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ADDENDA and CORRECTIONS

(ALL TIMES IN THIS BULLETIN ARE UTC)

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INCIDENT

Aircraft Type and Registration:	Airbus A321-231, G-MEDJ
No & Type of Engines:	2 International Aero Engines V2533-A5 turbofan engines
Year of Manufacture & Serial No:	2004, MSN 2190
Date & Time (UTC):	24 August 2010 at 0225 hrs
Location:	At FL360 over northern Sudan
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 7 Passengers - 42
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	34 years
Commander's Flying Experience:	Approximately 7,500 hours (of which approximately 1,400 were on type) Last 90 days - 165 hours Last 28 days - 61 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft suffered an electrical malfunction during a scheduled night flight between Khartoum (Sudan) and Beirut (Lebanon). The more significant symptoms included the intermittent failure of the captain and co-pilot's electronic displays and the uncommanded application of left rudder trim, which was not annunciated to the flight crew. The flight crew also reported that the aircraft did not seem to respond as expected to control inputs. A large number of ECAM[1] messages and cautions were presented on the pilots' electronic display units. The uncommanded rudder trim caused the aircraft to adopt a left-wing-low attitude and deviate to the left of the planned track. Normal functions were restored after the flight crew selected the No 1 generator to OFF in response to an 'ELEC GEN 1 FAULT' message. The aircraft landed safely at Beirut.

The No 1 generator was replaced, after which the fault did not recur. Damage was found on an electrical lead on the No 1 generator, but it could not be determined whether this had caused the symptoms experienced during the incident.

The aircraft manufacturer notified operators of this incident by issuing OIT 999.0105/10 on

Footnote

[1] Electronic Centralised Aircraft Monitoring system – this comprises two centrally mounted electronic display units, which present the flight crew with aircraft systems information, warning and memo messages and actions to be taken in response to systems failures.

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19 November 2010 and also updated the Quick Reference Handbook procedure for '*Display Unit Failure*' to include a check of the rudder trim position.

History of the flight

The incident occurred as the aircraft was cruising at Flight Level (FL) 360 over northern Sudan, with the commander as pilot flying and the No 1 autopilot (AP 1) and autothrust engaged. The conditions were night Instrument Meteorological Conditions, with slight turbulence. The commander reported that, without warning, his Primary Flight Display (PFD), Navigation Display (ND), and the ECAM upper Display Unit (DU) began to flicker, grey out, show lines or crosses, and go blank. Concurrently, there was a "chattering" heard coming from the rear circuit breaker panels, behind the two pilots' seats, which was thought to be relay operation. The abnormal behaviour ceased after a short time. The co-pilot checked the circuit breakers to see if any had operated and to look for signs of overheating, but nothing unusual was noted. The commander reviewed the ECAM electrical system page, which showed no abnormalities.

After a short interval the commander's PFD, ND, and ECAM upper DU began to flicker and grey out again, before blanking for longer periods. AP 1 was disconnected and the commander handed control to the co-pilot, whose display screens were unaffected at this time. The abnormal condition was once again short-lived and once conditions had returned to normal, the commander reassumed control and re-engaged AP 1.

The symptoms returned shortly thereafter, with the commander's displays becoming mostly blank, or showing white lines. When the displays were visible, the airspeed, altimeter, and QNH/STD indications were erratic. The co-pilot's PFD, ND, and the ECAM lower DU began to flicker and were sometimes unreadable. The crew reported that the cockpit lights went off intermittently. The commander handed control to the co-pilot again, who flew the aircraft manually. Reference was made to the standby flight instruments, which operated normally throughout the incident.

During this period, the chattering sound from the rear circuit breaker panels resumed and was, at times, continuous. Numerous ECAM messages were presented and there were a number of master caution annunciations. Amber 'X' symbols indicating flight control system reconfiguration to Alternate Law[2] appeared on the PFDs, the flight directors were displayed only intermittently and the autothrust system went into 'thrust lock' mode. The aircraft rolled to the left and adopted an approximately 10º left-wing-low attitude, without any flight control input from the crew. The flight crew reported that the aircraft did not seem to respond as expected to their control inputs and shuddered and jolted repeatedly.

The commander recalled selecting the Display Management Computer (DMC) switch from 'NORM' to 'CAPT 3' to switch the source for the captain's displays from DMC 1 to DMC 3, but this had no effect in restoring his displays. The switch was left in the 'CAPT 3' position for the remainder of the flight.

The flight crew became concerned that the aircraft was malfunctioning. The ECAM was only sometimes visible and did not identify the root cause of the problem and there were no fault indications visible on the overhead panel. Moreover, they were not aware of any procedure applicable to the symptoms experienced. The

Footnote

[2] Alternate Law is a mode of the flight control system in which certain protection features are unavailable.

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commander contemplated transmitting a MAYDAY, but considered that his priorities were to retain control of the aircraft and identify the problem.

At one point the commander saw the ECAM 'ELEC GEN 1 FAULT' message and associated checklist appear momentarily. The checklist required the No 1 generator to be selected to OFF. On doing so the juddering motion ceased, the chattering noise stopped, and all displays reverted to normal operation, although the aircraft's left-wing-low attitude persisted. The checklist directed that the generator should be selected ON again, and following discussion and agreement that it would be immediately deselected should the problems return, the commander selected it to ON. This caused the symptoms to return, prompting him to select it to OFF again.

The Auxiliary Power Unit was started and its generator was selected to power the systems previously powered by the No 1 generator. Shortly thereafter, the flight crew noticed that the rudder trim display indicated several units from neutral[3], although they had not made any rudder trim inputs. When the rudder trim was reset to neutral, the aircraft readopted a wings-level attitude. The aircraft had deviated approximately 20 nm to the left of the intended track during the incident.

The aircraft was flown manually for the remainder of the flight and landed at Beirut without further incident.

The aircraft was inspected in Beirut and the No 1 Integrated Drive Generator (IDG1) was removed as unserviceable and sent for overhaul. There was no recurrence of the symptoms reported in this incident in subsequent flights.

Footnote

[3] The rudder trim indicator is at the rear of the centre pedestal.

Reporting of the event

The commander reported the event shortly after arrival, both verbally by telephone to his managers, and in writing using an Air Safety Report (ASR) form which was placed in the operator's internal mail system when the flight crew returned to the UK. However, the full significance of the event was not apparent during the telephone call and the ASR form became lost in the operator's internal paperwork system. Consequently, an investigation was not commenced until several weeks later, when the commander enquired as to what progress had been made in finding the cause of the event. The operator stated that it had since taken actions to improve its processes for the reporting and tracking of air safety incidents.

Flight recorders

Because of the late notification of the event to the AAIB, both the Cockpit Voice Recorder (CVR) and the Flight Data Recorder (FDR) data for the incident were overwritten. Attempts were made to obtain information from various sources of non-volatile memory; however, such was the delay in reporting the incident, no information from the incident flight was available.

However, flight data was obtained from the operator's Flight Data Monitoring (FDM) programme, which recorded a similar set of parameters to the FDR. The systems associated with the FDM were powered by the No 2 electrical supply and so continued recording throughout the event.

Recorded parameters associated with the electrical supply system showed no loss of the AC 1, AC 2, DC 1 or DC 2 supplies[4] throughout the flight. However, these

Footnote

[4] AC denotes alternating current and DC denotes direct current.

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parameters were only recorded every four seconds so a transient interruption may not have been captured. The status of each of the electrical system contactors was not recorded but some recorded parameters exhibited signs of electrical transients, as evidenced by data spikes during each power reset.

The recorded data largely confirmed the flight crew's recollections. The effects of electrical transients were recorded at 0225 hrs and 0237 hrs. At 0240:00 hrs, further transients were recorded, this time leading to an increase in the recorded rudder position from 0° to +3.6° within 20 seconds (rudder trim was not recorded). Positive rudder deflection is deflection of the surface to the left which causes the aircraft to yaw to the left. As the secondary effect of yaw is roll, the aircraft then rolled to the left. The autopilot attempted to counter this with a right roll command and associated aileron and roll spoiler deflection.

At 0240:16 hrs, the recorded 'DMC transfer' parameter changed state, representing the DMC switch moving from the 'NORM' position to either the 'CAPT 3' or the 'F/O 3' position. Two seconds later, the autopilot disconnected and the roll angle increased to a maximum of 11.6° to the left before the co-pilot levelled the wings by commanding right roll with the sidestick.

The autopilot was re-engaged but the aircraft continued to yaw left as the rudder position remained at +3.6°. This again induced a left roll which was countered by the flight director commanding a right roll input. However, with the autopilot engaged and at an airspeed of 260 kt, the control surface deflection is automatically limited to ±9° for the ailerons and 4° for the roll spoilers. As a result, there was insufficient roll authority to allow the autopilot to roll the aircraft level and the aircraft continued to roll left to a maximum roll angle of 11°. At this point, the rudder deflection was +3.6° with the right aileron deflected 9° down, left aileron 9° up, right roll spoilers deflected to 4° and the aircraft heading decreasing at 0.5° per second.

The autopilot then disconnected and the aircraft was flown manually. In manual flight, the travel limits for the ailerons and roll spoilers are their maximum travel (±25° and 35° respectively). As a result, each time the autopilot was re-engaged, the aircraft rolled to the left and when disconnected, the co-pilot's control inputs were sufficient to maintain a wings-level attitude.

After the final autopilot disengagement at 0245 hrs, the aircraft was flown manually for the rest of the flight. At 0246:31 hrs, the rudder position began reducing from +3.6° to zero over a period of 17 seconds, six and a half minutes after the rudder surface first moved from the zero position.

Manufacturer's simulation

The aircraft manufacturer performed a simulation using the data available from this incident and reported that the aircraft performance was as expected. They also confirmed that in the event of maximum rudder trim being applied at this airspeed, sufficient aileron authority is available in manual flight to maintain the desired flight path.

Aircraft information

General

The A320 family of aircraft has extensive electrical services, fed from a system that broadly comprises two electrical networks, a left and a right, denoted No 1 and No 2, respectively. No 1 and No 2 networks are normally independent of one another, so that the failure of one network should not adversely affect the other. The power supplies for flight-critical systems are for

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the most part segregated, with the aim that the loss of a single power source should not result in concurrent failures of systems necessary for continued safe flight.

Electrical power generation system

The electrical system is powered primarily from AC sources (3-phase, 115/200 Volt (V) at a frequency of 400 Hz). Two engine-driven generators, one mounted on each engine, normally power the system. Each generator is driven from the engine high-pressure spool via an engine accessory gearbox and an integrated hydro-mechanical speed regulator. The regulator transforms variable engine rotational speed into a constant-speed drive for the generator. The constant-speed drive and the generator collectively form an assembly known as the Integrated Drive Generator (IDG).

Mounted externally on each IDG is an electrical cable referred to as the 'jumper lead'. This is for maintenance purposes and to provide commonality between different electrical system standards. The generator manufacturer uses several different suppliers for this lead. The lead is approximately 20 cm long and is formed into a tight 180° bend with a connector at each end. The jumper lead is supported halfway along its length by a 'P' clip. The lead comprises an outer protective layer, a layer of woven metal braid, and then seven individual wire cables. Each of the seven individual cables comprises an outer insulation layer, a layer of woven insulation and thin foil, and a central multi-strand electrical wire.

A Generator Control Unit (GCU) associated with each IDG monitors the IDG output and opens the Generator Line Contactor (GLC) if it detects an aircraft-manufacturer-specified out-of-limits condition, thus isolating the IDG from the electrical system.

Electronic flight instrument system

Information for the flight crew is presented primarily on an Electronic Flight Instrument System (EFIS), comprising six DUs on the flight deck forward panel. These include the PFD and ND in front of each pilot and two ECAM displays located one above the other on the central part of the panel (Figure 1). The ECAM is a tool to:

- display aircraft system information
- monitor aircraft systems
- indicate required flight crew actions, in most normal, abnormal and emergency situations

The DUs are driven by three identical DMCs, identified as DMC 1, 2 and 3. In the normal configuration, DMC 1 (which is powered by the No 1 electrical system) drives the captain's (left) PFD and ND, and the ECAM upper DU; DMC 2 (which is powered by the No 2 electrical system) drives the co-pilot's (right) PFD and ND and the ECAM lower DU. DMC 3 (which is normally powered by the No 1 electrical system) is available as a backup and can be manually selected to replace DMC 1 or DMC 2.

The DUs and DMCs have different transient response times in the event of a power loss. For the DUs this is around 25 ms and for the DMCs this is around 100 ms. In the event of an intermittent interruption in power to the No 1 electrical system and with DMC 3 selected to drive the co-pilot's displays, the different transient response times of the DUs and DMCs are likely to produce a greater effect on the captain's DUs than the co-pilot's.

Flight augmentation computers

A320 family aircraft have two Flight Augmentation Computers: FAC 1 and FAC 2. These perform several functions, one of which is to provide input commands to

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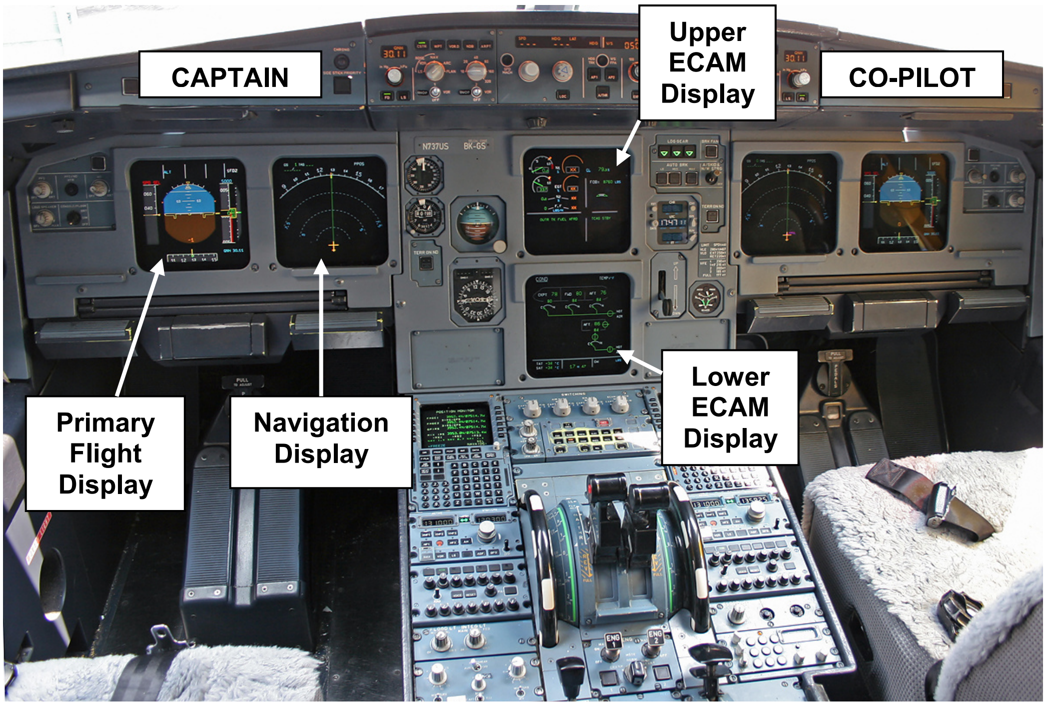

Figure 1

Electronic Flight Instrument System

the rudder trim actuator. The units operate with FAC 1 having priority and they are powered by a 28V DC Essential bus. If the power supply goes below 16V for more than 10 ms the FAC units will reset. This causes an offset of approximately 0.2° of rudder trim to be commanded. Multiple resets result in cumulative rudder trim offsets. The rudder trim limits are determined by the Rudder Travel Limiter (varying from ±3° at high speed to ±30° at low speed) or, if the logic in the FAC for a rudder trim runaway is triggered, no further rudder trim is input. At the aircraft speed in this incident the maximum available rudder trim was ±7°.

The aircraft manufacturer confirmed that a similar architecture is used on A330 aircraft and there is therefore the potential for a generator fault to cause similar problems with the DUs. However, no such faults have so far been reported on the A330 fleet in nearly 19 million flying hours.

Engineering investigation

Post-flight report

Although the fault memories of the onboard maintenance systems were overwritten, a copy of the Post-Flight Report (PFR) was available. This report contained 23 flight deck warnings and 44 fault messages for the incident flight, mainly attributed to the loss of electrical supply to the No 1 network. Of note was an 'AUTO FLT RUD TRIM1 FAULT' ECAM warning indicating that FAC 1 had detected a rudder trim fault. This warning is for crew awareness only. Additionally, the PFR listed a 'AFS: FAC1/RT ACTR 10CC' fault message which is generated when the rudder trim runaway monitoring is triggered by FAC 1. The outcome of this failure message is that the rudder trim function in FAC 1 is disengaged and automatically transferred to FAC 2.

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IDG and GCU testing

After the incident IDG1 was removed and sent for overhaul by the operator but nothing significant was found. When AAIB were notified of the event several weeks later, the IDG1 and GCU1 were quarantined and subsequently taken to the aircraft manufacturer's 'iron bird'[5] test rig facility for a functional check and to attempt to simulate the characteristics of the incident flight. Although both units functioned normally on the rig, it was possible to create symptoms that appeared similar to those reported by the crew. When repeated electrical shorts at a certain frequency were simulated on either wire No 1 or wire No 2 in the jumper lead, the DUs flickered, more so on the captain's side, and small and cumulative increments in rudder trim were produced. However, these symptoms only occurred when the co-pilot's DUs were selected to be powered by DMC 3. Other combinations of wires were equally exercised in this testing, but they did not produce these symptoms.

