributed to an unreported heavy landing incident, though no evidence or analysis was put forward to support this conclusion.

Certification requirements

Requirements exist in both FAA FAR 23 and EASA Certification Standards (CS) 23 regarding the ability of aircraft structure to withstand limit load and ultimate load. These state:

> ***'23.301 Loads***
>
> *(a) Strength requirements are specified in terms of limit loads (the maximum loads to be expected in service) and ultimate loads (limit loads multiplied by prescribed factors of safety). Unless otherwise provided, prescribed loads are limit loads.*
>
> ***23.305 Strength and deformation***
>
> *(a) The structure must be able to support limit loads without detrimental, permanent deformation. At any load up to limit loads, the deformation may not interfere with safe operation.*
>
> *(b) The structure must be able to support ultimate loads without failure for at least three seconds, except local failures or structural instabilities between limit and ultimate load are acceptable only if the structure can sustain the required ultimate load for at least three seconds. However, when proof of strength is shown by dynamic tests simulating actual load conditions, the three second limit does not apply.*
>
> ***23.307 Proof of structure***
>
> *(a) Compliance with the strength and deformation requirements of CS[FAR] 23.305 must be shown for each critical load condition. Structural analysis may be used only if the structure conforms to those for which experience has shown this method to be reliable. In other cases, substantiating load tests must be made. Dynamic tests, including structural flight tests, are acceptable if the design load conditions have been simulated.*
>
> *(b) Certain parts of the structure must be tested as specified in Subpart D of CS[FAR]-23.'*

The requirements/assumptions for braked roll load calculations are provided by CS[FAR] 23.493. The standard safety factor between limit and ultimate load is 1.5.

Subpart D does not specifically require dynamic testing of the braked roll condition to validate the theoretical loads analysis. However, CS[FAR] 23.601 does state:

> *'The suitability of each questionable design detail and part having an important bearing on safety in operations, must be established by tests.'*

There are two further regulations within subpart D which are also relevant. CS[FAR] 23.603 states:

> *'(a) The suitability and durability of materials used for parts, the failure of which could adversely affect safety, must –*
>
> *(1) Be established by experience or tests;*
>
> *(2) Meet approved specifications that ensure their having the strength and other properties assumed in the design data; and*
>
> *(3) Take into account the effects of environmental conditions, such as temperature and humidity, expected in service.*
>
> *(b) Workmanship must be of a high standard.'*

CS[FAR] 23.605 (a) states:

> *'The methods of fabrication used must produce consistently sound structures. If a fabrication process (such as gluing, spot welding, or heat treating) requires close control to reach this objective, the process must be performed under an approved process specification.'*

Operational analysis

The RAF Unit Inquiry reported a number of operational factors which were assessed to have contributed to the accident. These and others have been considered in this investigation.

The issues surrounding the approval of the content of the flypast meant that an opportunity to avoid or reduce the risks involved was lost. The limited preparation and rehearsal of the flypast may have been significant with regard to the deviations from standard procedures which occurred during the landing. The nature of the manoeuvres flown during the display, including those leading into the landing and rollout were not entirely routine and although well within the capabilities of the pilots involved, required higher level and more specific planning and preparation. Additional distraction and specific task focus was also encountered by the pilots as they felt pressure to ensure the display looked good for the spectators.

Both the No 2 and No 3 (G-BYWH) aircraft's pilots independently elected to fly at higher airspeeds than usual in the approach, as advised by the RAF procedure for suspected wake turbulence. However, when combined with the stronger than forecast tailwind, which was passed to the pilots by ATC but reportedly not heard or assimilated by them, it resulted in higher than normal groundspeeds. Their focus on maintaining a high standard of display formation spacing, combined with the missed radio call may have prevented the formation from considering the option of increasing aircraft separation during final approach, to reduce the likelihood of encountering wake turbulence or to take account of the tailwind and deliberately higher airspeed. Had this option been taken, it may have maintained the margin that was required to safely continue with the 'stream' landing.

The No 2 pilot landing to the right of the centreline resulted in the No 3 pilot electing to land to the left of the centreline on what should have been the 'slow' side of the runway. The briefed 1,000 ft minimum separation should have allowed the aircraft to land safely behind each other regardless of position on the runway, providing the aircraft were travelling at similar speeds and decelerated at the same rate. The pilot of G-BYWH stated that he considered it necessary to land on the opposite side of the runway to avoid wake turbulence. It is possible, however, that he had already anticipated a reduction in separation distance due to the speed differential between the aircraft, even if the minimum distance existed as he crossed the threshold. The normal safeguard of having an escape lane on the 'fast' side of the runway had also been lost by the positioning of the No 2 aircraft. The accident pilot stated that a perceived need to ensure the display looked good for the crowd contributed to his decision not to perform an 'overshoot' while the opportunity was available. It is possible, though not specifically stated by the pilot, that timing pressures resulting from the Royal Flight noise embargo may also have been a contributory factor.

The lead aircraft was not aware of what was occurring with the two aircraft behind. The taxiway turn-off he selected was safely achievable based on his own aircraft's ground speed. However, had the stopping distances been calculated prior to the flight, this may have emphasised the reduced margin available in the event of the landing not going to plan. The timing of the crossing manoeuvre by the No 2 pilot may also have been influenced by an anticipation of the need to follow the lead aircraft's turn to maintain the formation. Planning for an extended rollout may have helped to avoid the compressed landing distance available, which the pilot of the No 3 aircraft (G-BYWH) encountered. Including a target turnoff in the original brief may also have added to the pilots' situational awareness in anticipating a risk of collision before it reached a critical stage.

The higher groundspeed and lower drag attitude of the No 3 aircraft meant that the separation distance from the No 2 aircraft rapidly reduced following touchdown. Once the possibility of collision had become a critical concern, the pilot of G-BYWH made a non-standard radio call to the No 2 pilot to remain on the right of the runway. This was misinterpreted by the lead pilot who re-entered the runway and became a further obstacle to the accident aircraft's escape route.

These factors in combination resulted in both the pilot and passenger of G-BYWH sharply applying full and continuous operation of the brakes in an effort to avoid a collision.

Engineering analysis

When the brakes were applied during the avoiding action, both the wheels locked causing the aircraft to skid. The momentum of the aircraft effectively acting through the aircraft's centre of gravity and the effect of the locked brakes at the level of the wheels/tyres, produced moments around the gear leg attachment points in both the vertical and horizontal planes (Figure 4). These were transmitted into shear loads on the adhesive bonds locating the gear ribs. The adhesive bonds failed and the ribs separated from the spar and wing skins around a section of their circumference, with the ribs flexing outwards and downwards. This caused the rib and web to crack at the point where it kinks to meet the root rib. It also caused associated flexing and cracking of the lower wing skin, as it became a secondary path for the loads. Loss of the rigid location of the landing gear meant the deceleration loads could no longer be transferred to the primary aircraft structure, compromising stopping distance and the ability of the pilot to control the aircraft.

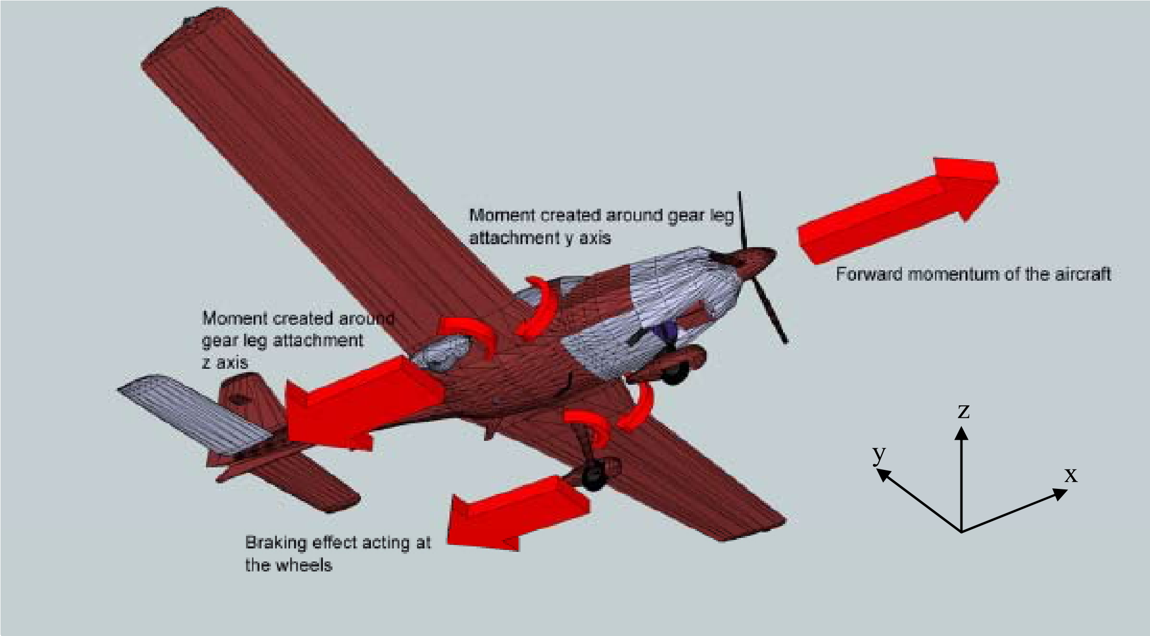

Figure 4

Illustration of loads acting on the aircraft

The adhesive in the failed joints had high levels of porosity. Industry studies have shown that the presence of porosity within epoxy-based materials causes a significant reduction in the mechanical properties of the material. Studies showed that shear strength reduction by a factor of ten was observed between a non-porous and porous epoxy material[2]. The thickness of the adhesive layer forming the bonds meant the presence of porosity was also likely to have had a greater influence on the mechanical properties of the bond, than would have been the case for thinner adhesive layers.[3]

A degree of porosity within epoxy-based resins is unavoidable, as the curing reaction produces hydrogen that becomes trapped as bubbles within the resin. However, there are a number of manufacturing issues which can cause excessive porosity and may have contributed to the high adhesive porosity identified on the accident aircraft. These are:

- Excessive use of hardening agent which accelerates the curing reaction and thus the production of hydrogen
- Incomplete or incorrect mixing of the resin and hardening agent resulting in localised concentrations of resin or hardener (resin rich or resin poor areas)
- Excessive thickness of the resin/hardener layer applied allowing migration and coalescence of hydrogen bubbles into larger pores
- A mixing process that incorporates air from the atmosphere into the resin/hardener mix such as stirring partially cured adhesive

Footnote

[2] Alonso MV, Auad ML and Nutt S – Short-fiber-reinforced epoxy foams. Composites A: Appl Sci and Manu, 2006.

[3] Harte A-M, Fleck NA and Ashby MF - Sandwich panel design using aluminium alloy foam. Adv Eng Mater, 2000,

It is likely that the porous nature of the adhesive created a weak bond which may have contributed to the failure of the joints between the ribs and the spar and skins. The thickness of the layers of adhesive and the presence of significant voids/pores may also have contributed to the weakness of the joints. In some areas the adhesive layer was found to be three times thicker than the manufacturers own design specification and 20 times thicker than the limit suggested by industry studies beyond which it becomes detrimental to the shear strength of the bond. Both these features can result from insufficient pressure holding the structure together during the curing process, excessive layer thickness can also result from the use of adhesive to fill gaps created by large tolerances in component dimensions.

A number of other features were noted which were also indicative of design and manufacturing processes that were not in line with industry recommended practice and demonstrated a lack of effective quality control. Although these were not directly linked to the failure, they have been shown by industry studies to be detrimental to component structural strength and can lead to premature failure of aircraft structure. As the issues relate to both design assumptions and manufacturing processes, the following Safety Recommendation is made:

Safety Recommendation 2010-078

It is recommended that the European Aviation Safety Agency in cooperation with the Luftfahrt-Bundesamt (LBA) conduct an audit of Grob Aircraft AG's design and quality standards, manufacturing processes and facilities to ensure that they meet current regulatory standards.

To determine if the findings from the examination of G-BYWH are present on other Grob G115E aircraft, the following Safety Recommendation is made:

Safety Recommendation 2010-079

It is recommended that the European Aviation Safety Agency require Grob Aircraft AG to introduce an inspection of all G115E aircraft to ensure their structural integrity complies with regulatory airworthiness standards and that design assumptions relating to fabrication techniques and material properties used during aircraft certification remain valid.

In the absence of any test data for the dynamic structural loads encountered under heavy braking on the Grob G115E aircraft, it has not been possible to demonstrate that the failure of the gear rib structure was solely the result of a weak adhesive bond. The design of the joint between the rib and the spar/skins was more typical of metallic rather than composite design standard practice and as such was not optimised to withstand the loads experienced, even if the adhesive bonds had been sound. The response of the manufacturer to the accident relies on the current certification requirements not specifically calling for demonstration of the capacity of the structure to withstand dynamic braking loads. As such they have stated that the aircraft still meets its airworthiness certification basis. They also point out that this was an emergency scenario and therefore not representative of normal operation, drawing attention to the fact that the Flight Manual instructs that a cadence braking technique should be used.

Although the aircraft was travelling at a slightly higher groundspeed than usual at touchdown, it was unlikely to have been excessive or outside the range where the aircraft could be expected to operate safely. The application of the brakes was not in accordance with the Flight Manual guidance, but was a foreseeable response to the circumstances, as was the lock-up of the wheels. The braking system does not have an 'emergency mode' and the Flight Manual draws no distinctions between emergency and normal braking technique, nor could this be considered an emergency landing. Furthermore the aircraft Flight Manual does not quote a specific limitation against full and continuous application of the brakes. As such, the braking technique employed by the pilots during the accident, even though the wheels locked as a consequence, should be considered part of the anticipated operating envelope of the system.

Reliance on cadence braking when attempting to avoid a collision is unrealistic, as demonstrated by this accident, and particularly in light of the aircraft's primary role as an elementary flight trainer. The aircraft must be capable of withstanding the loads that are generated by the rapid and continuous application of full brake pressure, either by ensuring the structure is strong enough to withstand them or by reducing the effect of brake application, such that the resulting loads remain within the structural strength limitations of the aircraft. The following Safety Recommendation is made:

Safety Recommendation 2010-080

It is recommended that the European Aviation Safety Agency in conjunction with the Federal Aviation Administration review the Grob G115E aircraft design to ensure that rapid, full and continuous application of the brakes at groundspeeds within the normal operating envelope, does not result in failure of the aircraft's structure.

With regard to the certification requirements, the following Safety Recommendations are made:

Safety Recommendation 2010-081

It is recommended that the European Aviation Safety Agency consider the introduction of a specific requirement, for CS 23 certified aircraft, to ensure that theoretical maximum landing gear dynamic loads under braking, calculated during the design process, are validated by dynamic testing and the capacity of the aircraft structure to withstand them is demonstrated as part of the certification process.

Safety Recommendation 2010-082

It is recommended that the Federal Aviation Administration consider the introduction of a specific requirement, for FAR 23 certified aircraft, to ensure that theoretical maximum landing gear dynamic loads under braking, calculated during the design process, are validated by dynamic testing and the capacity of the aircraft structure to withstand them is demonstrated as part of the certification process.

ACCIDENT

Aircraft Type and Registration:	Gulfstream AA-5A Cheetah, G-RATE
No & Type of Engines:	1 Lycoming O-320-E2G piston engine
Year of Manufacture:	1978
Date & Time (UTC):	13 May 2010 at 1617 hrs
Location:	Leicester Airfield, Leicestershire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 3
Injuries:	Crew - None Passengers - None
Nature of Damage:	Wings scratched, tailplane and one runway light damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	20 years
Commander's Flying Experience:	59 hours (of which 8 were on type) Last 90 days - 2 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The accident flight was the pilot's first flight in the aircraft as pilot in command with three passengers onboard. As part of the pre-takeoff checks, he set the pitch trim to a position he thought appropriate for the aircraft loading. However, during the subsequent takeoff, the aircraft became airborne several knots less than the published rotate speed. Shortly afterwards the pilot felt the right wing drop. He reduced the engine speed to idle and landed the aircraft back on the runway, during which both wing tips and the tail contacted the ground. He then applied the brakes, bringing the aircraft to a full stop in the grass field at the end of the paved runway. The pilot considered that he selected too much nose-up trim for takeoff and allowed the aircraft to get airborne prematurely. He believed that the aircraft then stalled and landed heavily back on the runway.