IDG1 and GCU1 were then taken to their manufacturer for further inspection. The IDG was subjected to a detailed strip examination under AAIB supervision with experienced overhaul and design specialists from the manufacturer present. The jumper lead appeared distorted (Figure 2) and when the outer cover was removed significant material damage to the wire braid was found at both ends, near the connectors (Figure 3).

The jumper lead was taken to a forensic laboratory for examination. Evidence that the strands of wire braid had been chafing against each other was found (Figure 4). It was confirmed that wear marks made by the braid were present on the insulation of the seven wires inside the braided outer sheath (Figure 5). The insulation was worn down on some of the cables, exposing the central conductor inside. Some cables exhibited holes in the insulation containing debris that was confirmed by an EDAX[6] technique as being of the same composition as the wire braid. Using a Scanning Electron Microscope (SEM), evidence of arcing was found on wire No 5 (Figure 6). Despite extensive efforts, it was not possible to positively identify arcing or a short on any of the other wires. It was concluded that the failure mechanism of

Figure 2

Jumper lead as removed

Figure 3

Jumper lead with outer cover removed

Footnote

[5] The iron bird is a static test rig which allows aircraft systems to be tested in laboratory conditions in the presence of all the aircraft systems. It also has a representative cockpit for flight simulation.

Footnote

[6] Energy-dispersive X-ray spectroscopy which can be used to determine the composition of material.

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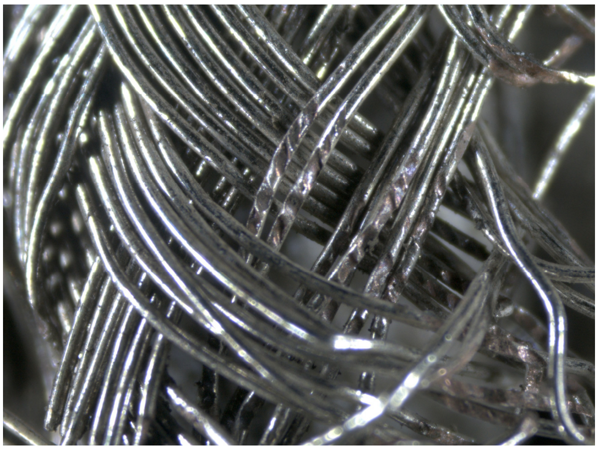

Figure 4

Close up of wire braid on jumper lead showing evidence of chafing

Figure 5

Close up of wire in jumper lead showing wear marks

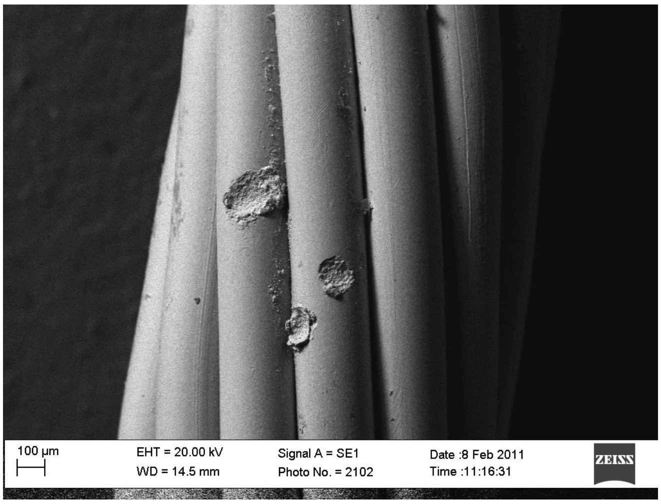

Figure 6

SEM image showing arcing damage on surface of strands in wire No 5

the jumper lead was the wire braid rubbing against the seven wires, with the vibration of the engine and the tight bend in the routing of the jumper lead providing the conditions conducive to wear. It was not clear if the ‘P’ clip, mid-way along the jumper lead, was a factor in the failure mechanism.

AAIB Special Bulletin S2/2010

In November 2010 AAIB published a Special Bulletin which contained preliminary findings of the investigation and the following Safety Recommendation:

Safety Recommendation 2010-092

It is recommended that Airbus alert all operators of A320-series aircraft of the possibility that an electrical power generation system fault may not be clearly annunciated on the ECAM, and may lead to uncommanded rudder trim operation.

Airbus notified operators of this incident by the issue of OIT 999.0105/10, dated 19 November 2010.

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Analysis

The delay in this incident being reported meant that potentially useful information in non-volatile memory, both in systems and the voice and data recorders was not available to the AAIB investigation. The delay in being able to interview the flight crew might have reduced the quality of their accounts.

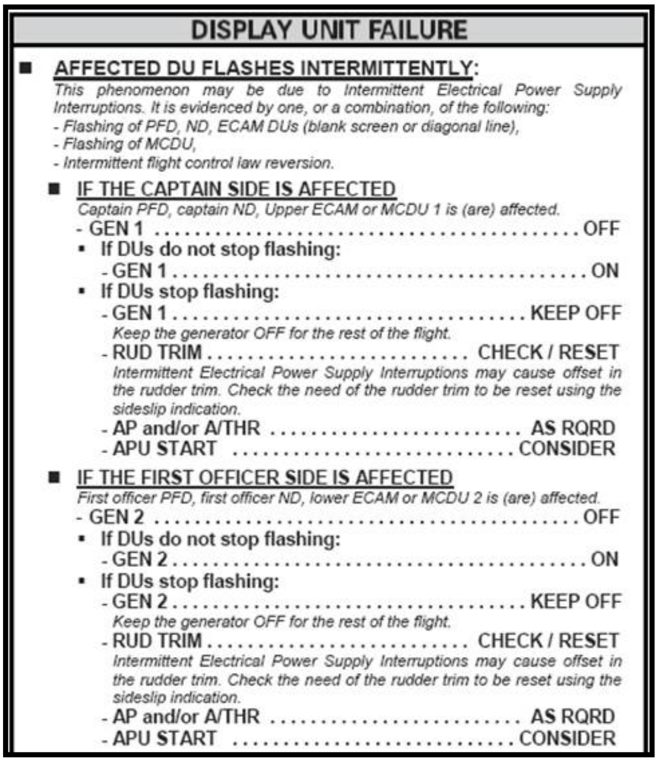
The incident appeared to have posed a number of challenges for the flight crew, in that they were presented with numerous and significant symptoms, including malfunctioning electronic displays and uncommanded rudder trim input, of which they were not aware, and the cause of which was not evident. The ECAM did not clearly annunciate the root cause of the malfunction, nor were any fault captions observed on the overhead panel. No information or procedures were available to assist the flight crew in effectively diagnosing the problem.

The aircraft manufacturer concluded that the aircraft responded as expected to the rudder trim inputs, which suggests that the rudder input alone was responsible for the divergence from the intended flight path. The 'ELEC GEN 1 FAULT' message during the incident, the resolution of the problem in flight when IDG1 was switched off and the lack of any further reported problems after IDG1 was replaced are good evidence that IDG1 had a fault which had affected aircraft equipment, causing the incremental rudder trim inputs.

The symptoms experienced during the incident may have been attributable to a short in the jumper lead on IDG1. Whilst the lead was clearly damaged, and a plausible failure mechanism identified, this was only valid if DMC 3 was selected to power the co-pilot's DUs, which is inconsistent with the crew's report.

Safety action

As a result of other incidents involving blanking display units, the aircraft manufacturer was, at the time of this incident, developing an update to the Quick Reference Handbook (QRH) for display unit failures. Whilst it was not possible to determine with any degree of certainty the cause of this incident, as a result of this investigation the QRH update was amended to account for the possibility that rudder trim could be affected (Figure 7).



DISPLAY UNIT FAILURE

- AFFECTED DU FLASHES INTERMITTENTLY:
  This phenomenon may be due to Intermittent Electrical Power Supply Interruptions. It is evidenced by one, or a combination, of the following:
  - Flashing of PFD, ND, ECAM DUs (blank screen or diagonal line),
  - Flashing of MCDU,
  - Intermittent flight control law reversion.
  - IF THE CAPTAIN SIDE IS AFFECTED
    Captain PFD, captain ND, Upper ECAM or MCDU 1 is (are) affected.
    - GEN 1 .... OFF
    - If DUs do not stop flashing:
      - GEN 1 .... ON
    - If DUs stop flashing:
      - GEN 1 .... KEEP OFF
        Keep the generator OFF for the rest of the flight.
      - RUD TRIM .... CHECK / RESET
        Intermittent Electrical Power Supply Interruptions may cause offset in the rudder trim. Check the need of the rudder trim to be reset using the sideslip indication.
      - AP and/or A/THR .... AS RQRD
      - APU START .... CONSIDER
  - IF THE FIRST OFFICER SIDE IS AFFECTED
    First officer PFD, first officer ND, lower ECAM or MCDU 2 is (are) affected.
    - GEN 2 .... OFF
    - If DUs do not stop flashing:
      - GEN 2 .... ON
    - If DUs stop flashing:
      - GEN 2 .... KEEP OFF
        Keep the generator OFF for the rest of the flight.
      - RUD TRIM .... CHECK / RESET
        Intermittent Electrical Power Supply Interruptions may cause offset in the rudder trim. Check the need of the rudder trim to be reset using the sideslip indication.
      - AP and/or A/THR .... AS RQRD
      - APU START .... CONSIDER

Figure 7

Updated page from Quick Reference Handbook

INCIDENT

Aircraft Type and Registration:	BN2A MK III-2 Trislander, G-FTSE
No & Type of Engines:	3 x Lycoming O-540-E4C5
Year of Manufacture:	1977
Date & Time (UTC):	17 January 2011at 0956 hrs
Location:	Alderney Aerodrome, Alderney, Channel Islands
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 1 Passengers - 5
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to the right navigation light
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	5,850 hours (of which 1,450 were on type) Last 90 days - 128 hours Last 28 days - 34 hours
Information Source:	AAIB Field Investigation

Synopsis

Following a non-precision approach, the aircraft manoeuvred to land on the runway and its wingtip touched the ground. During a go-around after touchdown, the aircraft departed the runway prior to getting airborne. This report discusses the use of instrument approach minima following a visual cruise segment, and the availability of GPS as an alternative to conventional non-precision approaches.

History of the flight

The pilot reported at 0700 hrs to fly several sectors between the Channel Islands. Weather forecasts indicated this would involve flying in a mix of VFR and IFR conditions. The first three sectors, from Alderney to Guernsey, Guernsey to Jersey and Jersey to Guernsey, were uneventful. Five passengers boarded for the fourth sector, from Guernsey to Alderney. While the aircraft was at the holding point prior to departure, ATC advised the pilot that the latest weather report from Alderney reported visibility of 3 km, with broken cloud at 300 ft. This was below the minimum descent height of 390 ft agl (680 ft AMSL) for an NDB approach at Alderney but more than the required visibility of 1,200 m for that approach. Also, because the weather at both Guernsey and Jersey was above applicable minima and the pilot had plenty of fuel, he decided he would attempt an approach to assess the conditions himself.

The aircraft took off at 0939 hrs and was vectored under radar control towards the NDB approach for

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Runway 26 at Alderney. The pilot used the autopilot to hold heading and altitude. Approximately ten minutes before touchdown, he requested the most recent Alderney weather. ATC reported 3 km visibility with broken cloud at 200 ft and few clouds below 100 ft.

As the aircraft positioned onto the approach, it was cleared to descend to 1,500 ft and approximately 4.5 nm from the runway, cleared to "DESCEND WITH THE PROCEDURE" and contact Alderney Tower, which the commander acknowledged. The pilot turned "late" to intercept the inbound course, so re-intercepted it from the north and commenced a descent using the AP to maintain the aircraft attitude. Approximately 4 nm from the ALD NDB, the aircraft was on the correct vertical profile for the NDB approach at 1,420 ft. The aircraft then started to descend at an average rate of approximately 900 ft/min (see Figure 1).

Approximately 3 nm from the runway, whilst descending through an altitude of approximately 1,000 ft, the pilot confirmed that the aircraft was established on the approach. Alderney Tower cleared the aircraft to land, advising that the surface wind was from 200° at 11 kt, runway surface was 'WET, WET, WET' with few clouds at less than 100 ft, broken clouds at 200 ft and that there was an area of fog near to the cliffs adjacent to the thresholds of Runway 03 and 32.

The pilot stated that he could by then see the island clearly. There was, however, some cloud over the south west of the island and he could not see the aerodrome or any of the visual references required to continue the approach below the minimum descent height specified for the NDB procedure. In sight of the ground and clear of cloud he decided he could apply the minimum visibility for a visual approach of 800 m and, using the NDB to assist with navigation, continued descending towards the aerodrome.

Shortly over one minute from touchdown and approximately 2 nm from the runway, the aircraft levelled off at 520 ft amsl. Approximately 35 seconds from touchdown, and approximately 1,300 m from the runway, Alderney Tower advised that the visibility had reduced to about 1,200 m. The pilot responded "I HAVEN'T GOT ANYTHING YET, VERY BROKEN". The aircraft remained at an altitude of 520 ft, approximately 230 ft agl. Several seconds later, the aircraft started to descend and with the aircraft almost abeam the ALD NDB, 680 m from the threshold of Runway 26, the pilot advised Alderney Tower "GOT THE LIGHTS". The track indicated by radar was then approximately 160 m north of the runway centre line.

The pilot stated that at a height of about 300 ft he saw the approach lights and realised he was to the north of the correct approach path. He disengaged the autopilot to manoeuvre the aircraft visually onto the extended centreline of the runway. This involved a turn of approximately 20º to the left using 15º angle of bank, which was followed by a steep right turn, "quite low to the ground" to align the aircraft with the runway. The aircraft landed on its right main wheels. With a surface wind from the left, the pilot felt uncomfortable and decided to go around. At 0956:29 hrs, ATC advised the pilot "CHECK YOUR WING TIP, I THINK YOU TOUCHED THE RUNWAY". Neither the pilot nor the passengers were aware of any other part of the aircraft contacting the ground.

The pilot positioned the aircraft for a second approach, during which ATC advised that the runway visual range (RVR) for Runway 26 had reduced to 325 m. As the aircraft approached the ALD NDB at approximately 1,400 ft, the pilot requested to enter a holding pattern. ATC then advised that the aircraft operator had requested the aircraft return to Guernsey. The return flight was uneventful and the aircraft landed safely.

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Figure 1

Data from approach and rejected landing at Alderney Airport Runway 26

Witness information

The ATCO heard the aircraft before he saw it, to the east of the aerodrome and north of the Alderney (ALD) NDB mast. He watched the aircraft turn first left then steeply right, and saw sparks from the wingtip as it touched the runway. He immediately informed the pilot that the wing had touched the runway. The aircraft then landed briefly before he heard the engine power increase and saw the aircraft go around.

An inspection of the runway revealed broken glass from the navigation light and tyre marks which indicated that after its brief touchdown the aircraft had departed the right edge of the runway before becoming airborne.

Recorded information

No accident protected data or voice recorder was required or fitted. Primary and secondary[1] radar information available from Jersey was recorded approximately once every six seconds and provided a complete record of the approach and go-around on Runway 26 (Figure 2). Radio transmissions during the flight were also recorded.

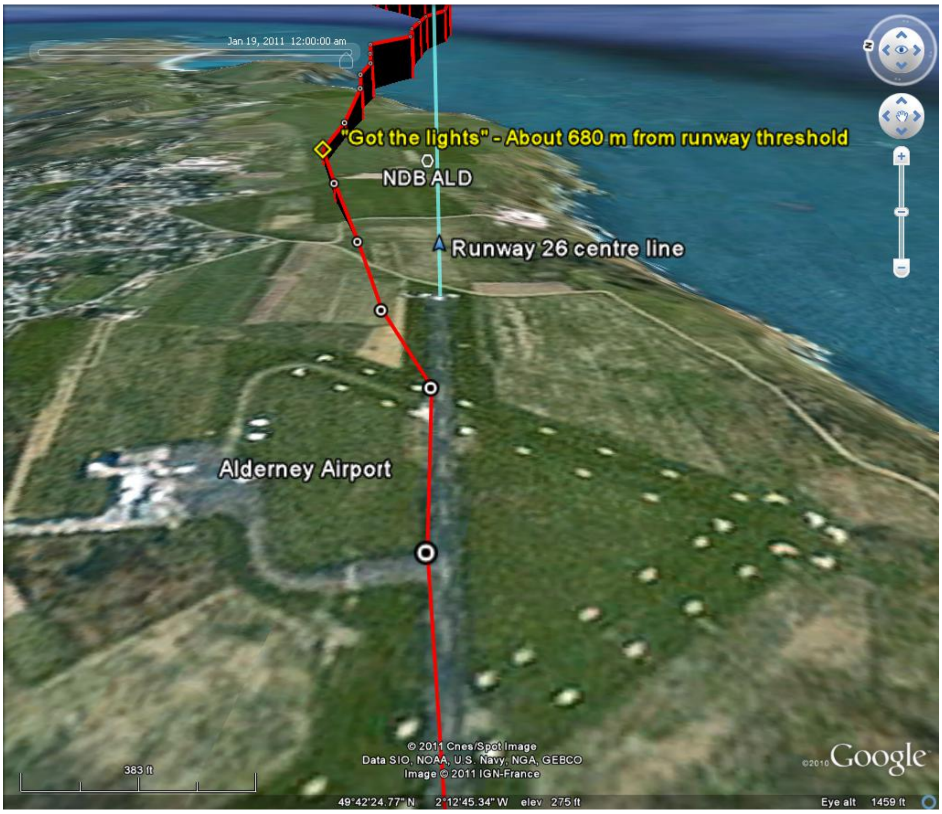

Figure 2

Radar track of final approach to Runway 26

Footnote

[1] Secondary radar information is provided by a transponder fitted to the aircraft. When interrogated by ATC radar, the transponder transmits pressure altitude data (Mode C) quantized to the nearest 100 ft. Pressure altitude is based upon the International Standard Atmosphere (ISA), which assumes a barometric pressure of 1013.25 millibars at sea level. ATC radar then corrects for differences between the ISA and local atmospheric pressure so that altitude is displayed on the radar display.