SERIOUS INCIDENT

Aircraft Type and Registration:	Piper PA 23, N2401Z
No & Type of Engines:	1 Lycoming TI0-540 SER piston engine
Year of Manufacture:	1980
Date & Time (UTC):	10 August 2010 at 1553 hrs
Location:	Bournemouth Airport, Dorset
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 2
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	48 years
Commander's Flying Experience:	1,150 hours (of which 150 were on type) Last 90 days - 75 hours Last 28 days - 45 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

The first flight of the day departed Filton with full fuel tanks, landed at Cardiff and flew on to Southampton. On departing Southampton the pilot needed to use excessive right aileron and elected to divert to Bournemouth, declaring a PAN. A go-around was flown from the initial approach to Runway 26 due to positioning problems associated with the control difficulties. The pilot then declared a MAYDAY and elected to carry out a flapless landing on Runway 08. The surface wind was reported as 240° at 14 kt. The touchdown was normal but with the higher speeds associated with the flapless landing, together with the 13 kt tailwind component and wet runway conditions, the pilot decided to overrun rather than risk bursting the tyres. The aircraft came to rest on the grass past the end of the runway. No injuries or aircraft damage were reported.

The control difficulties arose from a fuel imbalance; the port tanks were found full. The pilot reported that the previous pilot had reported issues with asymmetric fuel readings and so had tried cross-feeding the fuel. The accident pilot stated that he had missed the cross-feed item of the check list at the beginning of the day due to being distracted by a flat battery. He has since amended his own checklist.

ACCIDENT

Aircraft Type and Registration:	Reims Cessna F150M, G-HIVE
No & Type of Engines:	1 Continental Motors Corp O-200-A piston engine
Year of Manufacture:	1975
Date & Time (UTC):	5 September 2010 at 1105 hrs
Location:	Beverley Airfield, North Humberside
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Bent engine frame
Commander's Licence:	Student
Commander's Age:	16 years
Commander's Flying Experience:	44 hours (of which 44 were on type) Last 90 days - 9 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

After completing three circuits and a practice emergency landing with his instructor at Beverley Airfield, the student pilot carried out a further four successful solo landings on Runway 12. The weather was reported as clear, with a wind velocity of between 12 and 14 kt down the grass runway and 10 km visibility. The pilot reported that his fifth solo approach and flare appeared normal but, on touchdown, the aircraft bounced twice before finally landing heavily on the nosewheel, distorting the engine frame; he was uninjured. His instructor was unable to transmit on a radio in time to advise a go-around.

The pilot reported that he may have touched down on a bump in the grass runway causing the aircraft to balloon and, despite several attempts to regain control, did not prevent the heavy nosewheel landing. He further stated that he should have gone around as he had been instructed, and has since undergone further training on go-around procedures.

ACCIDENT

Aircraft Type and Registration:	Reims Cessna FR172H, G-RABA
No & Type of Engines:	1 Continental Motors Corp IO-360-D piston engine
Year of Manufacture:	1972
Date & Time (UTC):	18 July 2010 at 1240 hrs
Location:	Compton Abbas Airfield, Dorset
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	61 years
Commander's Flying Experience:	89 hours (of which 17 were on type) Last 90 days - 6 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent AAIB telephone enquiries

Synopsis

After refuelling, the pilot started the engine with the intention of taxiing the aircraft to the parking area. Upon starting, the engine went to high power, and the aircraft began to move rapidly forward and collided with a hangar before the pilot could intervene. The pilot was uninjured and was able to vacate the aircraft via the normal exit.

History of the flight

G-RABA was operated by a company specializing in airborne banner towing and aerial advertising. The aircraft had been tasked to tow a banner at an event in Tolpuddle. The plan was to fly from Blackpool to Compton Abbas, where the banner would be collected and the aircraft would be refuelled, before continuing to Tolpuddle. The aircraft departed Blackpool with three people on board, all of whom were pilots. Pilots A and B held Private Pilot's Licences and were the owners of the company which operated the aircraft. Pilot C was a commercial pilot, employed by the company on an ad hoc basis to undertake banner towing.

Pilot A acted as Pilot in Command for the flight from Blackpool to Compton Abbas. After landing at Compton Abbas, he taxied the aircraft to the asphalt apron, and shut down the engine prior to refuelling. All three people vacated the aircraft and Pilot A proceeded to refuel it. He then left the apron area, while Pilot B got into the aircraft with the intention of taxiing it to the parking area. Pilot C assisted in manoeuvring the aircraft so that it was facing away from the fuel pump and he was then seen on CCTV to move to the vicinity of the left door of the aircraft. When Pilot B started the engine the aircraft rapidly accelerated forward and collided with a hangar before he could react. Pilot C moved back as the aircraft began to move. A number of witnesses reported hearing the engine go to high power immediately after start.

Pilot A, Pilot C and another witness made their way immediately to the aircraft and determined that Pilot B was uninjured, although very shocked. They assisted him in completing the shutdown drills and vacating the aircraft.

Both wings were severely damaged in the collision, resulting in fuel spillage. Airfield staff responded to the incident to provide fire cover and the local Fire Service was also called to assist.

Discussion

Pilot B reported that the technique for a hot start requires the throttle to be set to full power and the mixture set to lean. As the engine fires, the mixture is advanced and the throttle is closed. He stated that the engine fired up on the first attempt, went immediately to full power and the aircraft accelerated forward, taking him by surprise. The parking brake was off during refuelling but he believed that he had reapplied it prior to starting the engine.

Pilot B had previously performed a number of hot starts on this aircraft using the same technique, without any problems. In those cases however, a longer time had elapsed between shutting down and restarting the engine. He considered that the very short time between shut down and restart in this case may have contributed to the engine firing immediately and going to full power before he could close the throttle.

ACCIDENT

Aircraft Type and Registration:	Scintex CP1310-C3 Super Emeraude, G-BJCF
No & Type of Engines:	1 Continental Motors Corp O-200-A piston engine
Year of Manufacture:	1965
Date & Time (UTC):	25 August 2010 at 1140 hrs
Location:	Little Snoring Aerodrome, Norfolk
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Left landing gear leg bent, propeller tip broken off, pitot head bent
Commander's Licence:	Private Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	113 hours (of which 7 were on type) Last 90 days - 9 hours Last 28 days - 6 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot had just completed his tailwheel differences training on the aircraft, having flown nine dual and three solo flights already that day. He had previously conducted 16 dual takeoffs and landings on the aircraft. He took off and flew one circuit to a full stop landing before he backtracked and took off for a short flight to the north of the airfield. On rejoining the circuit, he made an uneventful approach and touchdown but on the landing rollout, the aircraft drifted left. The pilot applied right rudder and the aircraft veered sharply to the right. He then applied left rudder and the aircraft veered sharply to the left and departed the grass runway. The aircraft's left undercarriage collided with the raised edge of a concrete track to the side of the runway, and collapsed under the aircraft. The pilot considered that he may have overcorrected with his rudder inputs and lost directional control during the rollout.