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Aircraft description

The Britten-Norman Trislander is an 18-seat three-engined piston-powered utility aircraft produced in the 1970s and early 1980s, normally flown by a single pilot. G-FTSE was equipped with basic navigation equipment, including a Relative Bearing Indicator (RBI) positioned in the centre of the aircraft instrument panel, separate from the pilot's primary flight instruments (Figure 3).

Figure 3

Instruments

Aircraft damage

The aircraft exhibited damage to the right wingtip and navigation light. An inclinometer was used to measure the angle of the scrape marks, which implied the aircraft was rolled 24° right when it made contact with the runway (Figure 4).

Meteorological information

On the 17 January 2011 the Channel Islands were under an area of relatively low pressure, with a cold front running from Lorient in north west France to Lugo in north west Spain. The weather at Alderney at approximately 1000 hrs was described by the Met Office as *'complex'*, the cold front having cleared recently to the east, and the area under the influence of a moist south-westerly flow.

Alderney Met actual reports (METAR's) were made as follows:

EGJA SPECI 0955 200/10 VRB 180v240 3000 800SW –RADZ FEW 000 BKN 002 9/8 1018
EGJA SPECI 1000 200/11 0600 –RAFG BKN 000 9/8 1018

Aerodrome information

Runway 26 at Alderney is 290 ft amsl, 880 m long and 18 m wide (23 m wide at the threshold), with high intensity approach lighting extending 420 m into

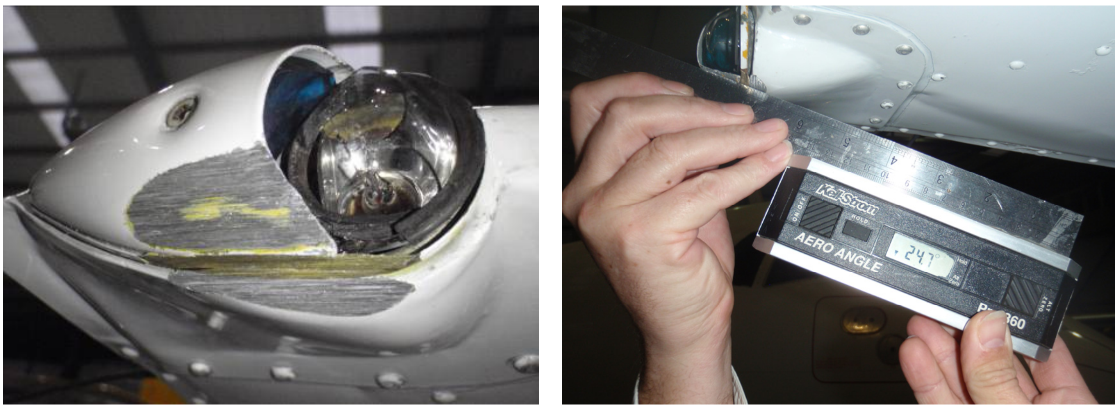

Figure 4

Aircraft damage

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the undershoot and a lighted crossbar 300m from the threshold. The PAPI is set to 3º (Figure 5).

Non-precision approaches

Air Operator Certificate holders conducting public transport operations to an aerodrome in IFR conditions require an approved instrument procedure based on an acceptable navigational aid. An aerodrome operator decides what types of approaches it wishes to make available at an aerodrome, and the CAA approves those approaches it assesses as suitable.

An NDB is subject to several sources of error including: night effect, where radio waves reflected back by the ionosphere can cause signal strength fluctuations 30 to 60 nm from the transmitter, especially just before sunrise and just after sunset; terrain effect, where, for example, mountains and cliffs can reflect radio waves, giving

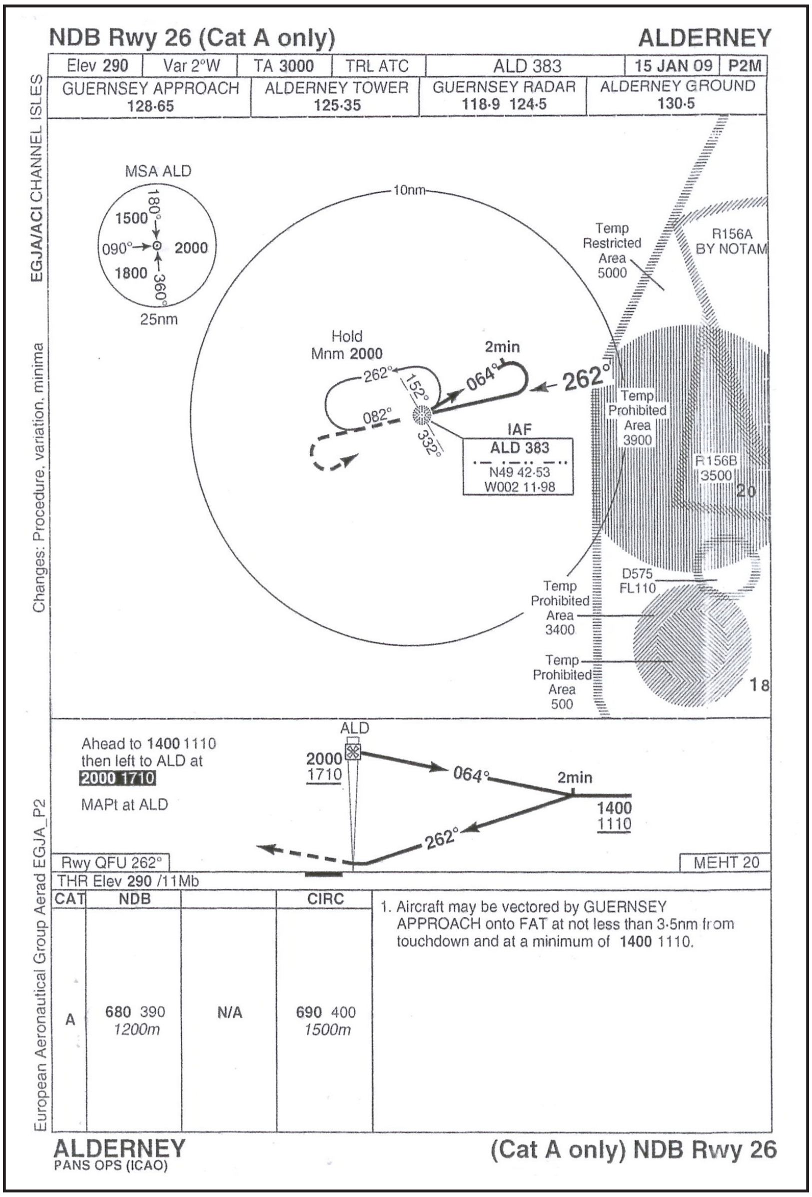

Figure 5

NDB procedure Alderney

erroneous readings; electrical effect, where electrical storms or electrical interference (from a ground-based source or from a source within the aircraft) can cause the ADF needle to deflect towards the electrical source; coastal effect, where low-frequency radio waves will refract or bend near a shoreline, especially if they are nearly parallel to it; and bank effect, by which the needle is deflected when the aircraft is banked. The effects of these errors reduce the accuracy of an NDB, and increase pilot workload.

There are two basic techniques for flying the vertical profile of a non-precision approach such as an NDB. On passing the final descent point the aircraft may descend to a minimum descent altitude and then fly level to the published missed approach point. This technique was more common in helicopter and light aircraft operations. Alternatively the aircraft may perform a continuous descent final approach (CDFA), which is the technique normally used by larger aircraft. Aircraft whose operations are governed by EU Ops will normally be required to use the CDFA technique.

EU OPS 1.430(d)2 – *'Aerodrome operating minima – General*, states:

> *'EU OPS 1.430(d)2. All non-precision approaches shall be flown using the continuous descent final approaches (CDFA) technique unless otherwise approved by the Authority for a particular approach to a particular runway.'*

GPS approaches

Approaches based on GPS provide more accurate guidance than NDBs. GPS approaches have been approved in some states for several years, but at the time of the accident were not widely available for IFR operations in the United Kingdom or the Channel Islands. Alderney did not have an approved GPS approach. The CAA had been assisting the States of Guernsey to develop GPS approaches at Alderney, but were awaiting for the availability of the new European Geostationary Navigation Overlay Service (EGNOS). That occurred on 2 March 2011. At the 37th session of the ICAO assembly ICAO, member states undertook to implement by 2016 GPS[2] approach procedures for all runways to which an instrument approach is to be provided. Whilst the policy of the CAA is to encourage aerodrome operators to achieve this, it does not have responsibility for aerodromes on the Channel Islands, which falls to the Director of Civil Aviation of the States of Jersey and Guernsey.

Stabilised approaches

To improve the chances of an approach ending in a successful landing operators require their aircraft to be stabilised on final approach by a predetermined height on the approach. The relevant section of the Operations Manual for the operator stated:

> *'2.36 STABILISED FINAL APPROACH*
>
> *All Trislander aircraft are to be operated in such a way that they are stabilised on the Final Approach at a minimum of 500 ft AAL.*
>
> *The aircraft is stabilised on final approach when all the following conditions are satisfied:*
> 1. *Vital Actions Before Landing are complete*
> 2. *ILS approach, maximum ½ scale deflection*
> 3. *Non precision approach, within 5 degree of the inbound track and +/- 100 ft of published altitude/distance*
> 4. *Visual Approach, PAPI max 3 Reds 3 Whites*
> 5. *Airspeed 90 Kts – 5kts to +15Kts*
> 6. *Approach power set*

Footnote

2 In this context, ICAO refers to APV – Approach with Vertical Guidance

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If an approach is not stabilised at the required height or becomes de-stabilised at any point below stabilisation height, a go-around must be initiated.'

Comment

The operator's Operations Manual listed the minimum visual references required on a non-precision approach for an aircraft to descend below the minimum descent altitude. All the required visual references were based on aerodrome features. The pilot was not visual with the aerodrome when he made the decision to continue visually, but considered that as he was clear of cloud and in sight of the surface, he could apply the minimum visibility for a visual approach. The Operations Manual stated that this was 800 m. However, this minima should only be applied when a pilot is visual with the aerodrome environment. A pilot would have to meet the minimum weather conditions for an aircraft flying at a speed of less than 140 kt in Alderney's class D airspace[3] until he became visual with the aerodrome environment, and he could then continue the approach with minimum visibility of 800 m.

Recorded information indicates that the aircraft was not aligned with the runway when, approximately 700 m from the threshold (less than 400 m from the lights), the pilot saw the runway lights. It is unlikely, therefore that the required visibility was available. The pilot then manoeuvred the aircraft abruptly in an attempt to align it with the runway. This was not in breach of the guidance given in the operations manual for a stabilised approach. However, the pilot agrees that going around would have been preferable:

The operator has issued a Flying Staff Instruction, which will become an amendment to its Operations Manual, such that significant manoeuvres below 300 ft agl will not constitute a stabilised final approach.

Conclusion

The aircraft made an NDB approach to Alderney in conditions of poor visibility. The pilot continued visually towards the aerodrome and reported sighting the runway late in the approach at a distance less than the required minimum visibility. The right wingtip touched the ground following a manoeuvre close to the ground to align the aircraft with the runway. During the subsequent go-around, the aircraft departed the runway. The aircraft operator has issued new instructions for the conduct of stabilised approaches.

Footnote

[3] 5 km visibility clear of cloud and in sight of the surface.

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INCIDENT

Aircraft Type and Registration:	Boeing 737-76N, 5N-MJI
No & Type of Engines:	2 CFM56-7 turbofan engines
Year of Manufacture:	2001
Date & Time (UTC):	21 November 2010 at 0855 hrs
Location:	Southend Airport, Essex
Type of Flight:	Commercial Air Transport (non-revenue)
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	43 years
Commander's Flying Experience:	5,100 hours (of which 3,500 were on type) Last 90 days - 90 hours Last 28 days - 65 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The crew had programmed the aircraft's Flight Management Computer (FMC) for a maximum thrust takeoff from Runway 24 at Southend Airport. As the aircraft taxied out, ATC changed the runway in use to Runway 06. The FMC was re-programmed but an incorrect 'assumed' temperature was entered, resulting in too great a thrust reduction for the runway length available. Although the aircraft became airborne before the end of the runway, had the takeoff been rejected just before V_1 there would have been insufficient runway remaining within which to stop.

History of the flight

The aircraft had been undergoing maintenance with an organisation based at Southend Airport and was to be repositioned back to the operator's base at Lagos Airport, Nigeria. The crew comprised two captains, one of whom was designated as the aircraft commander and the other, the co-pilot, as pilot flying (PF).

The co-pilot arrived at the airport first and commenced the flight planning, using the documentation provided. This included an Airport Analysis Table for Southend Airport. Unable to locate this table, the co-pilot used the Quick Reference Handbook (QRH), Performance Dispatch section, and the prevailing meteorological conditions to calculate the takeoff speeds using maximum thrust, in accordance with the operator's Standard Operating Procedures (SOPs).

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The commander arrived approximately 90 minutes after the co-pilot, due to transport problems, and was informed by the maintenance staff that the aircraft and documentation were ready. At this point the flight was running some two hours late. The commander joined the co-pilot onboard the aircraft, where the latter had programmed the FMC with the relevant weights and speeds and was in the process of entering the flight planned route, including the departure runway, Runway 24. Whilst this was being done, the commander carried out the external pre-flight inspection before rejoining the co-pilot on the flight deck. The two captains reviewed the FMC programmed data, in accordance with the operator's SOPs, and confirmed that it was correct. The aircraft engines were then started and the crew received clearance to taxi. The weather at the time was: surface wind 360°/ 05 kt, CAVOK, temperature 7°C, dew point 5°C and QNH 1010 mb. The runway was dry.

While the aircraft was taxiing for a departure from Runway 24, ATC changed the runway in use. The aircraft was cleared to Runway 06 via Taxiway Charlie and the commander taxied the aircraft as instructed. He also took over the radio calls, because the co-pilot was having difficulties with his external communications. The runway change necessitated a reprogramming of the FMC. This was carried out with some urgency by the co-pilot, who called out the data as it was entered. Reprogramming the FMC with the new runway deleted the previously entered performance data, thus allowing an 'assumed' temperature to be entered, for a reduced thrust takeoff[1], should it be required. When entering the 'assumed' temperature for the new runway, the co-pilot entered a temperature in the region of 50°C[2]. The crew normally operated from longer runways, mainly in Africa, where such an 'assumed' temperature was appropriate. The aircraft was configured for a takeoff with the flaps at 5°, engine bleeds ON and anti-ice OFF. The engines were rated at 24K (24,000 lbs) maximum thrust.

The aircraft backtracked and lined up on Runway 06 and the crew were cleared for takeoff. However, instead of backtracking the full length of Runway 06, they lined up at the displaced threshold, which was 600 ft from the start of the runway. The co-pilot was given control and, following the pre-takeoff checks, the thrust levers were advanced and the autothrottle was engaged.

As the aircraft accelerated along the runway, the commander recalled thinking, at about 100 kt, that the acceleration was slow and calling for maximum thrust, which he thought the co-pilot applied. At the V_R speed of 133 kt the rotation was initiated and the aircraft lifted off, climbing away on the programmed departure route.

Airport information

Southend Airport has a single runway, orientated 06/24. Runway 06 is 5,264 ft in length and 121 ft wide, with an asphalt surface and friction course. There is an arrester bank some 85 ft beyond the end of the paved surface and a main railway line 145 ft beyond that. Further on there are housing estates. The Take Off Run Available (TORA) is published as 4,785 ft.

Recorded data

Analysis of the recorded flight data showed that the aircraft taxied onto Runway 06 and backtracked, with

Footnote

[1] Reduced takeoff thrust (ATM) is a takeoff thrust level less than the full rated takeoff thrust. Reduced takeoff thrust is achieved by selecting an 'assumed' temperature higher than the actual ambient temperature. When using ATM, the takeoff thrust setting is not considered a takeoff operating limit since minimum control speeds (VMCG and VMCA) are based on full rated takeoff thrust. At any time during takeoff, thrust levers may be advanced to the full rated takeoff thrust.

Footnote

[2] The programmed temperature was not recorded on the FDR or other memory storage.

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the flaps set at 5° and the autothrottle armed. The aircraft lined up at the displaced threshold of Runway 06 and held for two minutes and 10 seconds whilst the before takeoff checklist and crew actions were completed. The wind was from 360° at less than 5 kt, with an OAT of 6°C.

Before brake release, the thrust levers were advanced to give 80.9% and 81.9% N_1 on the left and right engines, respectively. The brakes were then released and the autothrottle was engaged, accelerating the engines to the reduced thrust takeoff setting. Within the first 500 ft of the aircraft's takeoff roll, the left and right engines increased to 86.0% and 86.1% N_1, respectively. As the takeoff roll continued, the respective N_1 values increased further to 86.1% and 86.6%, where they stabilised. The PF commenced the rotation at V_R and, as the aircraft accelerated through the V_2 speed of 140 kt, it became airborne, passing through the 35 ft screen height after travelling 4,317 ft from point of brake release.

The aircraft crossed the threshold of Runway 24 at a height of 150 ft, with the landing gear retracting. A positive climb gradient of 21% had been achieved, with a rate of climb of 2,590 fpm.

Aircraft performance

The aircraft manufacturer was provided with the airport and meteorological information and asked to review the aircraft performance, using an (incorrect) 'assumed' temperature of 50°C.

The results indicated that, had the crew elected to abandon the takeoff just before V_1, there would have been insufficient runway remaining in which to stop. Using maximum braking and maximum reverse thrust, the aircraft would have required a further 656 ft of runway surface beyond that available. It was calculated that the aircraft would have overrun the end of the runway at approximately 60 kt.

Had the aircraft suffered an engine failure one second before V_1, and the takeoff had been continued, it would not have been airborne before the runway end. Conversely, had the engine failed one second after V_1, the aircraft would have lifted off before reaching the end of the runway surface. The manufacturer noted the performance requirement to achieve a 35 ft screen height by the end of the runway. This would not have been possible in the event of an engine failure at these stages.

It was concluded that the maximum 'assumed' temperature for Runway 06 in the ambient conditions should have been 29°C.

Safety action

Following the incident, the operator introduced four safety actions. These were:

- The crew received a structured training package in order to return them to line flying operations.
- Performance and Mass Balance calculations and takeoff and landing exercises in and out of Southend Airport, and other similar maintenance bases used by the operator, will be incorporated into the operator's biannual simulator recurrent training cycle for all their Boeing 737 pilots.
- Operations into and out of Southend Airport, and other similar airfields, will be limited to daylight operations only, so that the perception of speed is not impaired as it would be at night or in low visibility.

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- The company Operations Control Centre will include 'Special Briefings' for unusual and limiting airfields, such as Southend, accompanied by a Route and Airfield checklist. The briefing should serve to remind pilots of the need and circumstances under which a full thrust takeoff is required.

Discussion

The crew considered that they were under time pressure to depart as soon as possible, due to the delay caused by the commander's transport problems. Despite this, they had correctly carried out the flight planning and performance calculations for the departure from Runway 24. Neither crew member was familiar with the airport, so the commander, who was taxiing the aircraft and carrying out the radio communication, was concentrating on ensuring he complied with the taxi clearance. When the runway change was given, the co-pilot carried out the re-programming of the FMC. Although he called out the data he was entering, neither crew member noticed that an incorrect 'assumed' temperature had been entered, as opposed to the maximum thrust setting.

By commencing the takeoff roll from the displaced threshold, the runway TORA was effectively reduced by 600 ft. The commander, recognising the slower than expected acceleration, called for maximum thrust but, although he thought it had been applied, the recorded engine parameters did not support this.

Both pilots were qualified aircraft commanders and there appears to have been an element of mutual confidence in the other pilot's ability to perform his task correctly. The adherence to SOPs, when the FMC was programmed for a departure from Runway 24, broke down when it was re-programmed for a departure from Runway 06.

Whilst the aircraft became airborne and achieved the screen height by the end of the runway, with both engines operating, the manufacturer considered that, had an engine failed at or close to V_1, the aircraft may not have stopped, if the takeoff had been rejected, or become airborne by the end of the runway if the takeoff had been continued.

In view of the safety actions taken by the operator after this incident, no Safety Recommendation is considered necessary.

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ACCIDENT

Aircraft Type and Registration:	Boeing 737-800, EI-DYM
No & Type of Engines:	2 CFM 56-7B26 turbofan engines
Year of Manufacture:	2008
Date & Time (UTC):	12 May 2011 at 0815 hrs
Location:	Liverpool John Lennon Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 6 Passengers - 169
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to aircraft's nosewheel tyre and left main undercarriage assembly, and substantial damage to ground towing equipment
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	48 years
Commander's Flying Experience:	14,266 hours (of which 11,283 were on type) Last 90 days - 180 hours Last 28 days - 64 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot, and reports from the airport authority, ground handling company and Air Traffic Control

Synopsis

The towbar used to connect the aircraft to the pushback tug remained in the aircraft's path after the pushback ground crew had signalled to the flight crew that their taxi route was clear. The aircraft subsequently taxied forward and struck the towbar, which became lodged against the aircraft's left main landing gear.

Description of events

The aircraft was operating a 0800 hrs scheduled service to Alicante, with 169 passengers and a crew of six on board. It was daylight and the weather was fine. Pushback from Stand 8 commenced at 0812 hrs, using a tug and towbar arrangement. It was conducted by two ground crew personnel, comprising the tug driver and a headset operative who was also the dispatch officer.

The pushback was completed normally, with normal exchanges taking place between the headset operative and the aircraft commander. After receiving confirmation that the steering bypass pin[1] had been removed and the towbar disconnected, the commander cleared the headset

Footnote

[1] The bypass pin is used to isolate the hydraulic nosewheel steering while the tow bar is connected to the aircraft nose gear leg for pushback.

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operative to disconnect his headset and wait on the left of the aircraft. He subsequently received a 'thumbs up' from the headset operative, who also showed the commander the bypass pin, as was standard practice.

The flight crew requested taxi clearance and subsequently taxied for Runway 27. After travelling some 400 m, the crew received a call from Air Traffic Control, stating that their aircraft may have struck a towbar and to hold position to await an inspection. This revealed that the towbar had become lodged against the aircraft's left main landing gear and that the aircraft had sustained damage. The flight crew reported that they had felt or heard nothing untoward.

Passengers were disembarked and the aircraft was towed to stand. A sweep was carried out of the taxiways concerned, which were then returned to service.

Local investigations

The accident was investigated by the airport authority and the ground handling company concerned; the findings of these investigations were made available to the AAIB upon request.

Ground crew

The headset operative reported that he disconnected the towbar from the aircraft as usual and removed the steering bypass pin. He walked to the left side of the aircraft and saw the tug driver connect the towbar to the rear of the tug. As the tug started to move away, he showed the pin to the commander, who then waved him off. He boarded the tug and rode in it back to the parking area.

The tug driver reported that he connected the towbar to the back of the tug and, after receiving clearance from the headset operator to do so, drove back to the parking area. At this point, he looked back and saw the towbar still on the apron, in front of the aircraft. He alerted the headset operator who attempted to attract the crew's attention but was unable to do so. The ground crewmen then rushed to their office to alert ATC to the situation.

Equipment

The pushback tug was not fitted with a radio but the tug driver was in possession of a hand-held radio. There had been a failure of the airport's radio communications system shortly before the aircraft was pushed back but this, reportedly, would not have affected calls from vehicle radios or hand-held sets. However, the tug driver reported that his handset was showing a very low signal strength at the time and he did not attempt to use it.

The pushback tug was found to have a towbar locking pin that was not fitted to the vehicle and was apparently not the original pin supplied with the vehicle. The history of the pin was not established but it was confirmed that the tug driver had used it before on two occasions.

From photographs supplied to the AAIB, the locking pin was seen to be fitted with a square flange at one end to which was attached the remnants of a handle, which had broken off a considerable time beforehand. The pin was photographed with the square flange resting on top of a locking mechanism, which was intended to prevent a correctly fitted pin from jumping out of the towing bracket whilst the tug was in motion (Figure 1). In the photographed position, the pin would only partially engage the towbar eye-end fitting if the fitting was inserted into the lower of the three available positions, and would not be mechanically prevented from lifting the small amount required to release the towbar.

Procedures

The ground handling company's investigation established that procedures intended to prevent such

Photograph courtesy of Liverpool John Lennon Airport

Figure 1

Tug vehicle's rear towing bracket with locking pin

an occurrence had not been fully complied with. Once pushback was complete and the towbar attached to the tug, the driver was required to position the vehicle forward of the aircraft, in view of the flight crew but blocking its taxi path, so preventing premature movement of the aircraft. Then, upon clearance from the headset operator, the tug should have been positioned to a point beyond the aircraft's wing tip from where the driver should make a visual check that no obstacles, such as chocks or a towbar, had been left on the taxiway.

The headset operator was required to show the bypass pin and give the 'thumbs up' once he had established that the tug, towbar and all people were clear of the aircraft's taxi route. This should have been done from a position level with the wing tip in view of the flight crew. The procedures stressed that this action by the headset operator confirmed to the flight crew that the immediate taxi route was clear of people and equipment.

Safety actions

Disciplinary actions were taken against the two ground crewmen. The tug concerned was removed from service pending the installation of a radio and all tugs were inspected to ensure that correct towbar locking pins were fitted. Additionally, a programme of daily ramp inspections was initiated to ensure correct pushback procedures were being followed.

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SERIOUS INCIDENT

Aircraft Type and Registration:	Boeing 777-236, G-YMMP
No & Type of Engines:	2 Rolls-Royce RB211 Trent 895-17 turbofan engines
Year of Manufacture:	2001
Date & Time (UTC):	14 June 2010 at 1617 hrs
Location:	Singapore International Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 12 Passengers - 202
Injuries:	Crew - None Passengers - None
Nature of Damage:	Extensive damage at rear of right engine nacelle and further airframe damage
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	44 years
Commander's Flying Experience:	14,770 hours (of which 4,934 were on type) Last 90 days - 192 hours Last 28 days - 79 hours
Information Source:	AAIB Field Investigation

Synopsis

On departure from Singapore International Airport to London a number of EICAS (Engine Indicating and Crew Alerting System) messages were displayed for the right engine. During the climb the crew interrogated the system and established that the event had been transient and that it was safe to continue en route. During the flight there were further events associated with the right engine, showing increased fuel consumption and the crew elected to divert to Amsterdam, Netherlands, transmitting a PAN. After the aircraft landed safely it was found that the right aft inner nacelle was severely damaged and largely missing, with further minor airframe damage and this matched items of nacelle recovered from the runway at Singapore, but not yet identified. Examination indicated that the nacelle damage was due to thermal disbond originating from the HP3 duct area. There have been a number of separate but similar events in other airlines and the airframe manufacturer has issued a series of Service Bulletins to reduce the rate of occurrence.

History of the flight

The aircraft was on a scheduled flight from Singapore International Airport to London Heathrow Airport. Due to the length of the sector four flight crew operated the flight: a commander and co-pilot, and a 'heavy' captain and co-pilot. The commander was the handling pilot for the takeoff and climb to cruise.

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The commander and both co-pilots were on the flight deck for the start up, takeoff and climb to cruising altitude. The start up was uneventful, however due to a high takeoff weight, with a minimal derate to the engines' thrust, high EGTs were expected during the takeoff and briefed by the commander. At this time it was dark.

The aircraft took off from Runway 02L at 1617 hrs on 14 June 2010. At approx 500 ft aal the right engine's EGT fluctuated by approximately ± 100°C and the ENG THRUST R caution message momentarily illuminated on the Engine Indication and Crew Alerting System (EICAS), along with the ENG RPM LIMITED R advisory message. At this point the flight crew also noted that the right engine's N1 was at its maximum of 100.5%. As no recall items were required from the QRH the autopilot was engaged and the departure continued while the situation was monitored. At acceleration altitude the thrust was reduced to 'climb thrust' on both engines; the ENG RPM LIMITED R message cleared and both engines' parameters settled in their normal range.

At a suitable point in the climb the STATUS page and Maintenance Access Terminal (MAT) were accessed by the co-pilots; an EEC C1 R status message remained but this required no crew action. The MAT showed several discrete failures, including a 'short' on the fire loop for the right engine core. Interrogation of the maintenance pages produced an automatic snapshot of the engine event after takeoff. This showed that the right engine's N1 had reached its limit, with fuel flow, EPR, EGT, N2 and N3 all depressed during the event.

With both engines apparently running normally, as the aircraft climbed through 10,000 ft the commander disconnected the autothrottle and selected full thrust as a 'confidence and troubleshooting' check. Full rated thrust was achieved, although N1 was higher on the right engine. Climb thrust was re-selected and the autothrottle re-engaged. The crew elected to continue en route while evaluating the situation. Possible causes were considered to be a birdstrike, fan damage, spurious indications or a failure within the EEC or associated systems. At this stage the only unusual indication was that the right engine N1 was approximately 3.5% higher than the left engine. At this point the 'heavy' co-pilot went into the cabin for his rest.

Once the aircraft had reached its initial cruising altitude the only technical discrepancy was that for a given EPR, the right engine's N2, N3, fuel flow and EGT were depressed compared with the left, while the N1 was higher. The crew considered possible fan damage, but the vibration indicator showed only 0.8 units[1], with N2 being the dominant item. Maintenance control in London was contacted to discuss the possibility of erroneous N1 indications, as this seemed a likely cause of the displayed symptoms; they suggested it was unlikely. A higher noise level reported from the cabin was also discussed, and the likely cause of this was deemed to be an ongoing issue with the wing root fairing, which had been recently subject to a tape repair due to previous reports of cabin noise.

Approximately 4 hours into the flight an ENG EEC MODE R advisory message was displayed on the EICAS and the QRH checklist actioned. The EEC has two control modes, 'Normal' and 'Alternate' and this message was advising that the right engine had switched to 'Alternate'

Footnote

[1] The engine vibration monitoring system is primarily intended for engine condition monitoring, but it is also a useful tool for isolating and determining corrective action for engine anomalies. There is no certified vibration limit, but when a high vibration level is reached, the secondary engine parameters are automatically displayed. Since there are no operating limitations for the airborne vibration monitoring system, there are no specific flight crew actions (or procedures) based solely on vibration indication.

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mode; as part of the QRH actions, the crew also switched the left engine to 'Alternate' mode . Given the MAT indication of several failures in this area and the EEC C1 R status message this was not a cause for alarm for the crew as they had suspected EEC issues. Following this action, the discrepancy between left and right N2, N3, and fuel flow increased, as would be the case if the right N1 was over-reading; vibration remained normal.

The crew consulted the "*Performance In Flight*" section of the FCOM 1 relating to Alternate Mode EEC. This suggested a 20 tonne decrement to 'primary mode' performance limit weight for climb and net level-off weight. The crew decided that climb decisions would be based on this higher assumed weight.

Approximately 5 hours into flight the Flight Management System's 'fuel remaining' calculations at London Heathrow started reducing. While the required thrust and fuel flow were high they were not entirely inconsistent with a 20 tonne performance decrement, although the fuel flow was higher than would be expected. As a result, reaching London Heathrow with the minimum required fuel of 5,400 kg was becoming unlikely, and the trend was worsening. At this point the aircraft was over Afghanistan and the route ahead had few suitable alternates for several hours. The crew considered that if a turnback were attempted it would still be several hours before the aircraft would reach an acceptable alternate airport. As the fuel on board was about 52,000 kg of fuel and total fuel flow was about 8,000 kg/hr the crew felt it was prudent to continue towards better alternates, with several less suitable, but usable, places to go if conditions worsened. A crew handover took place and it was agreed the 'heavy' crew would continue to monitor the situation closely, liaise with operations, and advise the operating crew if conditions deteriorated.

Approximately 8 hours 45 mins into the flight the commander was woken in his rest bunk by what he believed was an engine compressor stall. As the engines continued running, with no change in thrust, he decided it had been imagined. The relief crew heard a "thud" and felt a slight movement of the aircraft. They then noticed that the required thrust setting and fuel flow had reduced, and that the fuel state, although now showing insufficient for London, had stopped deteriorating. They then began planning what options were available, given the remaining fuel state, and contacted the operator to see which alternates were preferable. The 'heavy' crew suspected that a panel had become loose, creating drag for several hours, and suddenly detached. As it was now daytime the 'heavy' captain examined the aircraft exterior as far as possible but could find no evidence of missing panels or other damage. The rear of the engine was not visible from the cabin. The possibility of reverser blocker or cascade doors detaching was considered, although engine parameters remained unchanged.

The crew elected to divert to Amsterdam International Airport, Netherlands, primarily because the weather was excellent, multiple runways were available and the aircraft would arrive with about 2,000 kg above minimum reserve fuel, thus allowing for contingencies. Having established that rated thrust was available from the right engine, a standard Flap 25 landing was planned. As the crew did not know how many track miles remained or which runway to expect prior to establishing contact with Amsterdam ATC, and any delay caused by ATC or a latent technical problem might have resulted in landing below reserve fuel, they transmitted a PAN on initial contact. The aircraft landed without further incident, using idle thrust reverse, at 0511 hrs on 15 June 2010. Having vacated the runway near the AFRS, who were on standby, the commander

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elected to get visual inspection from them; this was inconclusive.

After shutdown and passenger disembarkation the crew vacated the aircraft to see if there were signs of damage. They discovered that the aft inner nacelle on the right engine was severely damaged, and much of it missing, and that there was further airframe damage.