ACCIDENT

Aircraft Type and Registration:	Streak Shadow, G-BUGM
No & Type of Engines:	1 Rotax 582 piston engine
Year of Manufacture:	1992
Date & Time (UTC):	10 July 2010 at 1729 hrs
Location:	Wold Lodge Farm Strip, Northamptonshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nosewheel detached, nosecone and fuselage substantially damaged
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	40 years
Commander's Flying Experience:	251 hours (of which 103 were on type) Last 90 days - 7 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent enquiries by the AAIB

The aircraft was flying from Sibson Airfield to Northampton Airfield when, approximately 10 nm north-east of the destination and at a height of about 1,500 ft agl, the engine lost power over a period of five seconds. Attempts to restart the engine failed. The prevailing wind was southerly at 15-20 kt, reducing to 10 kt at the surface. The pilot turned the aircraft into wind and made a MAYDAY call. He identified a field and carried out a forced landing. The landing was abrupt and resulted in damage to the nosewheel, nose cone, fuselage and strobe but no injury to the pilot. The pilot cancelled the MAYDAY, turned off the fuel and electrical power and vacated the aircraft. Having exited the aircraft the pilot discovered that he had landed across Wold Lodge Farm Strip. The strip runs east to west and had a standing crop about 18 inches high on either side.

The pilot reported that there was sufficient fuel and oil onboard. The weather conditions presented a moderate risk of carburettor icing using cruise power and a serious risk with descent power. At the time of this report, the cause of the engine failure is unknown.

ACCIDENT

Aircraft Type and Registration:	Ikarus C42 FB80, G-CDUK
No & Type of Engines:	1 Rotax 912-UL piston engine
Year of Manufacture:	2005
Date & Time (UTC):	21 September 2010 at 1400 hrs
Location:	Croft Farm Strip, Defford, Worcestershire
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Significant damage to forward fuselage and right wing
Commander's Licence:	Student pilot
Commander's Age:	53 years
Commander's Flying Experience:	40 hours (of which 40 were on type) Last 90 days - 6 hours Last 28 days - 6 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The student pilot was undertaking a solo flight from Long Marston to Croft Farm. He was landing on Runway 09 with a light and variable crosswind from the south. The aircraft bounced on landing and veered to the left. He elected to go around to avoid a runway edge marker and applied full power. The aircraft struck a hedge a few metres from the runway and came to rest in the adjacent field. The student pilot, who was uninjured, attributed the accident to having insufficient speed for a go-around.

SERIOUS INCIDENT

Aircraft Type and Registration:	Lindstrand Balloons Ltd LBL180A, G-CBZU
No & Type of Engines:	N/A
Year of Manufacture:	2003
Date & Time (UTC):	28 August 2010 at 0845 hrs
Location:	Sarratt, Hertfordshire
Type of Flight:	Public Transport
Persons on Board:	Crew - 1 Passengers - 6
Injuries:	Crew - None Passengers - 1
Nature of Damage:	None
Commander's Licence:	Commercial Pilot's Licence (Balloons)
Commander's Age:	69 years
Commander's Flying Experience:	1,920 hours (of which 40 were on type) Last 90 days - 69 hours Last 28 days - 6 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and AAIB enquiries

Synopsis

During the approach to the planned landing site, the balloon was caught in an updraft and climbed away. The pilot, unable to land in an adjoining field due to the presence of livestock, initiated a second descent over the field in which he had originally planned to land. The rapid descent resulted in the balloon basket striking the ground with some force, during which a passenger, who had not adopted the briefed landing position, received an injury to his knee. There were no other reported injuries.

History of the flight

On arrival at the takeoff site, the balloon was prepared for flight by its ground crew, assisted by five of the six passengers, after which the passengers boarded the balloon basket. Prior to takeoff, the pilot informed the passengers about numerous aspects of the flight, including a briefing on the procedure to adopt during approach and landing. Statements made by some passengers confirmed that this included a practical demonstration of the brace position to adopt when landing, which they all had to demonstrate to ensure that they fully understood the procedure.

After being airborne for approximately 90 minutes, the pilot informed the passengers that the balloon was about to descend to land in a field and told them to adopt the briefed landing brace position, after which he continued to concentrate on controlling the balloon's flight path. However, a passenger, in the rear compartment of the basket remained standing and continued to use his video camera.

In the final stages of the descent, the balloon was caught in an updraft which caused it to climb. The balloon overshot the planned landing site and flew towards an adjacent field, in which the pilot now intended to land. As the balloon gained height, the pilot observed livestock in that field and decided to carry out an immediate landing to reduce the risk of injury to the livestock, in line with the British Balloon and Airship Club code of conduct for farmers and pilots. The resulting descent was rapid and resulted in a hard landing. In the video footage recorded by the standing passenger, the pilot's voice can be heard informing the passengers of the balloon's rapid descent and to prepare for a "big bump" 12 seconds prior to the landing. As the balloon touched down, the standing passenger reported feeling a sharp pain in his right knee. When questioned by the pilot, during the de-rigging of the balloon, the passenger said that he thought he had aggravated an old injury. The passenger stated that the injury appeared to improve prior to being returned to the pre-arranged drop-off point with the other passengers, after which he had increasing difficulty in walking and subsequent medical examinations revealed that the he was suffering from a fracture of the knee.

ACCIDENT

Aircraft Type and Registration:	P & M Aviation Ltd QuikR, G-JFAN
No & Type of Engines:	1 Rotax 912ULS piston engine
Year of Manufacture:	2010
Date & Time (UTC):	16 October 2010 at 1430 hrs
Location:	Oldshoremore Beach, Kinlochbervie, West of Scotland
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Wing, propeller, cockpit
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	41 years
Commander's Flying Experience:	78 hours (of which 41 were on type) Last 90 days - 31 hours Last 28 days - 10 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

During the flight from Tain to Durness, in light winds and with good visibility, the pilot noticed a higher than normal cylinder head temperature reading. He decided to make a precautionary landing on the beach at Oldshoremore, Kinlochbervie. The landing was on firm sand but at the end of the landing run the nosewheel sank into softer sand, dug in and the plane rolled over, coming to a stop upside down. The aircraft sustained wing, propeller and cockpit damage but there were no injuries to the pilot or passenger. The pilot contacted the police and pulled the aircraft up the beach for recovery the next day. In hindsight the pilot stated that his precautionary landing, in response to the higher cylinder head temperature, may have been unnecessary. At the time of writing this report, the cause of the higher than normal cylinder head temperature is unknown.

ACCIDENT

Aircraft Type and Registration:	Pegasus Quantum 15-912, G-BZMI
No & Type of Engines:	1 Rotax 912 piston engine
Year of Manufacture:	2000
Date & Time (UTC):	21 March 2010 at 1630 hrs
Location:	Longacre Farm, Bedfordshire
Type of Flight:	Air Experience flight (Exercise 3)
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Serious) Passengers - 1 (Serious)
Nature of Damage:	Damaged beyond economic repair
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	47 years
Commander's Flying Experience:	1,051 hours (of which 963 were on type) Last 90 days - N/K hours Last 28 days - N/K hours
Information Source:	AAIB Field Investigation

Synopsis

After rotation, the flex-wing microlight entered a constant gradual right turn, which could not be controlled by the pilot. Eventually the aircraft lost height, the right wingtip hit the ground and the aircraft came to rest in a field. The investigation identified that the battens, received with the wreckage, had been adjusted significantly more than the manufacturer's published limits permitted.

History of the flight

The passenger had been given a flight experience voucher purchased by her husband, which entitled her to a 30-minute flight in both a 3-axis and a flex-wing microlight at a local flying school. She returned from the flight in the 3-axis microlight and was provided with the necessary protective clothing for her flight in the flex-wing aircraft. This was to be the fifth flight of the day in G-BZMI for the pilot. The pilot, with the passenger in the rear seat, taxied the aircraft to Runway 17, and tookoff at 1615 hrs. The weather was fine, but with a 15 kt crosswind from the west. After rotation, the pilot found that a constant, but controllable, uncommanded turn to the right, that had been present on the aircraft all day, had become noticeably worse. He therefore flew a circuit and landed to address this issue.