Engine debris at Singapore International Airport

Aircraft parts were found by a Singapore International Airport Airside Operations vehicle on the edge of Runway 02L during a scheduled maintenance closure of Runway 01 on 14 June at 1715 hrs (0115 hrs Singapore time). Attempts were made to identify the parts, but without success. At 0843 hrs (1643 hours Singapore time) on 15 June 2010 the airport authorities received a call from the operator of G-YMMP, saying that parts of an engine nacelle were missing on arrival in Amsterdam. The operator's representative in Singapore subsequently identified the parts as belonging to G-YMMP.

Initial examination

The operator and the airframe manufacturer made initial assessments at Amsterdam of the damage to the aircraft. It was clear that the left inner wall 'D-duct' on the right engine thrust reverser had separated from its engine and that a large portion of the turbine exhaust nozzle was missing (Figure 1). There was also damage to the inboard flap fairing and flaperon, consistent with the separation of the items from the engine, with scraping and gouge damage on the right lower wing skin and the right horizontal stabiliser.

The manufacturer's initial examination indicated that buckling damage to the inner wall D-duct was consistent with a:

> *'typical of loss of stability due to disbond of inner facesheet'*

and that this form of failure had been seen on a number of previous occasions. It appeared likely that

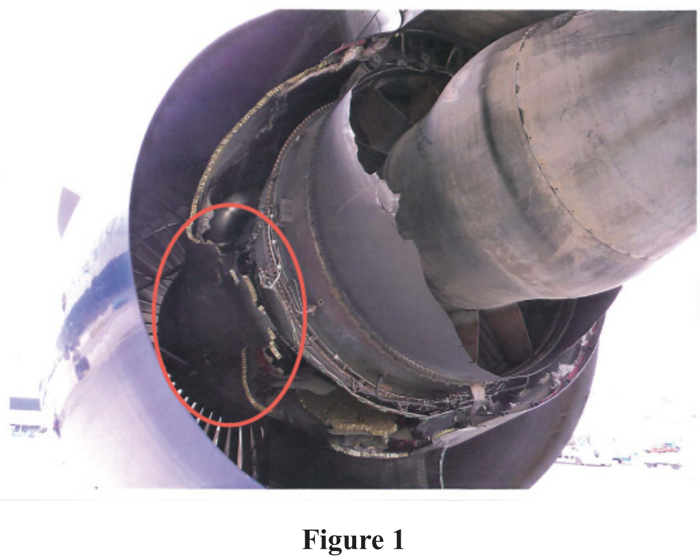

Figure 1

Thrust reverser buckled inner wall and missing nozzle the separation of the turbine exhaust nozzle had been caused by the failure of the duct structure as the inward collapse of the inner wall applied bending loads to the nozzle supporting structure.

This initial examination by the manufacturer also indicated areas in which there did not appear to be sufficient sealant to preserve firewalls, such as on the leading edges of the insulation blankets, around cooling tube penetrations and around the interface between the left HP3 duct and the insulation blankets, without evidence as to how much this had contributed to the failures. The airframe manufacturer reported that:

> *'preliminary results of hardware and engine fault codes and QAR data are consistent with the loss of the nozzle being secondary to the loss of the inner wall.'*

Thrust reverser thermal barrier system - description

The affected parts of the thrust reverser system and engine cowlings are within the design responsibility of the airframe manufacturer, not the engine manufacturer. The maintenance manual for the aircraft describes the function of the thermal barrier protection applied to the thrust reverser as being to keep it:

> *'structurally serviceable'*

and to prevent:

> *'parts separating from the airplane in flight.'*

The inner wall of the fan duct cowl (Figures 2 and 3) is a composite material susceptible to;

> *'radiant heat damage from fires and [normal] engine operation'*

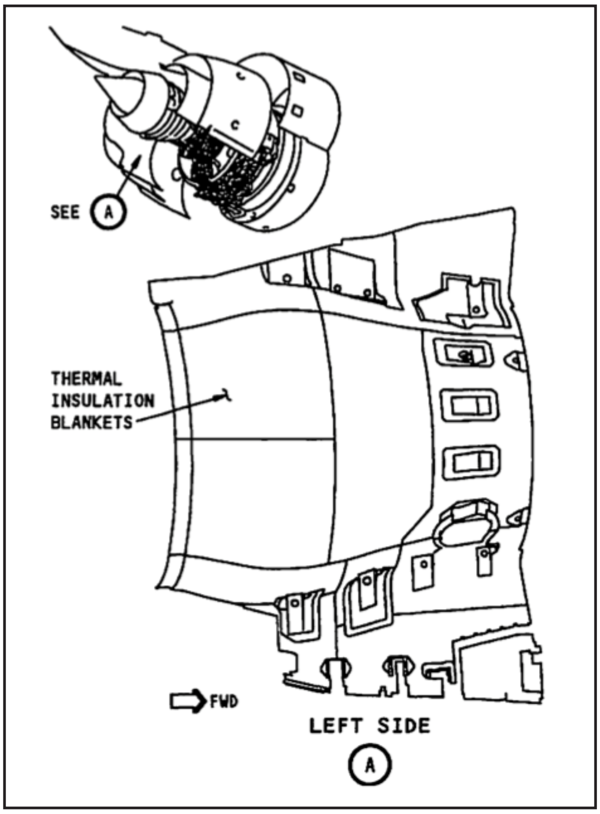

Figure 2

Thrust reverser thermal barrier in fan duct cowl
(courtesy Boeing)

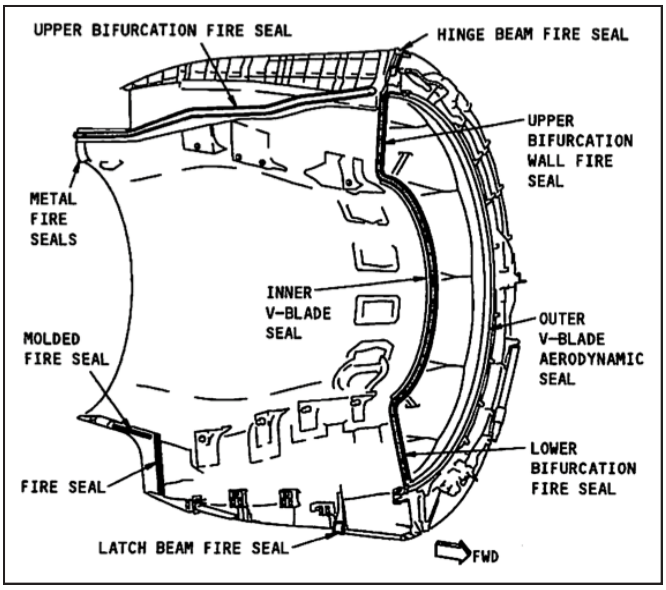

Figure 3

Location of thermal blanket seals in fan duct cowl
(*courtesy Boeing*)

without the thermal barrier. The barrier consists of thermal insulation blankets installed in the area bounded by the fire seals in Figure 3.

The integrity of the blanket-to-blanket seal, the blanket penetration seals and the blanket edge seals is critical to the success of the thermal barrier protection and to the preservation of the structural integrity of the thrust reverser inner wall. The maintenance manual states that large amounts of hot (leaked) compressor air:

> *'can penetrate through the gaps between the overlapped blankets to cause convective heat damage to the T/R inner wall'*

and that it is:

> *'important to find any holes in the bleed offtake pneumatic ducts, or gaps at pneumatic duct connections, or damaged kiss seals and kiss seal mating surfaces during engine visual inspections.'*

Flight data recorders

Data downloaded from the flight data recorder (FDR) for the incident flight is presented in Figures 4 & 5. Figure 4 shows the takeoff and climb to 7,000 ft amsl from Singapore International Airport. At 1618:35 hrs, as the aircraft climbed through 500 ft, the right engine

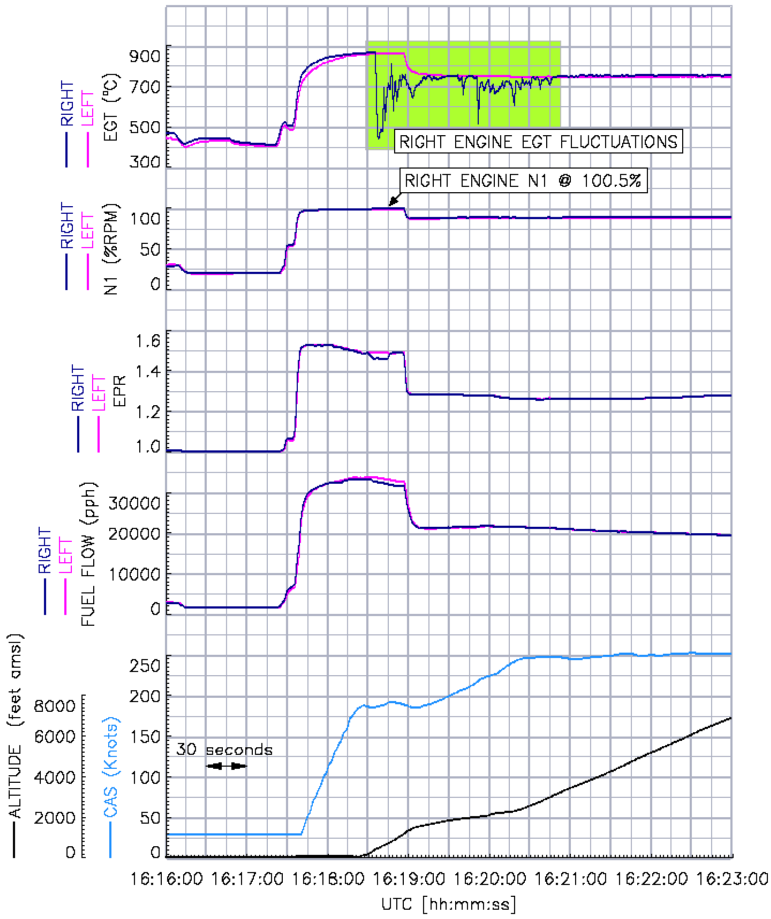

Figure 4

FDR data for the takeoff, showing right engine fluctuations

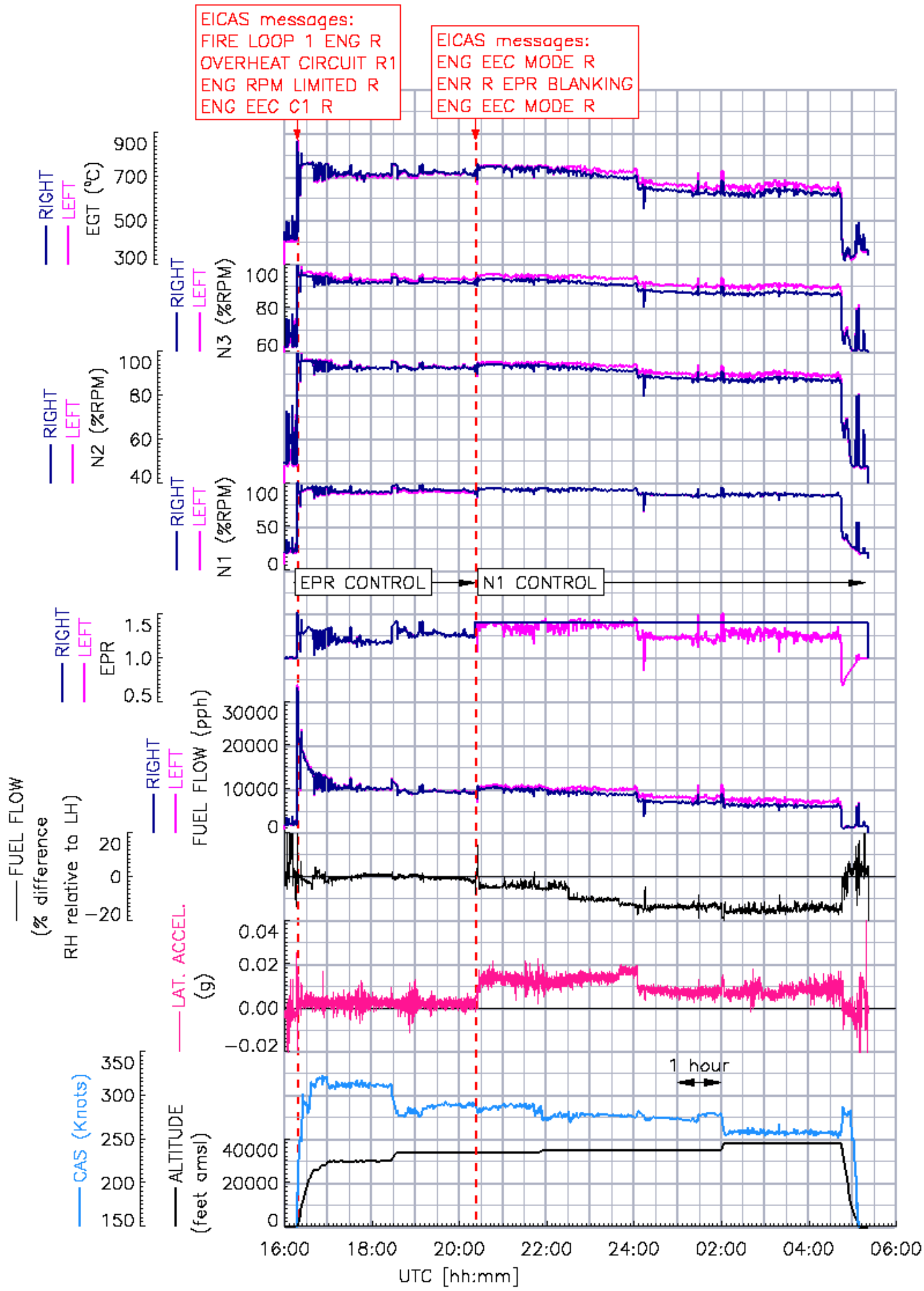

Figure 5

Salient FDR parameters of incident flight

N1 increased from a nominal 99% to 100.5% and the left engine remained at 99%. At the same time, the right engine EGT dropped from 867ºC to 448ºC and then fluctuated around 700ºC for about 130 seconds, before rising to 750ºC; the left engine EGT remained steady at 865ºC, dropping smoothly to 750ºC as the engine thrust was reduced to climb thrust.

Figure 5 shows data for the complete flight to London Heathrow Airport. Also indicated on Figure 5 are the EICAS messages displayed to the crew. These messages were recorded on the Maintenance Message Data Report, downloaded from the EICAS after the flight. The first set of messages were at 1618 hrs during the time of the right engine EGT fluctuations. However, the report only records the time for each message as hours and minutes so the exact timing is unknown. For the next four hours the EPRs and fuel flow for both engines were matched but small discrepancies between the engines were recorded for N1 (1 to 3.5%RPM), N2 (0 to 1%RPM), N3 (1 to 2%RPM), and EGT (0 ºC to 8ºC).

The second set of EICAS messages occurred at 2023 hrs, approximately four hours into the flight, as the right engine EPR signal was lost. It was at this point the engines switched from Normal EEC mode ('EPR') to Alternate EEC mode ('N1'). From this point onwards the engine N1s were matched but discrepancies between the engines (left greater than right) were recorded for fuel flow, N2, N3 and EGT. In particular, a 5% difference in fuel flow was measured, increasing in steps to 15% by the end of the cruise portion of the flight. Also recorded was a lateral asymmetry to the right: rudder trim (not shown) was only used between 0254 and 0320 hrs, when 0.05 inches of left rudder trim actuator movement was recorded.

Engine performance review

During the investigation, the engine manufacturer conducted an analysis of the performance of both engines during the flight, primarily using data from the EHM (engine health monitoring) and QAR (quick access recorder).

This analysis reflected the account of the flight given by the flight crew and by the FDR data. In particular, it identified the anomalies between N1 and EPR during the initial event at takeoff and the relatively high power settings on both engines during the first four hours of flight, reflecting, and compensating for, some degree of exhaust nozzle area change on the right engine.

Following the event at about four hours, and the switching to 'Alternate' EEC mode (controlled by N1, rather than EPR), the higher power settings continued, with the left engine reflecting scheduled performance but the right engine performance degraded by the changes in effective nozzle areas. The total fuel consumption by the engines, resulting in the PAN diversion into Amsterdam, matched the aircraft tank quantities.

Detailed examination

Following the initial investigations at Amsterdam and in the United Kingdom, the significant items from the failed duct on G-YMMP were despatched to the USA for more detailed investigation at the airframe manufacturer.

During this examination the manufacturer identified several locations with clear indications of thermal exposure and disbond. Of those, the location of greatest interest was around the drag link fitting, immediately above the HP3 cutout (Figure 6). This was among the more discoloured areas, and it was clearly included in the disbonded region of the panel. The discolouration of

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other areas of the inner wall was evidence of overheating at those locations, but the manufacturer reported that discolourations outside the disbond region associated with the panel collapse were '*unlikely to be implicated in the failure*' of the panel. This was consistent with the manufacturer's initial assessment at Amsterdam.

The manufacturer further noted significant characteristics of the disbonded surface. These included areas with low bond strength, as evidenced by small fillet scars and/or adhesive failure between the honeycomb core and the facesheet, and a region of significantly overheated adhesive between the drag links next to the HP3 cutout.

Service history and safety actions

This was the first event of this type experienced by the operator of G-YMMP but it followed approximately 10 other events on 777 aircraft with this airframe-engine combination. A further two events have been recorded since that to G-YMMP.

As a result of the initial incidents, in February 2005 the aircraft manufacturer issued Service Bulletins 777-78A0059 and 777-78-0060. These SBs principally involved one-time inspections of the thrust reverser inner wall, insulation blankets, compression pads, and drag link fittings (-059), and the application of sealants (-060).

Following further events at other operators, one of which was on an airframe which had SBs -059 and -060 correctly completed, an additional Service Bulletin, 777A78-0065 was issued in June 2008, requiring recurring inspections. Initial inspection of the blanket sealing on G-YMMP was carried out on 5 February 2010 and a repeat inspection was carried out on 14 May 2010, with no significant damage reported.

Figure 6
HP3 duct disbond location

However, a full NDT inspection of the inner wall with all the thermal blankets removed had not yet been completed on G-YMMP at the time of this incident, as the inspection was not yet due.

The airframe manufacturer issued a further, and extensive, Service Bulletin in late 2009, 777-78-0071, stating that the existing thermal protection system was insufficient to prevent damage to the inner wall of the thrust reverser and incorporating a new thermal protection system to reduce the temperatures experienced by the inner wall during flight. There was some initial delay in the approval by the EASA of the design change included within this Service Bulletin, as EASA was requesting further data and design substantiation from the airframe manufacturer, and the design change had not been fully approved at the time

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of this event to G-YMMP (14 June 2011). However, the operator of G-YMMP commented that, even with earlier EASA approval, the scope of the work and the number of aircraft to be covered leaves it uncertain whether G-YMMP would have been modified by the date of this incident.

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ACCIDENT

Aircraft Type and Registration:	British Aerospace Jetstream 41, G-MAJD
No & Type of Engines:	2 Garrett Airesearch TPE 331-14GR-807H turboprop engines
Year of Manufacture:	1992
Date & Time (UTC):	4 February 2011 at 1921 hrs
Location:	Leeds/Bradford Airport
Type of Flight:	Commercial Air Transport (passenger)
Persons on Board:	Crew - 3 Passengers - 5
Injuries:	Crew - None Passengers - None
Nature of Damage:	Left main landing gear outboard trunnion pin fractured
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	48 years
Commander's Flying Experience:	5,237 hours (of which 3,530 were on type) Last 90 days - 121 hours Last 28 days - 46 hours
Information Source:	AAIB Field Investigation

Synopsis

After landing in strong and gusty wind conditions, damage was found to the aircraft's left Main Landing Gear. It was determined that the gear outboard trunnion pin had failed in overload due to upward loading on the outboard wheel.

History of the flight

The aircraft was operating a scheduled service from Teeside to Southampton, with a transit stop at Leeds/Bradford. On board was a flight crew of two, one cabin attendant and five passengers. The crew had commenced duty at 1615 hrs, and the flight was the first of their duty period.

As the aircraft neared Leeds/Bradford, the crew received ATIS code 'G' (valid from 1829 hrs) which reported a surface wind from 250º at 29 kt gusting 46 kt. Lowest cloud was FEW at 1,200 ft agl and visibility was 20 km. Runway 32 was in use and was reported damp in all sectors. The aircraft's maximum demonstrated crosswind value was 35 kt. After a period of holding, the crew elected to make an approach whilst monitoring reported wind; the commander was the handling pilot.

Because of the strong wind and gusts, a flap 15 landing was planned (normal flap setting for landing was 25). The approach was reported to be quite steady until the latter stages when it became destabilised

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and the aircraft descended below the glideslope. The commander initiated a go-around, during which the aircraft's main gear briefly made light contact with the runway surface.

The crew decided to make a second approach. As the wind had appeared steady during the first approach, they decided to use flap 25. In the latter stages of the approach the Tower controller passed a wind report of 250º at 45 kt. The crew continued the approach and received a further report of 270º at 33 kt on short finals, at which point the decision to land was made.

The commander recalled that the touchdown was not heavy but, as the aircraft slowed, he experienced directional control difficulties. The aircraft first yawed right, which he corrected. However, the aircraft nose then swung further left than intended before regaining the runway track. The commander thought that reducing rudder authority and a sudden response to nosewheel steering input may have contributed to the handling difficulties in the strong crosswind.

The aircraft vacated the runway as normal, but once on stand damage to the left main landing gear was discovered.

Recorded data

Radio Telephony (R/T)

Recorded R/T data for Leeds/Bradford Approach frequency (125.575 MHz) and Tower frequency (120.300 MHz) was examined.

At 1837 hrs, when the aircraft was routing towards the 'LBA' hold, the Approach controller passed the crew an average wind for the past ten minutes of 240º at 30 kt, maximum 42 kt. The crew informed ATC that they would remain holding and that the maximum permissible wind strength for landing would be 37 kt, providing the direction remained steady from 250º. The controller replied that the instantaneous wind was 240º at 25 kt. The crew announced that they could start an approach but would require instantaneous wind readouts throughout.

The aircraft contacted the Tower controller at 5.5 nm from touchdown. The controller passed instantaneous wind reports during the approach, which varied between 26 kt and 32 kt, the lower figure being reported with the aircraft on short finals. At 1903:45 hrs the crew transmitted "GOING AROUND". Less than a minute later, the Approach controller passed an instantaneous wind report to another aircraft of 250º at 36 kt, noting that the maximum in the last 10 minutes was 42 kt.

When the aircraft transferred back to Tower controller for its second approach at 1916 hrs, the crew were given a reported wind with their landing clearance of 240º at 28 kt gusting 42 kt. Again, the Tower controller passed instantaneous wind reports during the aircraft's approach.

Recorded flight data was synchronised with R/T data using aircraft transmission keying. This indicated that the penultimate wind report of 250º at 45 kt (the highest value reported on the approach) had been made by the controller when the aircraft was passing about 1,216 ft altitude (554 ft ARTE), or about 1.6 nm from the runway[1]. The final wind report of 270º at 33 kt was passed when the aircraft was about 1.1 nm from the runway at about 1,073 ft altitude.

Footnote

[1] The calculations assume that the aircraft was on or close to the published 3° glideslope. Runway Threshold Elevation was 662 ft amsl.

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Meteorological data

An anemometer recording was provided by Leeds/Bradford Airport. The device recorded maximum and minimum values for wind speed and direction over successive 30 second periods.

In the time period covering the two approaches, the wind direction averaged between 240º and 250º with occasional greater variations between 210º and 270º. The variations became more frequent during the second approach, with a single variation up to 277° recorded at about the time of landing.

Recorded wind speeds for the period are shown graphically at Figure 1. The figure also shows the time and values of instantaneous winds passed to the crew by ATC.

Flight Data

The aircraft was fitted with a CVR and an FDR. The CVR records the last 30 minutes of operation. The time taken to recognise the problem and preserve the recording was inadequate for the given duration of CVR and so the relevant recording was overwritten. The 25 hour FDR recording covered the period of interest.

The recordings showed erratic normal and lateral accelerations associated with windy conditions. Two approaches were flown with the autopilot coupled to the ILS for the majority of the descent. High on the first approach the aircraft had more than 20º of drift; this reduced further down the approach but was still varying about an average drift angle of approximately 15º before reaching the runway. The radio altimeter

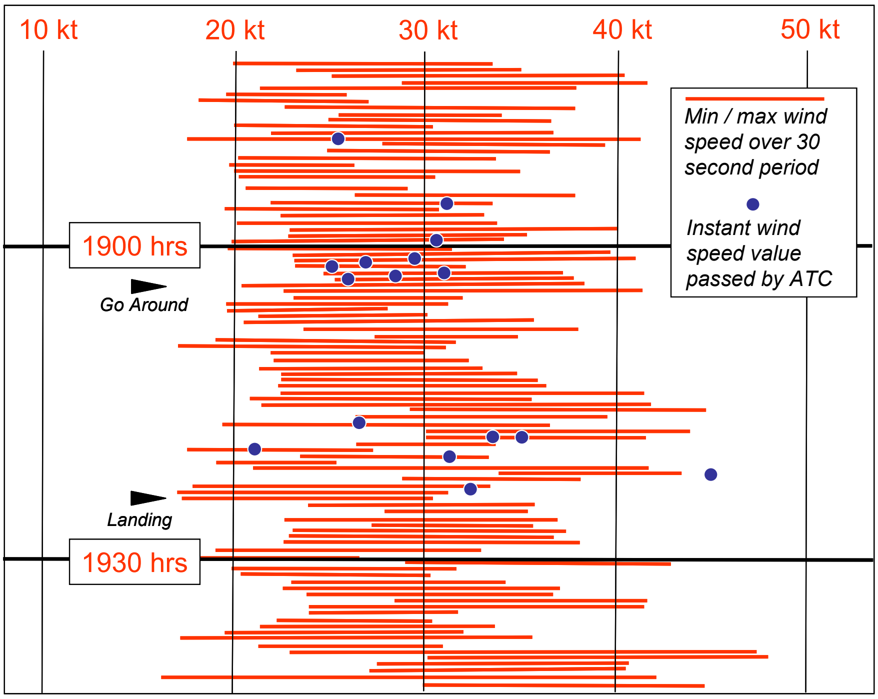

Figure 1

Anemometer data, with blue dots indicating time and value of ATC reported wind strength registered zero but none of the gear or air/ground parameters were triggered. Whilst above the runway, the localizer showed the aircraft to be on the centreline and the recordings indicated a drift angle averaging approximately 10º.

On the second approach, the drift angle just prior to landing was approximately 15º. This equated to a crosswind component of approximately 34 kt. Figure 2 shows the pertinent parameters on the final landing. The data registered a small elevator deflection with a small change in pitch attitude but no significant flare. The required recording accuracy of the pitch parameter is only ±2º, however the data showed that the pitch was generally more nose-down than any of the other 46 landings recorded.

Just prior to touch down, the drift was reduced to near zero. All three gear parameters registered as on the ground within the same one second sample period,

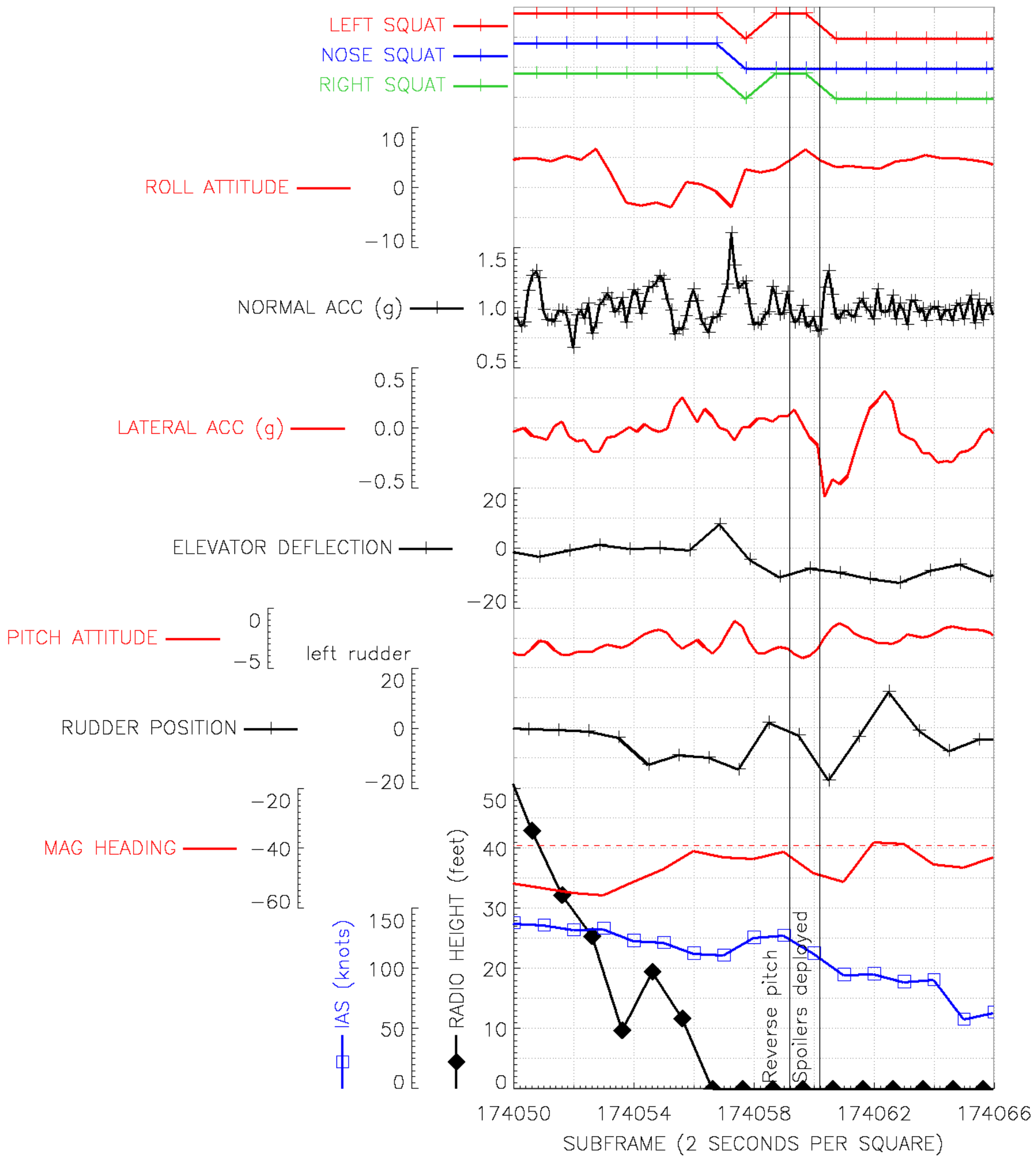

Figure 2

Pertinent FDR data

associated with a peak recorded normal acceleration of 1.6 g and the aircraft slightly rolled to the left. The subsequent two samples, one second apart, showed that the main gears were no longer sufficiently compressed to register as on the ground, with the nose gear still showing on the ground. The aircraft yawed right before being brought back rapidly left in the same timeframe as the main gear recompressing. This was coincident with the peak recorded lateral acceleration of 0.6 g and a normal acceleration spike of 1.3 g.

Altitude rate was not recorded, and the quality of the altitude and height parameters did not support a robust derivation of altitude rate. Whilst the aircraft had a left roll rate at the time of the spike in normal acceleration, it was not large enough to significantly affect the overall closure rate of the gear with the ground.

Examination of the aircraft

The AAIB examination of G-MAJD took place on the night of the accident. The aircraft was parked on the apron and was supported on jacks. It could clearly be seen that the left Main Landing Gear (MLG) was leaning outwards and, when looking into the left MLG bay, it was found that the outboard trunnion pin had broken. The trunnion pin is a fusible link and is designed to fail at a descent rate at touch down of approximately 10 ft/s. The trunnion housing was resting against the outboard rib (Rib 8), which had been damaged but was supporting the MLG leg albeit at a splayed angle (Figure 3). Also apparent was that the MLG doors were open, because the trunnion pin, which is attached to a bellcrank, is part of the door actuating mechanism; with the pin failed, the doors were able to drop down under gravity.

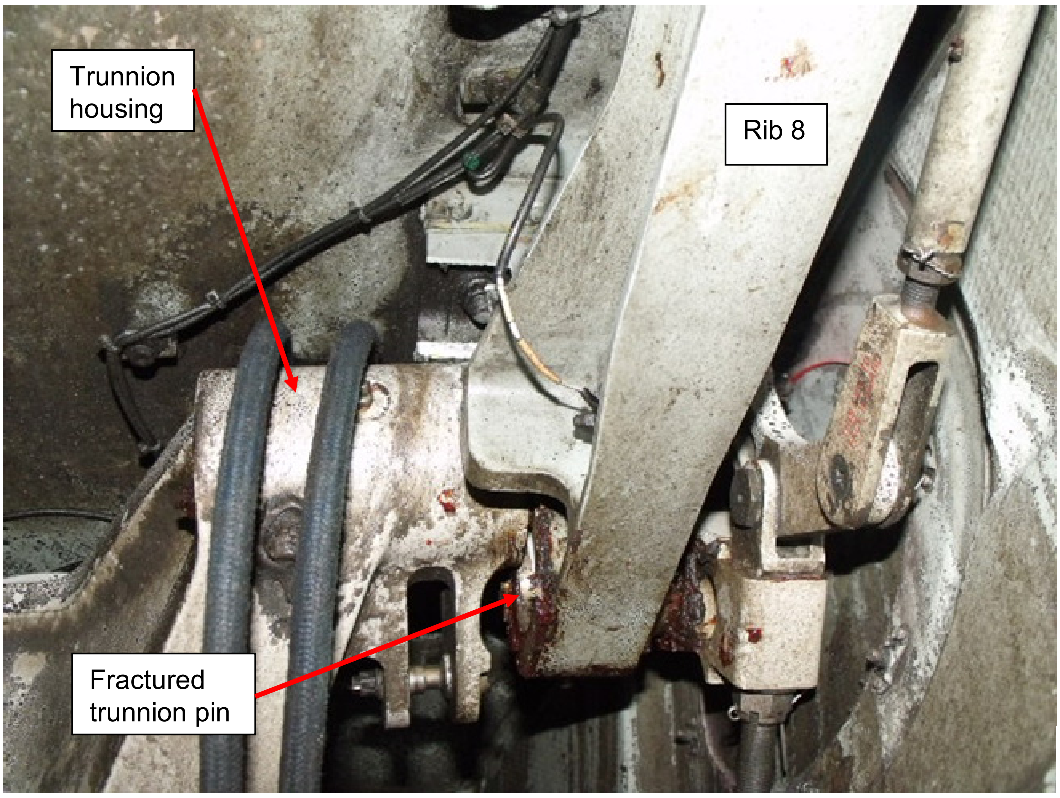

Figure 3

Photograph of left MLG showing fractured trunnion pin and trunnion housing forced up against Rib 8

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The degree of movement did not allow the propeller to strike the ground and, apart from some small fuel leaks which became apparent upon detailed inspection, there was no damage outside of the MLG assembly and Rib 8 on the left side.