The pilot stated that he removed one of the two elastics, which held the wing ribs/battens in place, on each of the wingtip ribs, in an effort to reduce the tension in the wing. He also recalled trying to adjust the shape of ribs 8 and 9 on the left wing, in-situ, by attempting to bend the trailing edge approximately 5 mm, to 'tune-out' the turn. The passenger stated that the pilot was away from the aircraft for approximately a minute and worked on the left wing for around 30 seconds, appearing to shake it. The pilot then returned to his seat and taxied the aircraft to Runway 17 for a second takeoff. This time, following rotation at a height of 20 to 30 ft, the pilot found that even with full opposite control input, the aircraft continued to bank right and he could not recover to straight and level flight.

The pilot attempted to manoeuvre the aircraft to land on the alternate east/west runway, but could not turn the aircraft to align with the runway centreline. He continued to bank right in an effort to complete the circuit and land back onto Runway 17, but lost height, resulting in the right wing striking the ground and the aircraft coming to rest in a field, lying on its right side. The aircraft was significantly damaged and both the pilot and passenger suffered serious lower limb injuries.

Aircraft information

The Pegasus Quantum is a two-seat, permit-to-fly, flex-wing microlight. It can be flown solo or dual. During flying training the student pilot generally occupies the front seat and the instructor the rear. The pilot occupies the front seat when carrying a passenger not under instruction or during air experience flights. Due to CG restrictions, the pilot must sit in the front seat when flying solo. The sail is manufactured from

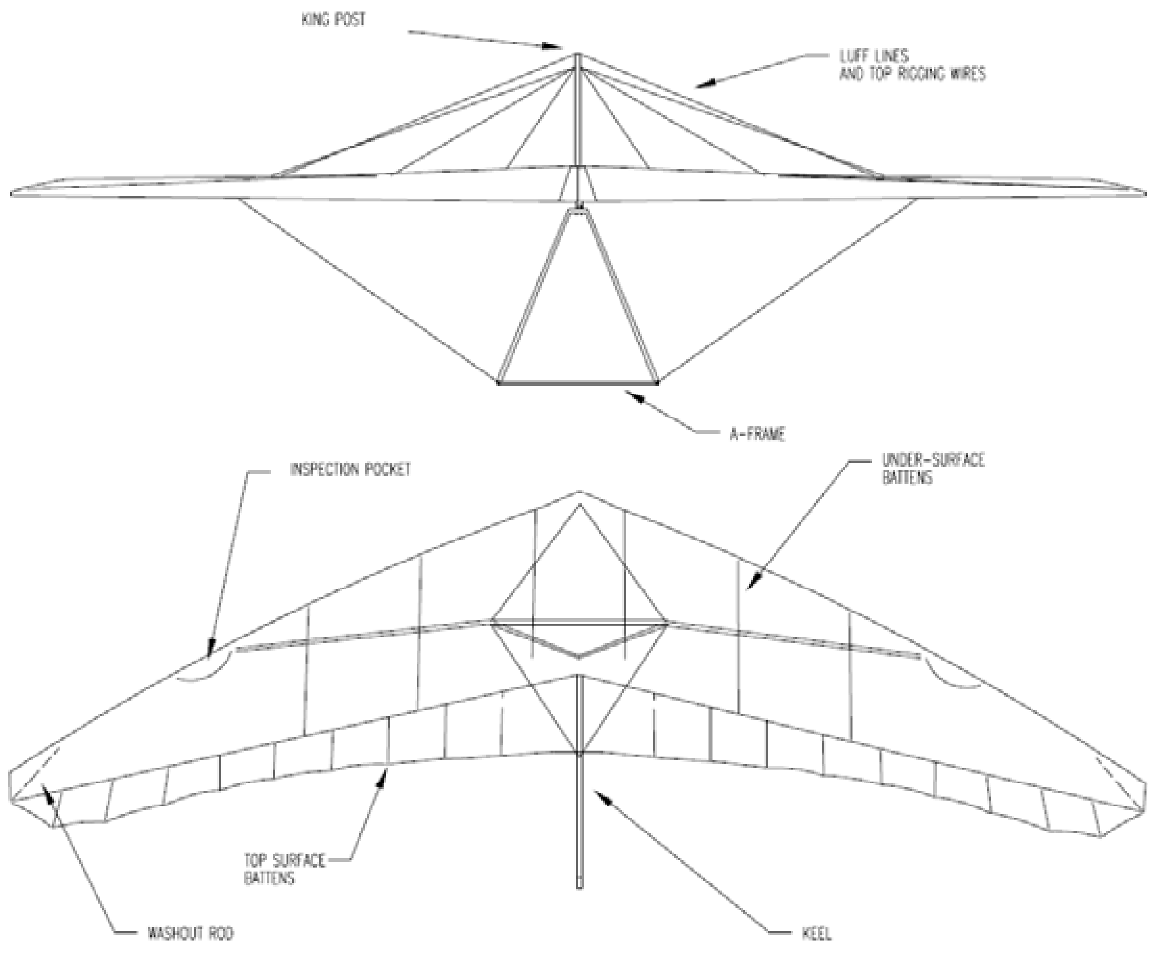

Figure 1

Pegasus Quantum wing diagram (by courtesy of P&M Aviation) stabilised polyester, reinforced with Tri-lam and Kevlar. The aerofoil section is defined by pre-formed aluminium and aluminium/composite ribs or battens which are located in pockets stitched into the sail fabric (Figure 1). Wing tension is maintained by various cables, including 'luff lines' which run from the 'king post' to the wing trailing edge. The luff line tension can be adjusted in-flight by the pilot, allowing the wing to be trimmed in pitch for the selected cruise speed.

Aircraft control

Roll control in a flex-wing weight-shift microlight is achieved by the action of the pilot moving the CG of the trike relative to the hang-point (Figure 2). At normal cruising speeds of 45 mph upwards, turns are initiated by the A-frame control bar being positioned to the side away from the required direction of turn. As the required bank angle is reached the roll control input should be relaxed. Rollout is achieved by positioning the control bar towards the lower wingtip.

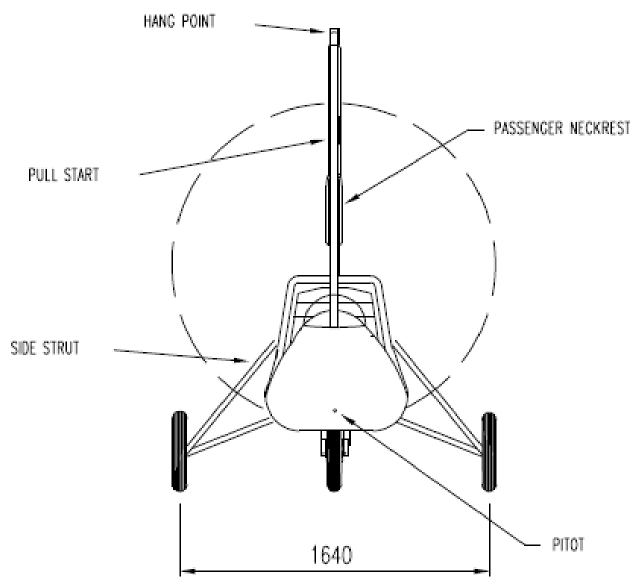

Figure 2

Pegasus Quantum trike diagram
(by courtesy of P&M Aviation)

Roll response is aided by the intentional flexing of the airframe and the sail, assisted by a 'floating keel' design, which reduces the effort required by the pilot to produce and stop a roll manoeuvre. As the wing is only deflected a certain amount by the action of the pilot, the rate of roll varies with airspeed, becoming faster with increasing speed.

Wing tuning

A flex-wing microlight's wing should be trimmed so that in the absence of any control input, it flies straight at steady speed. A properly tuned wing allows the pilot to fly at a range of steady speeds without the need to apply correcting control inputs. However, an incorrectly tuned wing will often result in a constant turn at all speeds or an increasing turn with increasing airspeed, which must be continually corrected by the pilot. This can become tiring for the pilot and can cause difficulties during takeoff, landing and when flying through turbulence. A turn induced by a grossly out-of-trim wing can exceed the control authority available to the pilot, preventing controlled flight.

The Quantum wing is fitted with tip turn adjustors at each wingtip. These can be adjusted to tune out turns occurring at all airspeeds. For turns which are more pronounced with increasing airspeed, adjustment can be made by bending battens numbered 7 to 10 (11 being the wingtip batten) to change the wing profile. Applying an upward reflex (bend upwards) in the trailing edge results in a small downforce being generated, this changes the incidence of the wing section increasing the lift generated. As lift is a function of airspeed, the effect increases with increased airspeed. By only adjusting the inside wing of the turn in this manner, for example the right wing in a right turn, this undesirable handling characteristic can be tuned out.

Guidance on tuning the Quantum's wing is provided in the aircraft Operator's Manual, the relevant sections of which are shown in Figures 3a to 3c.

11. TUNING THE WING

11.1. NEW AIRCRAFT

⚠ WARNING

Prior to delivery to the customer all new aircraft are flown and set up by either the Factory or by Appointed Dealers. A full check flight is carried out and adjustments made to the wing to ensure that it is properly trimmed out and flies hands off at the right speed. Owners are discouraged from making any adjustments. If you feel your new Pegasus aircraft is not performing as it should, it is essential that your dealer is immediately informed.

The following notes are for guidance only. Since tuning of flexwings is a specialised technical procedure, no adjustment should be made without a full understanding of the principles involved. Please observe the following simple guidelines:

1. Before making any adjustments check for correct rib profiles against the rib plan supplied. If the aircraft is not new, then also check the airframe components, particularly the outer leading edges.
2. Never exceed the adjustments specified in this Tuning Guide.
3. Make notes of every adjustment made. Only ever make one adjustment at a time, and carry out a flight test to gauge the effect before making further adjustments.
4. When the exercise is complete, you should discuss any adjustments made with your Instructor or Dealer and then enter them in the Aircraft Technical Log.
5. If you cannot get the aircraft to fly as it should, then first return all the settings to standard and reassess the situation. If this cannot be made to work, contact your Dealer immediately.

11.2. WING TRIM

A well tuned wing will fly in a straight line hands-off and will respond to control inputs equally in each direction. However, fabric can stretch slightly with age and ribs can alter shape and get bent or distorted. The most common problem with flexwings is the tendency for the wing to acquire a turn one way which can be irritating and tiring on a long flight. Turns like this can be tuned out and are invariably due to rib shape or tip setting problems. However, it may be that airframe damage has occurred so if a turn becomes apparent the first thing to do is to check the frame carefully, inspecting for bends and distortion particularly in the leading edges. If the frame is alright, you should check the ribs against the template and adjust accordingly.

Figure 3a

Extract from Aircraft Operator's Manual

11.3. TUNING GUIDE

For successful tuning, the weather conditions must be smooth, small adjustments must be made ONE AT A TIME, and notes must be made immediately any changes have been made and check flown. The loading of the aircraft must also be similar for trials to have comparable results.

WARNING

If the wing used to fly straight but has recently developed a turn, then the probability is that damage has occurred. It is necessary to strip and inspect the aircraft before your next flight. Failure to do so may result in injury or death.

Tuning turns

Example: The aircraft turns right at all speeds. The trim speed is correct.

Solution: In this case the tip turn adjusters. On the tips you will find an adjustment scale where the leading edge emerges from the sail. Rotate the starboard tip plug 1mm on the scale anti-clockwise (i.e. trailing edge down). Check in flight. If the turn persists, rotate the tip one further mm. Check fly. Rotate the left tip 1mm anti-clockwise (i.e. trailing edge up). Check results before moving the tips further.

WARNING

Do not exceed the adjustment range which is ±6mm (1/4 inch) from the initial factory setting, or the aircraft may become unstable.

Example: At high speed, the aircraft turns to the right. At low speed, the turn is not so pronounced. The trim speed is correct.

Solution: Use ribs numbers 7-10 (the tip rib is number 11 and has very little effect) on the **starboard (right wing)** side to tune out the turn. The tip ribs respond well to "tab effect", i.e. application of reflex near to the trailing edge will produce a downforce at the trailing edge which will increase the incidence of the section as a whole. The overall effect is to increase the lift on the side where reflex is applied, so correcting the turn. The effect becomes more pronounced as the speed rises. The reflex should be applied 200mm (8 inches) from the trailing edge and applied in small increments up to a maximum of 25mm (1 inch). Start with 10mm (3/8 inch) reflex, test fly, then 15 - 20 - 25mm (5/8 - 3/4 - 1 inch) as required. Do not exceed 25mm reflex!

Example: The wing flies completely straight sometimes, and turns to the right at other times!

Solution: This is happily an easy problem to solve, since it usually only happens when you have to rig everytime you fly. Then it is a question of exactly how the tension sets up on the outer leading edge webbings. Simply take hold of the leading edge cloth right out near the trailing edge and twist it anti-clockwise; you should feel it move. It will then be held there by the tension.

Figure 3b

WARNING

Those operators who wish to tune the Q2 wing should contact a P&M Aviation agency for additional advice. Before any tuning is attempted, a careful and thorough check of the airframe is essential. A sudden indication that the wing requires tuning may be the result of damage caused in an unreported accident or from a heavy landing. Unless your are an experienced flexwing pilot, you should ask your Instructor/Dealer or Inspector to assist with all tuning operations and have him/her carry out the flight tests.

Figure 3c

Manufacturer's maintenance recommendation

The aircraft Operator's Manual recommends that the wing ribs/battens are inspected every 50 hrs for aircraft which remain rigged and every 25 hrs for aircraft subject to continual rigging and de-rigging. When under tension in the wing, over time, the battens may lose their initial profile. To address this, the manufacturer recommends the battens be removed and adjusted until they match a batten profile template.

Aircraft inspection

The aircraft was recovered from the accident site by the owner and stored in an open access hangar for a period of time prior to being moved to the AAIB's facilities for inspection. The battens forming the left wing were separate from the sail when the aircraft was collected from the owner's facilities. Inspection of the wing battens identified that a number of them had been re-shaped and were not to the manufacturer's recommended profile.

Right wing

Batten 6 was bent up at the trailing edge end by 20 mm; battens 7 and 8 had a downward bend at the trailing edge end. Batten 9 had suffered impact damage and distortion during the accident. The profile of Batten 10 still matched the manufacturer's profile template. The tip trim adjustor at the end of the leading edge pole had been adjusted four divisions down.

Left wing

Battens 1 to 5 matched the manufacturer's profile template. Battens 6, 7, 8 and 9 had a trailing edge upward reflex of 50 mm at the end of the batten (Figure 4; note the rule in this picture indicates where the adjustment measurement was taken). Batten 10 had a bend which was consistent with the upward reflex being applied with the batten still in the sail; the bend was orientated differently from the other battens which were all consistent with bends having been applied with the battens removed. The position and amount of bending of the battens was not consistent with impact damage. The tip trim adjustor at the end of the leading edge pole had been adjusted one division down.

.

Aircraft storage and adjustment

G-BZMI was owned by the flying school's proprietor/ chief flying instructor and was operated as a flying school aircraft. It was stored in a hangar with the wing detached from the trike, but continuously rigged. The wing had not been fully de-rigged for several months. The pilot's understanding was that the wing battens were only re-profiled when someone noted a reduction in performance in-flight, at which point the wing would be de-rigged and the battens adjusted. The pilot advised that he had some experience of this activity during the assembly and rigging of previously disassembled aircraft, but not on a regular basis.