The fractured pin and the broken Rib 8 were removed and submitted to a metallurgical laboratory to ascertain whether there had been any material defects contributing to the failure and also for information concerning directionality of the fracture ie vertical or lateral loading being involved in the failure. The report from the laboratory showed that the pin had no pre-existing material defects and had failed primarily in overload shear. Starting at the lower surface, a crack propagated rapidly around the pin until full rupture finally occurred with the remaining material bending and fracturing in tension.

After pin failure, the whole MLG leg assembly moved upward, breaking two stiffening webs on Rib 8 before the trunnion housing became wedged against the rib, preventing further upward movement of the outboard trunnion but leaving the whole MLG leg to splay outwards.

Summary

The landing had been carried out in strong and gusty crosswind conditions. There were no signs of any pre-existing material defects and that significant lateral loads contributing to the failure. Consideration of the MLG geometry and the direction of the fracture led to the conclusion that the trunnion pin had failed in overload due to purely upward loading on the outboard wheel.

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ACCIDENT

Aircraft Type and Registration:	Cessna 750 Citation X, G-CDCX
No & Type of Engines:	2 x Rolls-Royce AE 3007C1 turbofan engines
Year of Manufacture:	2002
Date & Time (UTC):	9 December 2010 at 1021 hrs
Location:	Doncaster Airport, South Yorkshire
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Right mainwheels detached, damage to flaps and outboard wing skin, puncture of right elevator
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	34 years
Commander's Flying Experience:	4,800 hours (of which 600 were on type) Last 90 days - 72 hours Last 28 days - 34 hours
Information Source:	**AAIB** Field Investigation

Synopsis

The aircraft was positioning to Doncaster Airport for minor maintenance. Shortly after a normal touchdown, the right main landing gear trailing link failed and both mainwheels on that side detached. The aircraft slid to a halt just off the right side of the paved surface. The link failed due to a long stress corrosion crack and a Safety Recommendation is made for frequent visual inspection of the links for the presence of such cracks.

History of the flight

The aircraft was flown from Luton to Doncaster, its maintenance facility, where it was to undergo minor preventative maintenance. The weather conditions for the flight were good, and the flight was described by the crew as normal. The aircraft was radar vectored onto the ILS approach for Runway 20 at Doncaster, and at five miles on the final approach the commander disengaged the autopilot and continued to fly the approach manually. ATC passed the surface wind as 290º at 11 kt, which was well within the aircraft's crosswind landing limit, and cleared the aircraft to land. The pilots described the approach, and the flare as normal. The landing, which was to the left of the runway centreline and within the instrument landing area, was described as smooth, although the commander recalls the right Main Landing Gear (MLG) touched down slightly before the left. He then became aware that, as the nose began to drop, the aircraft rolled gently to the right and he felt a judder

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through the control yoke. The commander quickly realised he had a landing gear problem and attempted to keep the aircraft straight on the runway using the left brake and rudder. The co-pilot advised ATC that they had a problem with their landing gear, and shut down the engines. As they slowed down the commander started to lose directional control and the aircraft began to veer to the right. They came to a halt on the edge of the runway. The crew shut down the remaining systems and vacated the aircraft normally.

ATC saw the aircraft land in what appeared to be a normal landing. They then noticed sparks coming from the right side of the aircraft and saw what appeared to be a wheel bouncing down the runway. They immediately initiated their aircraft crash procedures, and the fire service responded immediately, reaching the aircraft seconds after it came to a halt. They reported that a considerable amount of debris was on the runway, including both right mainwheels.

Flight Recorders

The aircraft was fitted with a two-hour Cockpit Voice Recorder (CVR) and a 25-hour Flight Data Recorder (FDR). The CVR did not highlight any issues associated with the flight, crew or aircraft until the MLG failed. It had lost power when the crew shut down the aircraft electrical power shortly after the aircraft came to rest. The FDR provided good data relating to the accident.

The aircraft took off from Luton at 0950 hrs, climbed to FL120 and headed for Doncaster. The aircraft was fully configured for landing, with gear down, 35° of flap and the autopilot disengaged by 1,600 ft amsl on the approach. The aircraft descended with minimal deviation from the glidepath with approximately 10° of left drift.

From a height of 120 ft the pitch was increased and the rate of descent reduced. Figure 1 shows the pertinent FDR parameters from just before touchdown. The heading was gradually reduced and just before touchdown the aircraft started to drift left of the centreline.

The aircraft initially touched down with a descent rate of approximately 100 ft/min with a small amount of right roll and a small, but increasing, fly-right localizer deviation. The nose was lowered, during which small lateral acceleration oscillations were recorded. During the period when the Weight On Wheels (WOW) parameters became active, the aircraft started rolling right. The pitch reached zero and the speed brakes were deployed. When the roll reached approximately 5º, a 1.9 g spike in normal acceleration and a -0.35 g spike in longitudinal acceleration were recorded.

There were no brake related parameters recorded.

Passing through a ground speed of 90 kt the thrust reversers were deployed for approximately three seconds. The heading remained stable until the ground speed reduced through 30 kt, when it started yawing right. This was corrected by deploying the left thrust reverser for approximately three seconds. Passing through 20 kt the right engine fuel flow quickly reduced to zero; the fuel flow for the left engine also reduced to zero over the next five seconds. Just before coming to a complete stop the aircraft yawed right.

Flight Recorder analysis

It is likely that the gear detachment occurred during the initial touchdown phase, with a low descent rate. Just prior to this, whilst drifting to the left, small oscillations in the normal and lateral acceleration parameters were recorded, possibly associated with intermittent contact with the runway or ridges of ice observed on the

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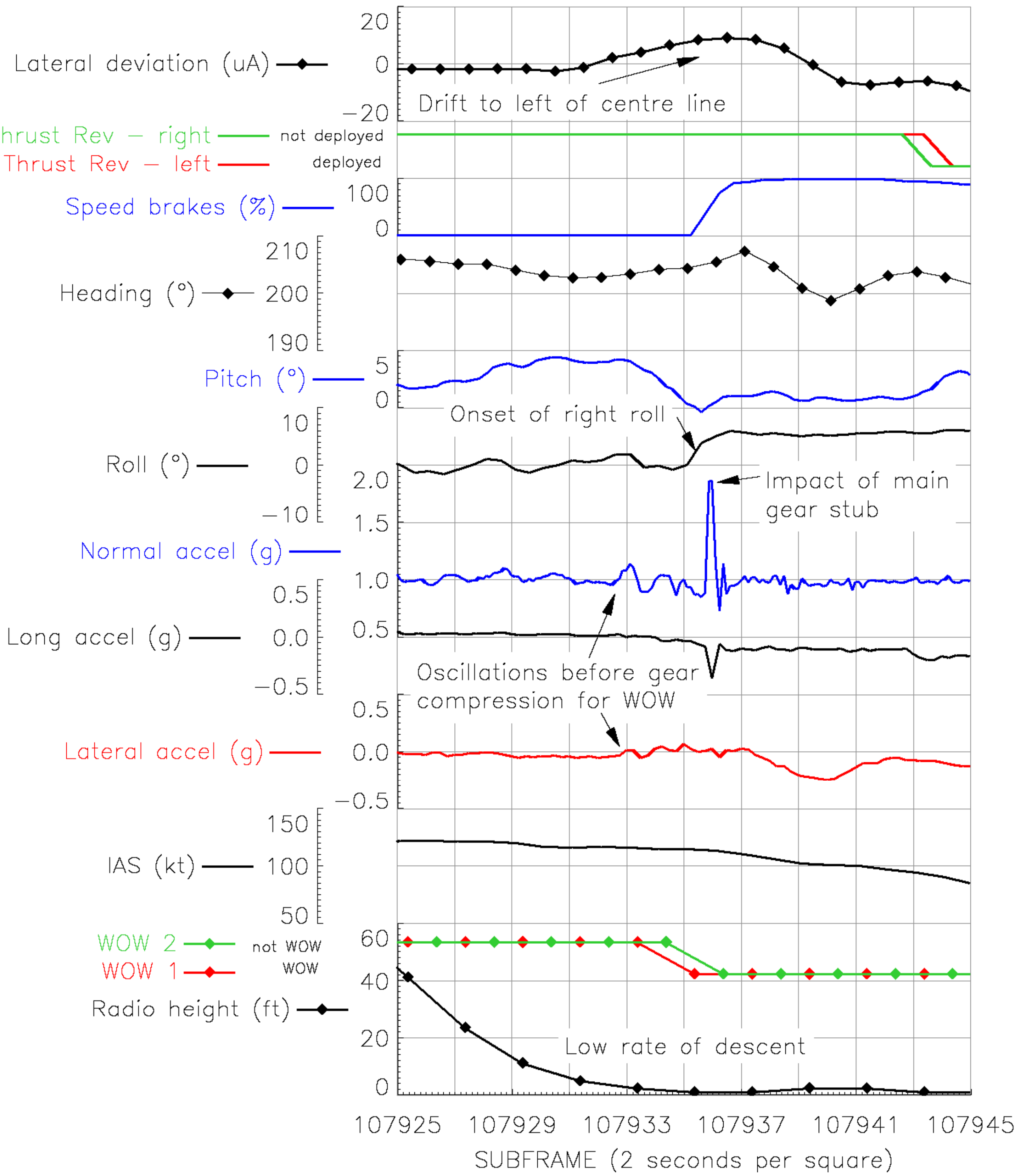

Figure 1

Pertinent FDR parameters from just before touchdown runway. A right roll initiated with the failure of the gear component and the accelerometer spikes were the result of the aircraft rolling onto the remaining structure after the wheel assembly had detached.

Description of the Citation X Main Landing gear (MLG)

G-CDCX used a 'trailing link' design (part number 6741013-3) of MLG. The vertical cylinder, incorporating the retraction trunnion, at the top, has the trailing link articulated at the bottom (Figure 2). At the rear of the link, the axle for the double wheels is pressed and bolted into it and a lug roughly in the middle serves as the attachment for the oleo shock absorber strut. The change in angle of the axis of the link at this point is referred throughout this description as 'the knee'.

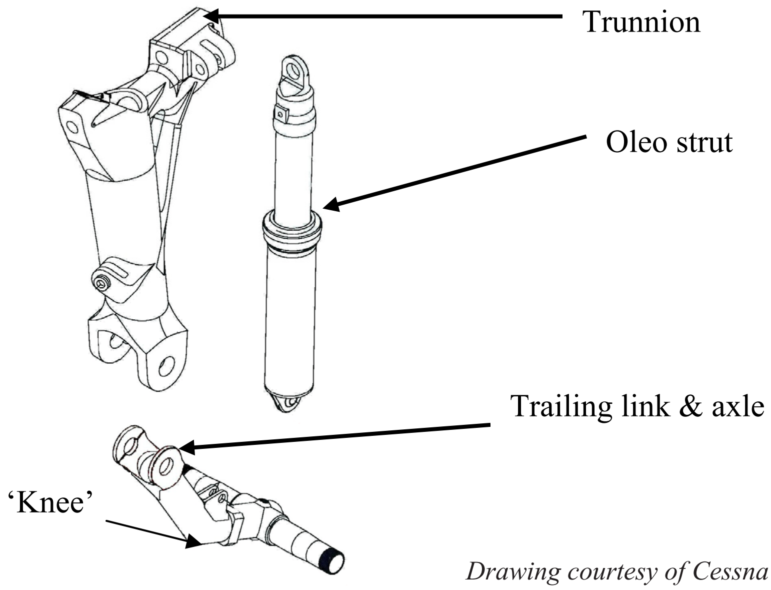

Figure 2
Citation X Main Landing Gear

The wiring harness for the anti-skid transducers runs inside the trailing link and, at the forward end, emerges through a closing end cap and a grommet which is additionally sealed with a flexible sealant to keep moisture out of the interior. The link itself is made from a 300M forging, an ultra-high tensile strength steel which, after machining where necessary, is shot-peened, grit-blasted and cadmium plated. The interior of the link bore is then finished with a corrosion-resistant chromate primer whilst the exterior is primed and finish-painted.

Examination of the aircraft

The aircraft was examined by the AAIB in the late afternoon of the day of the accident. It had come to rest just off the paved surface to the right of the runway, having turned through about 45° to the right. The ground was frozen hard and there had been no sinking of the wheels into the grass. The aircraft was resting on its right wingtip and flaps and the remains of the MLG vertical cylinder, which had been partially ground away by runway contact, obliterating the trunnion forks which locate the forward end of the trailing link. There was also a small puncture of the right elevator.

Examination of the runway marks could not identify the first touchdown point but, close to the touchdown area, twin gouges caused by the trunnion forks could be seen, becoming a broader, single scrape mark as the forks wore down. Towards the end of the ground slide, further marks were made by the outboard flap and wingtip. It was noted that the commencement of the gouge marks from the right MLG was about one metre to the left of the runway centreline, indicating that the aircraft had been displaced to the left on touchdown. However, this was not considered to have had any bearing on the failure.

Debris was found along the length of the ground slide marks, the largest being the two mainwheels, with most

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of the fractured trailing link, and the shock absorber oleo strut. Most of the remaining debris was small, comprising clips, hydraulic piping etc. but included the fork fitting of the failed trailing link, together with the trunnion pin, which had been ground down to about half of their diameter.

It was apparent that the trailing link had fractured in a roughly circumferential manner at its forward end although, at the upper surface, the fracture surface turned aft towards a longitudinal crack which ran for some 27 cm (Figure 3) along the top surface. Evidence of a darker area where the longitudinal crack met the circumferential fracture suggested that the crack pre-existed the final fracture and that it was responsible for an overload failure of the component. This was later confirmed by metallurgical examination.

Detailed examination

The failed link was transported to a metallurgical laboratory for expert examination in the presence of a specialist from Cessna Aircraft Company. One of the first actions was to section the link longitudinally, so that the interior of it could be examined (Figure 4). The crack on the upper face could clearly be seen, as could an extensive area of corrosion and loose paint in the vicinity of the knee, again on the upper surface. The lower half of the link appeared crack and corrosion-free with no loss of paint. However, there was an apparent black stain, suggesting long-term pooling of some liquid – this would later be examined to discover its nature.

A few centimetres of uncracked material held the two halves of the upper segment together, so this had to be sawn and then broken apart in order to examine the crack faces. As can be seen in Figure 5, the faces were heavily corroded and it was not possible to identify

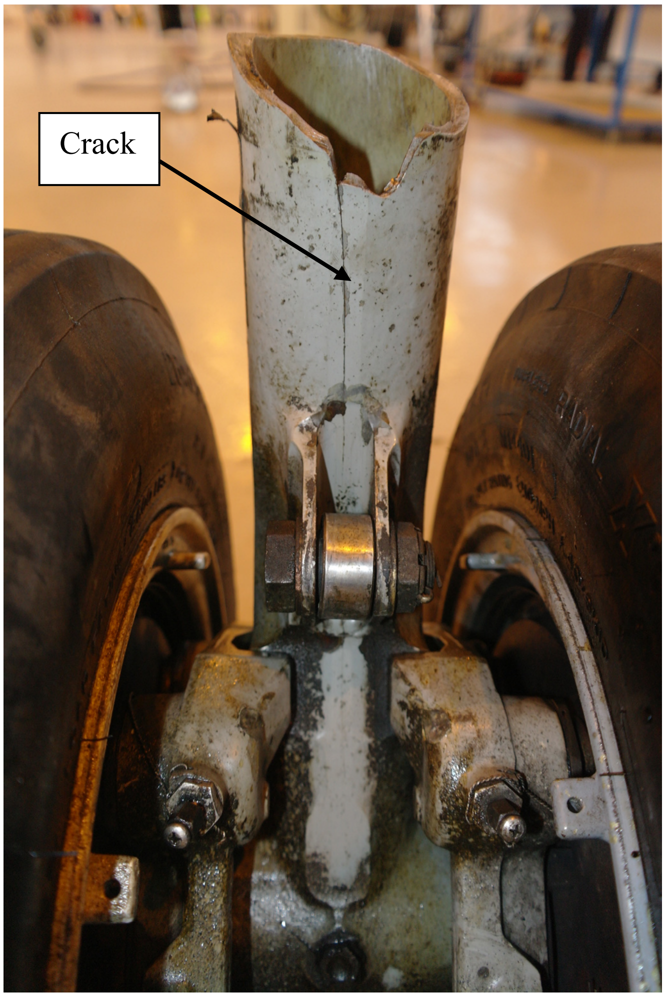

Figure 3

Broken trailing link showing circumferential facture and longitudinal crack on upper face

precisely the origin of the crack but, judging by the varying degrees of severity of the corrosion attack, it was judged to have been just forward of the knee on the inner surface, propagating forward and aft from this point simultaneously until the total crack length reached approximately 275 mm, at which point instantaneous rupture of the forward part of the link occurred in a circumferential direction. Sections placed in a Scanning Electron Microscope (SEM), showed that the crack had propagated through Stress Corrosion Cracking (SCC).