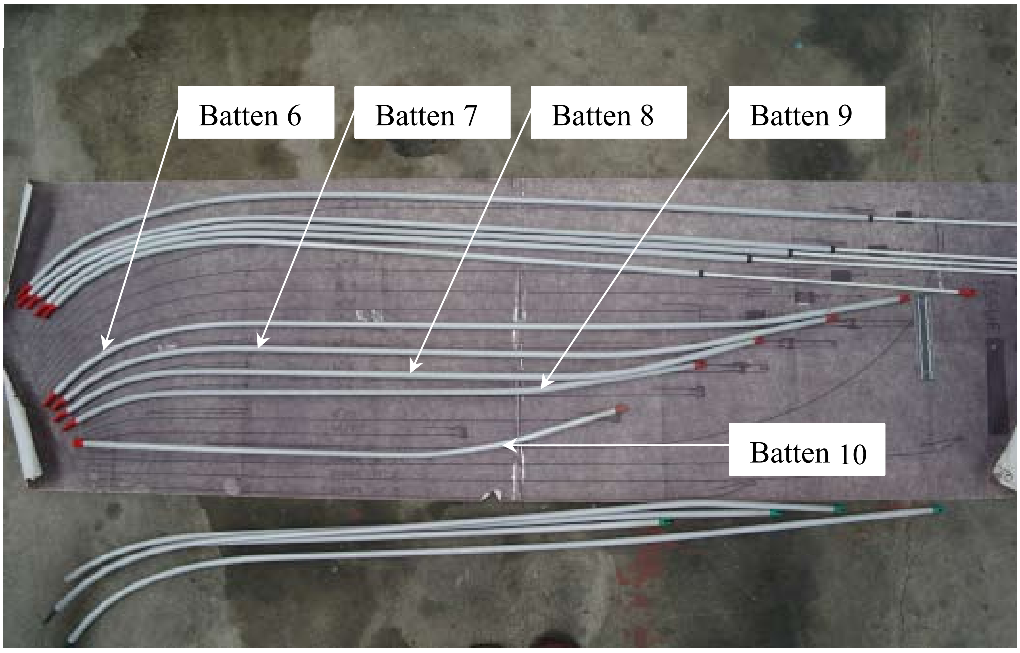

Figure 4

Batten profile for left wing showing trailing edge reflex on outboard battens

The proprietor of the flying school stated that students were taught how to reprofile battens in accordance with the manufacturer's template, but that tuning of battens on flying school aircraft was only permitted to be done by him or by the manufacturer. The aircraft logbook contained three entries for batten reprofiles, all completed by the proprietor, at various intervals since the aircraft was purchased in January 2008. The last of these entries was on 30 September 2009, 87 flight hrs prior to the accident.

Records from the annual permit to fly renewal inspection for G-BZMI, dated 8 January 2010, showed the check item covering batten conformity to the manufacturer's template was ticked as satisfactory. However, guidance provided to inspectors for this check item does not require them to physically compare the battens to the manufacturer's template in order to satisfy the requirement, unless they consider it necessary. The guidance does require confirmation that the aircraft is being maintained to the manufacturer's recommended maintenance schedule or an alternative agreed means of compliance.

Context of the flight

Air experience flights provided by microlight flying schools should be delivered within the framework of the Microlight National Private Pilot's Licence (NPPL) Syllabus, the content of which has been approved by the CAA and standardised with other forms of recreational flying and their respective training syllabi. The Microlight NPPL syllabus consists of a number of exercises, which teach the skills necessary to obtain a licence. Experience flights are covered by Exercise 3 from the syllabus, which consists of the following:

> *'Ex 3. Air experience*
>
> *Aim: To introduce and become accustomed to the aircraft, the sensation of flying and to sample the aspect of the ground from the air. Detailed instruction is not normally undertaken*

on this flight. It can, however, be a valuable lesson. It is an opportunity for the instructor to become acquainted with the student and decide upon the most suitable approach for subsequent instruction. During the flight all actions performed by the instructor should be accompanied by an explanation. Any sudden manoeuvring or expected turbulence should be discussed before it is encountered. The student should inform the instructor of any discomfort, in order to allow a rapid return to the airfield. During the latter part of the flight, the student should have the opportunity to handle the controls to provide a foundation for the next exercise. If the student has some previous flying experience, then this exercise can be combined with 'effects of controls.'

The passenger, in her statements following the accident, did not consider that she was receiving flying training and that important aspects of instruction, such as the pre-flight briefing were not conducted prior to the accident flight. The flying school's website offers *'Experience Flights'* as a separate option to *'Training'*. The description of the experience flight on the website suggests that some elements of instruction are involved and states an extensive pre-flight briefing is conducted prior to each flight. The passenger also received an information pack with the voucher, which contained a set of Frequently Asked Questions (FAQ). These stated that a pre-flight briefing would be provided and also advised that the flight time counted towards the minimum experience required to obtain a licence.

The British Microlight Aircraft Association (BMAA) includes a specific section on flying training and conducting first lessons in their code of good practice:

'Lesson plans

All lessons should follow a similar format. The student should be briefed on the exercise to be carried out. The flight should be flown in accordance with the briefing. The student should be de-briefed on the actual sequence and content of the flight.

Briefing*. The briefing should prepare the student pilot for the planned flight. The BMAA Instructor and Examiner Guide contains specific guidance on the conduct of flight briefings. The content of the brief must always be relevant to the flight.*

For first flights*, referred to as Trial Lessons or Air Experience flights (BMAA Exercise 3) the briefing is generally not technical but will prepare the student for the experience of flying in a microlight. It is usual to include a basic brief on the effect of the controls to prepare the student for some "hands on" during the flight.*

Many first time flyers are not aware that lessons in microlights are not treated by the Authorities in the same way as commercial flights in Airliners and it is important that the student is made aware of this and not lead to believe that there is "no risk". Making the student aware of this difference does not take away any responsibility from the school to ensure that the flight is conducted safely.

The briefing must cover the normal requirement for pilots to brief any passenger on the safety aspects of the flight. The brief must include use of seat belts, doors and helmets if applicable and actions in the case of an emergency.'

Pilot qualification

The pilot held a National Private Pilot's Licence, with an instructor's rating for flex-wing microlights. He had held an assistant instructor's rating since 2007 and was granted full instructor authorisation in April 2009. The pilot stated that he had not been put under any external pressure to continue with the flight given the issues with the aircraft, but had felt a certain amount of self-induced pressure not to disappoint the passenger by cancelling the flight.

Analysis

Accident flight

During the aborted flight prior to the accident, the pilot experienced an uncommanded roll which was significant enough that he felt it necessary to land and perform adjustments to the wing. Following these reported adjustments a flight test was not conducted to assess whether the uncommanded roll had been rectified, prior to flying with a passenger.

Regardless of whether a flight is for 'valuable consideration' or private there is a responsibility when carrying passengers to conduct the flight in a safe manner. As highlighted in the BMAA code of good practice, this should also be the case for flying training. A key aspect of this is to maintain and operate an aircraft which is appropriately serviceable for the intended purpose of the flight. When defects become apparent, comprehensive maintenance investigation and rectification work should be completed before further flight and the serviceability of the aircraft ensured before the carriage of passengers.

Whilst the provenance of the left wing battens which were provided with the wreckage could not be confirmed, analysis has been made based on the received battens having been removed from G-BZMI subsequent to the accident. The downward reflex identified in battens 7 and 8 on the right wing would result in a worsening right turn in-flight. Adjusting the battens in this manner is not permitted by the manufacturer. The excessive upward reflex applied to the left wing battens would lead to an extreme right roll in-flight. The 50 mm deviation from the manufacturer defined profile was double the limit of 25 mm of adjustment permitted in the aircraft Operator's Manual and was significantly greater than anything tested by the manufacturer during aircraft development. The position of the wingtip trim adjustors in isolation would have resulted in a constant left turn at all speeds.

The pilot stated that following the initial aborted flight, he adjusted the elastics holding the wingtip battens in place and slightly adjusted the profile of battens 8 and 9 of the left wing in situ and by no more than 5 mm each. This is consistent with the statement made by the passenger, who reported that the pilot was only away from his seat for a minute between flights. Manipulation of the battens within the sail is not endorsed by the manufacturer, as it prevents accurate adjustment and could result in a larger change in profile than anticipated. However, only batten 10 displayed the characteristics associated with an in situ adjustment and it is unlikely that the consistent adjustment of 50 mm found on battens six to nine in the left wing could have been achieved by the pilot bending the battens within the sail during the short period between the initial aborted flight and the accident flight. It was not possible to confirm when or how the battens came to be adjusted to the extent evident during inspection of the wreckage.

The adjustment to the battens, as found, exceeded the manufacturer's limits by such a significant amount that, combined with the downward reflex on two of the right wing battens, severe control problems would be anticipated even before any apparent adjustment reported by the pilot. Nevertheless, manipulation of the trailing edge by applying an upward reflex to the left wing instead of the right wing would have exacerbated, rather than reduced a right turn. Whilst increasing airspeed can increase the severity of the turn induced by an out-of-trim wing, as the problem occurred almost immediately after rotation on both flights, it was not possible to determine why the aircraft was reported as uncontrollable on the accident flight, but not on the initial aborted flight, or why the aircraft handling deteriorated after the flights successfully undertaken by the pilot in G-BZMI earlier in the day. However, in the absence of any evidence of other pre-impact defects, it is likely that the uncommanded right roll experienced by the pilot was the result of the wing being excessively out of trim.

Inappropriate adjustments to the sail profile of a flex-wing microlight can have a marked effect on the handling characteristics, particularly on modern aircraft which can cruise at speeds of around 100 mph. Although an older, slower design, this is still true of the Pegasus Quantum and the manufacturer includes a number of warnings in the Operator's Manual to proceed with caution when tuning the wing. They advise that initially the wing should be reset to the datum profile, adjustments should then be incremental and made in a controlled manner, with test flights carried out to confirm the effects of each change. The manual recommends this work should only be conducted by experienced pilots or by a representative of the manufacturer and that any changes should be recorded in the aircraft logbook. Routine checks of the wing at the appropriate intervals, as recommended by the manufacturer, would allow this work to be properly planned and controlled. If the aircraft develops a sudden increase in out-of-trim forces, the Operator's Manual highlights that this could indicate a more serious defect on the aircraft, which should be properly investigated and rectified before further flight.

This highlights the need that following any work completed on an aircraft which affects the handling characteristics, consideration should be made of the requirement to ensure the maintenance has been appropriately conducted, recorded and coordinated with any associated check/test flying. Flight tests to confirm serviceability need to be conducted by pilots with appropriate experience and skills and be planned and conducted as a distinct activity from routine flying.

Passenger information and briefing

Experience flights provided by flying schools are a valid and important stage in the process of learning to fly a microlight, providing they are conducted within the context of the NPPL syllabus. The passenger stated that in her opinion she was not undertaking a flying lesson and was unaware of the training context in which experience flights are provided. The content of the flying school's website and the information sent with the experience voucher also lacked clarity in this respect and did not fully inform the passenger in line with the recommendations relating to first time flyers within the BMAA code of good practice. Discussion with the CAA highlighted that the need for flying schools to provide clear information, with regard to the context in which experience flights are provided, is an issue which exists across all forms of recreational flying. Most significantly however, was the passenger's recollection that important safety-related aspects of instruction, such as the pre-flight briefing, had not been completed before the flex-wing flight. Microlight operators are encouraged to comply with the BMAA code of good practice as its guidance is intended to improve safety.

ACCIDENT

Aircraft Type and Registration:	Pegasus Quik, G-SHEZ
No & Type of Engines:	1 Rotax 912-UL piston engine
Year of Manufacture:	2003
Date & Time (UTC):	31 August 2010 at 1800 hrs
Location:	Bycross Farm Airstrip, Preston on Wye, Herefordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Leading edge of right wing and king post bent, right wheel spat damaged
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	36 years
Commander's Flying Experience:	225 hours (of which 185 were on type) Last 90 days - 51 hours Last 28 days - 8 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The aircraft was approaching to land on Runway 36 at Bycross Farm Airstrip in calm wind conditions. The pilot reported that, due to an excessive approach speed, the aircraft landed long on the 235 m grass runway, which had a wet surface due to the presence of dew. The pilot applied the brakes fully which caused the aircraft to skid on the wet runway surface and the right wing contacted the ground. The aircraft rolled onto its right side, bending the right wing leading edge and the king post, and damaging the right wheel spat. The pilot and his passenger were uninjured and were able to leave the aircraft without further incident. The pilot reported that he had placed himself under pressure to land expeditiously due to his passenger becoming nervous. He considered that with hindsight, and given the calm wind conditions at the time, he should have gone around and landed on the longer 300 m Runway 27/09 that was also available to him. The pilot commented that the dew formation was surprisingly rapid as the grass surfaces at the airstrip were dry when he had taken off 30 minutes earlier.

ACCIDENT

Aircraft Type and Registration:	Skyranger R100(1), G-CCBA
No & Type of Engines:	1 BMW R100 piston engine
Year of Manufacture:	2003
Date & Time (UTC):	22 September 2010 at 1330 hrs
Location:	Barton Ashes Farm Strip, near Winchester, Hampshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Nosewheel and strut, propeller, windshield, wing struts and pilot seat bolts
Commander's Licence:	Private Pilot's Licence
Commander's Age:	69 years
Commander's Flying Experience:	328 hours (of which 235 were on type) Last 90 days - 19 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot was flying from Barton Ashes Farm Strip, which has one undulating runway orientated 25/07 surrounded by trees approximately 25 ft high. The approach to Runway 07 crosses open fields and the approach to Runway 25 crosses a strip of woods.

The pilot used Runway 25 for takeoff and landing on a previous flight about an hour before the accident, with a light breeze from approximately 190°. During the approach he experienced turbulence caused by the wind funnelling through a gap in the adjacent woods, but landed safely.

On the accident flight, having taken off from Runway 25, the pilot planned to land on Runway 07 in order to approach across open fields. The wind had increased to approximately 10 kt. The approach was "smooth" but just before touchdown the aircraft encountered a "rotor" of turbulent air from the right. This caused the aircraft to pitch forward uncontrollably onto its nosewheel, which collapsed. The aircraft came to rest inverted. The uninjured pilot and passenger vacated the extensively damaged aircraft with the aid of another pilot.

The pilot commented that the effects he experienced are well known at this farm strip and that a diversion would have been sensible.

FORMAL AIRCRAFT ACCIDENT REPORTS ISSUED BY THE AIR ACCIDENTS INVESTIGATION BRANCH

2009

3/2009 Boeing 737-3Q8, G-THOF
on approach to Runway 26
Bournemouth Airport, Hampshire
on 23 September 2007.

Published May 2009.

4/2009 Airbus A319-111, G-EZAC
near Nantes, France
on 15 September 2006.

Published August 2009.

5/2009 BAe 146-200, EI-CZO
at London City Airport
on 20 February 2007.

Published September 2009.

6/2009 Hawker Hurricane Mk XII (IIB), G-HURR
1nm north-west of Shoreham Airport, West Sussex
on 15 September 2007.

Published October 2009.

2010

1/2010 Boeing 777-236ER, G-YMMM
at London Heathrow Airport
on 28 January 2008.

Published February 2010.

2/2010 Beech 200C Super King Air, VQ-TIU
at 1 nm south-east of North Caicos Airport, Turks and Caicos Islands, British West Indies
on 6 February 2007.

Published May 2010.

3/2010 Cessna Citation 500, VP-BGE
2 nm NNE of Biggin Hill Airport
on 30 March 2008.

Published May 2010.

4/2010 Boeing 777-236, G-VIIR
at Robert L Bradshaw Int Airport
St Kitts, West Indies
on 26 September 2009.

Published September 2010.

5/2010 Grob G115E (Tutor), G-BYXR
and Standard Cirrus Glider, G-CKHT
Drayton, Oxfordshire
on 14 June 2009.

Published September 2010.

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

Published November 2010.

7/2010 Aerospatiale (Eurocopter) AS 332L Super Puma, G-PUMI
at Aberdeen Airport, Scotland
on 13 October 2006.

Published November 2010.

8/2010 Cessna 402C, G-EYES and
Rand KR-2, G-BOLZ
near Coventry Airport
on 17 August 2008.

Published December 2010.

AAIB Reports are available on the Internet
http://www.aaib.gov.uk