The area of paint loss and surface corrosion was also closely examined. This was found to be severe, with

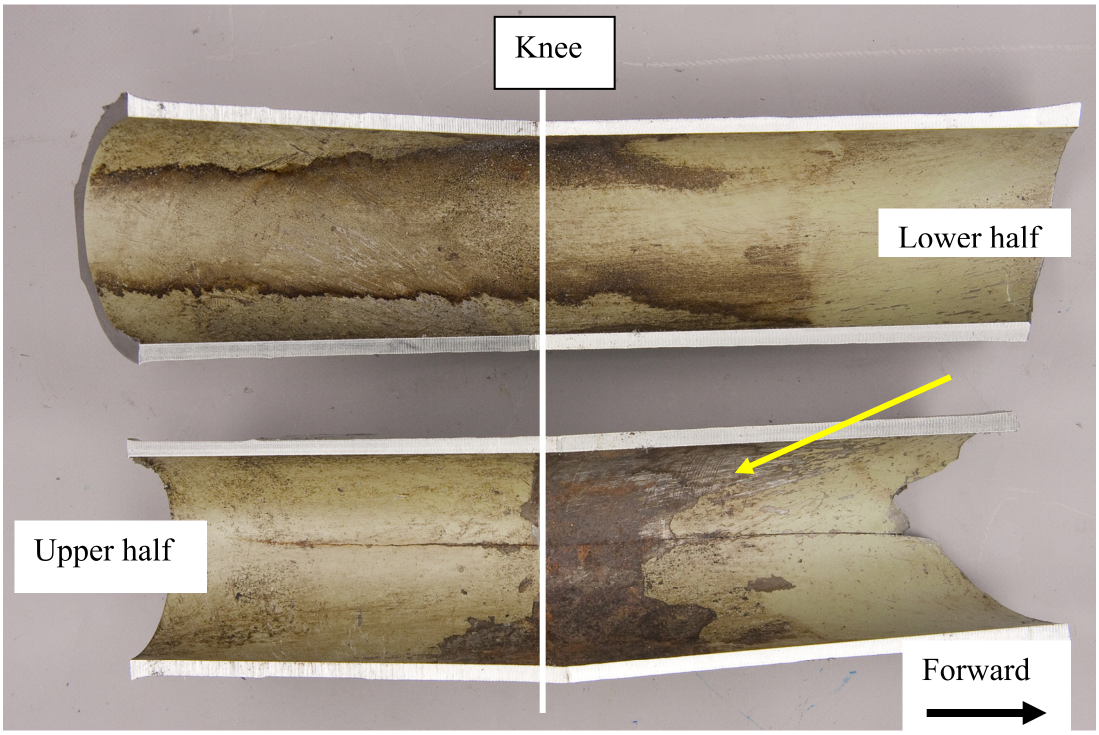

Photo courtesy of QinetiQ

Figure 4

Longitudinal section through failed link showing extent of crack and corrosion on upper half and staining on lower half. Note scratches (arrowed)

Photo courtesy of QinetiQ

Figure 5

Picture of SCC showing probable area of origin complete loss of the cadmium plating and deep pitting of the base metal. Also noted was a series of roughly longitudinal scratches in the paint (Figure 6), which appeared relatively fresh and were thought to have been caused post-failure of the link, possibly by scooping-up runway debris. However, microscopic examination showed that similar marks appeared in the heavily corroded region in a similar orientation, manifesting themselves as linear regions of deeper corrosion. Furthermore, the 'fresh' scratching appeared to run under a region of black staining, similar to that which was noted on the lower half of the link.

Photo courtesy of QinetiQ

Figure 6

Close-up of longitudinal scratches

Chemical samples were taken to try and establish the nature of the black staining. The first observation was that the stain was very persistent – it remained despite the fact that both upper and lower sections of the link had been washed for more than an hour in a hot detergent ultrasonic bath as part of the initial forensic examination. It comprised small particles which were analysed to contain carbon (a possible residue from oil or grease) together with compounds such as aluminium silicate and calcium carbonate and elements found in the primer paint. Other elements which would be expected if the stain contained oil or grease residue were not, however, detected.

Away from the corroded area, further sections were taken to measure the thickness of plating and paint on the interior and exterior surfaces of the link; both recorded average values of 38% (exterior) and only 21% (interior) of the minimum drawing requirements for plating thickness. The primer was measured to be an average of 40 microns thickness.

The base 300M steel was found to be within drawing specifications with respect to dimensions, composition and mechanical properties.

Examination of the left MLG trailing link

The left MLG trailing link was examined using a borescope and was found to have a patch of corrosion in the same area as the right link, but apparently not as severe or extensive, and with no obvious signs of cracking (Figure 7). It was despatched to Cessna for detailed examination, where it was prepared for examination in a similar manner to the right link.

When the corroded area was examined using an SEM, it could be seen that some micro cracks (identified as SCC) were growing from some of the deeper corrosion pits. There was also some external surface corrosion on the outside diameter of the link, between the oleo attachment lugs, but no cracking was present.

It was also seen from visual examination that the internal

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diameter of the link had been recoated with primer over a wide area around the area of corrosion, appearing to be a darker shade compared with the original paint. This was clearly a second coat applied after a corrosion repair which was performed in October 2004, after an inspection to comply with an Alert Service Letter (ASL) 750-32-19, but much of the chromate had leached out and adhesion was extremely patchy, despite it being of the correct type of primer. Little is known about this repair beyond the fact that it was found to be necessary and had been dressed-out with the correct grade of abrasive pad and primer re-applied.

Photo courtesy of Cessna

Figure 7

Interior of left link at the knee, showing corrosion and flaking of re-applied primer

The thickness of the plating was measured away from the damaged area and, like the failed right link, was found to be well below the minimum drawing requirements on the internal diameter. On the external surface, it was found to be satisfactory.

As with the right link, the 300M material was found to be within specification.

Maintenance and inspection requirements

In August 2004, Cessna issued an Alert Service Letter (ASL) 750-32-19 to all Citation 750 operators, the contents of which were classified as 'mandatory'. It required that, for aircraft with more than 3,000 total landings or aircraft bearing Manufacturer's Serial Numbers (MSN) 0044 through 0079, an inspection be performed on the MLG trailing links within 50 landings, and on all aircraft with less than 3,000 landings, within 100 landings. G-CDCX was MSN 0194 and at the time of the accident had completed 1,931 landings.

The inspection comprised a flexible borescope examination of the interior of the link, via the hole through which the anti-skid wiring passes at the front of the link, and was specifically looking for small 'craters' on the inner wall. Although the ASL did not state the origin of such craters, it was known to be a possible defect during plating of the interior in which the electrode wire may have come into contact with the link material, causing an arc and damage to the surface.

Although ASL 750-32-19 was intended to be a 'once-off' inspection, in November 2005 a further ASL, 750-32-22, was issued and which again was considered mandatory. The ASL called for a two-part inspection of the trailing link '*for pits, corrosion and cracks*'. Part one of the inspection was an external visual examination of the link using a high-intensity torch; having cleaned the area with a degreasing solvent, particular attention was to be paid to the area close to or between the oleo attachment lugs, since cracks were known to originate in that area. This

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inspection was to be accomplished within 5 landings of receipt of the ASL. Part two of the procedure was essentially a repeat of the borescope inspection required by ASL 750-32-19 and was required to be performed by two independent inspectors before 50 landings had been accomplished. This time, however, cracks and corrosion were mentioned as well as the arcing marks. Also, this ASL gave details of a 'repair scheme' should corrosion (presumably superficial) be found, essentially allowing the removal of the primer paint and any corrosion using a fine grade of 'Scotch-Brite' abrasive pad. If this was necessary, then the primer finish was to be restored by hand touch-in.

ASL 750-32-22 also advised operators that the 'craters', were caused by possible contact and arcing between the anode used in plating the interior and the link and could lead to:

> *'fatigue cracks along the length of the training link if they go undetected.'*

Shortly after this, in January 2006, the trailing link internal inspection was incorporated into the Model 750 Aircraft Maintenance Manual (AMM) as part of task 32-90-10-210 'Main Landing Gear Detailed Inspection' with a repeat interval of 36 months. In this case, no cleaning or repair was allowed and any findings, positive or negative, were to be reported to Cessna.

In addition a requirement existed in the AMM as part of task 32-10-00-210, to:

> *'Visually inspect the main gear assembly and trunnion for security of attachment, cleanliness, corrosion, missing or damaged components, cracks, gouges, nicks, fluid leaks and evidence of damage.'*

The periodicity of this inspection was 24 months.

According to its technical records, G-CDCX had accomplished ASL 750-32-19 in October 2004 and ASL 750-32-22 in November 2005. Two AMM internal trailing link inspections were carried out in August 2006 and February 2009.

Previous cases of cracks/corrosion in Model 750 trailing links

Information from Cessna is that they are aware of 33 cases of trailing link internal corrosion being discovered over the past three years. In total, they knew of three cases of cracked links including G-CDCX, two being SCC and the other being due to fatigue caused by the plating craters which led to the issue of ASL 750-32-19. It was noted that two (one fatigue and one SCC) had led to failure of the link whilst the third crack was found on a walk-round inspection and was only slightly shorter than the one which existed on G-CDCX's right trailing link.

Discussion

Had the left MLG link remained in service, it could have developed a major stress corrosion crack which may have also run to failure.

However, this link had had some removal of the primer to address corrosion in October 2004 – this might explain why it corroded again, due the possibility that the already sub-thickness plating was removed by the abrasive pad with no means of replacing it and given the difficulty inherent in trying to touch-in the primer by hand in the region of the knee. This 'repair' option does not form part of the current AMM procedure.

There is no record of such a repair for the failed right MLG link but the corrosion was much more advanced and a lengthy stress corrosion crack had developed. With this component, it could have been that the

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scratching damage found during this investigation was responsible for the initial development of corrosion. Two possibilities were considered, the first being that insertion of the borescope probe to inspect as prescribed by the ASLs and the AMM had damaged the paint and plating. This appeared unlikely given that the borescope recommended by Cessna had a relatively soft-coated probe head; the actual equipment used in the inspections is unknown. The second possibility arises from anecdotal evidence that if, for any reason, it becomes necessary to remove and replace the anti-skid wiring harness, it can be a difficult operation and some mechanics may resort to using metal wire to guide the coiled loom through the small apertures. Whatever the damage mechanism, the importance of taking precautions not to scratch the surface of the link interior must be stressed.

It appears that corrosion is the biggest threat to integrity of the link. Initially, small craters created during the plating process were thought to be responsible but corrosion pits can also initiate fatigue and now SCC. How the necessary tensile stresses for either fatigue or SCC are generated on the top surface of the link is unclear, for it would seem to experience largely compressive loading with the aircraft on its wheels. Equally the cases of corrosion discovered all appeared to be on the top surface, since it might be expected that the bottom surface would be more prone to pooling liquids and hence longer exposure to a corrosive environment. This again points to damage to the protective finish during maintenance as a possible instigator, perhaps due to difficulty in negotiating the bend at the knee.

The question of how long the corrosion and crack existed before failure of the link was considered. It has to be assumed that it was not visible in February 2009 when both links were inspected and judged to be defect-free. The degree of corrosive attack near the origin of the crack suggests that it was present for some considerable period of time and should have been visible on the outside of the link. Whilst decreasing the 36-month internal inspection interval may be seen as one mitigating measure (which needs to be balanced against the risk of introducing damage), adopting an external visual check of the top surface in the region of the oleo attachment lugs (ie similar to the inspection described in ASL 750-32-22 Part 1) at much more frequent intervals would offer a means of detecting a crack before failure. Therefore:

Safety Recommendation 2011-072

It is recommended that the Cessna Aircraft Company amends the Maintenance Schedule for the Model 750 Citation X aircraft to include a suitably frequent external visual inspection of the MLG trailing link upper surface for cracks.

Although the above Safety Recommendation does not specify the time interval, the fact that the failure on G-CDCX occurred due to SCC, which is not necessarily cycle-related, should be recognised.

Flight data recorder documentation

Whilst the accident flight was a private flight, the aircraft is normally operated under an Air Operators Certificate under EU-OPS requirements. EU-OPS 1.160 (a) (4) (ii), requires the operator to keep a document that defines how the FDR contents is converted into engineering units. The operator did not hold such a document.

The FDR installation was part of the Type Certification (TC) of the aircraft. Enquiries with the aircraft manufacturer ultimately yielded two documents, neither controlled, that between them enabled adequate

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analysis of the FDR data to be performed for this event. No controlled document was available from any source to enable the accurate decode of the FDR, despite the aircraft, with FDR installation, having an EASA TC. The ability to decode the FDR is an important part of continued airworthiness and therefore FDR decode documentation should be included in the set of complete instructions for continued airworthiness provided to the owner/operator, by the holder of the type certificate, as required under EASA Part 21 requirement 21A.61. The EASA TC is based on the Federal Aviation Administration (FAA) Type Certificate. The FAA does not require FDR decode documentation as part of the TC process. Both the UK Civil Aviation Authority (CAA) and the FAA have published guidance material on what information these documents should contain, under CAP 731 and AC20-141B respectively. No equivalent guidance is currently available from the EASA. This highlights areas of certification that require clarification and areas that require improved compliance checking.

Other recent and ongoing AAIB investigations involving other aircraft types and at least one other aircraft manufacturer has had similar findings. The report on the accident to a Cessna Citation Sovereign, G-CJCC, on 30 September 2010 has made the following safety Recommendations to the CAA, EASA and the FAA to resolve the issues that also affected this investigation:

Safety Recommendation 2011-024

It is recommended that the Civil Aviation Authority ensure that UK operators of aircraft equipped with flight data recorders hold and maintain controlled documentation that satisfies the intent of CAP 731 and complies with the requirements of EU-OPS 1.160 (a) (4) (ii).

Safety Recommendation 2011-025

It is recommended that the Civil Aviation Authority include in their processes associated with the issuing of Air Operator Certificates a check to ensure that the operator's procedures comply with requirements of EU OPS 1.160 (a) (4) (ii).

Safety Recommendation 2011-026

It is recommended that the European Aviation Safety Agency ensures that design organisations under their jurisdiction responsible for approvals affecting Flight Data Recorder (FDR) installations, hold the documentation required for decoding the FDR data, and that the documentation is to a suitable standard and available to operators.

Safety Recommendation 2011-027

It is recommended that the European Aviation Safety Agency review their certification requirements, guidance and procedures to ensure that controlled documentation, sufficient to satisfy operator flight data recorder documentation requirements, are explicitly part of the type certification and supplemental type certification processes where flight data recorder installations are involved.

Safety Recommendation 2011-028

It is recommended that the Federal Aviation Administration ensure that controlled documentation, sufficient to satisfy operator flight data recorder documentation requirements, is part of the type certification and supplemental type certification processes where flight data recorder installations are involved.

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Safety Recommendation 2011-029

It is recommended that the European Aviation Safety Agency provides guidance detailing the standards for the flight data recorder documentation required for the certification of systems or system changes associated with flight data recorders.

Safety Recommendation 2011-030

It is recommended that Cessna Aircraft Company issue controlled documents, applicable to Cessna aircraft equipped with flight data recorders, that satisfy the EU-OPS 1.160 (a) (4) (ii) requirement, and make them available to all operators of the applicable aircraft. Furthermore, it is recommended that the documentation issued should follow the guidance given in Federal Aviation Administration document AC 20-141B and UK Civil Aviation Authority document CAP 731.

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SERIOUS INCIDENT

Aircraft Type and Registration:	Socata TBM 850, N850TV
No & Type of Engines:	1 P&W Canada PT6A-66 SER turboprop engine
Year of Manufacture:	2009
Date & Time (UTC):	12 January 2011 at 1535 hrs
Location:	Birmingham Airport
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 3
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	FAA Private Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	1,100 hours (of which 180 were on type) Last 90 days - 30 hours Last 28 days - 12 hours
Information Source:	AAIB Field Investigation

Synopsis

Following a loss of communications on approach due to a frequency mis-selection by the pilot, the TBM 850 passed over the top of an aircraft holding on the Birmingham Airport Runway 15 starter extension and landed. No injuries or damage occurred. Four Safety Recommendations are made**.**

History of the flight

The history of the flight has been derived from interviews with the personnel involved, data recorded on the TBM 850, surface movement radar and air traffic recordings. Figure 1 shows the TBM flightpath and radio communications for the last nine minutes of the flight. Figure 2 shows relevant recorded data for the last four minutes.

The aircraft was on a private flight from Voghera, Italy to Birmingham Airport. It was being flown by the chairman of a business with the intention of attending a meeting in Birmingham; he departed Voghera at 0843 hrs. En-route he stopped at Angers, France and Antwerp, Belgium to collect members of his staff who were also to attend the meeting. There were NOTAMs in force at Birmingham Airport in respect of the replacement of the Runway 15 ILS and availability of navigation aids; these were not noted by the pilot prior to commencing the flight to Birmingham. The flight was routine until the arrival at Birmingham.

During the cruise the pilot had received the Birmingham ATIS which reported that the ILS for the runway in

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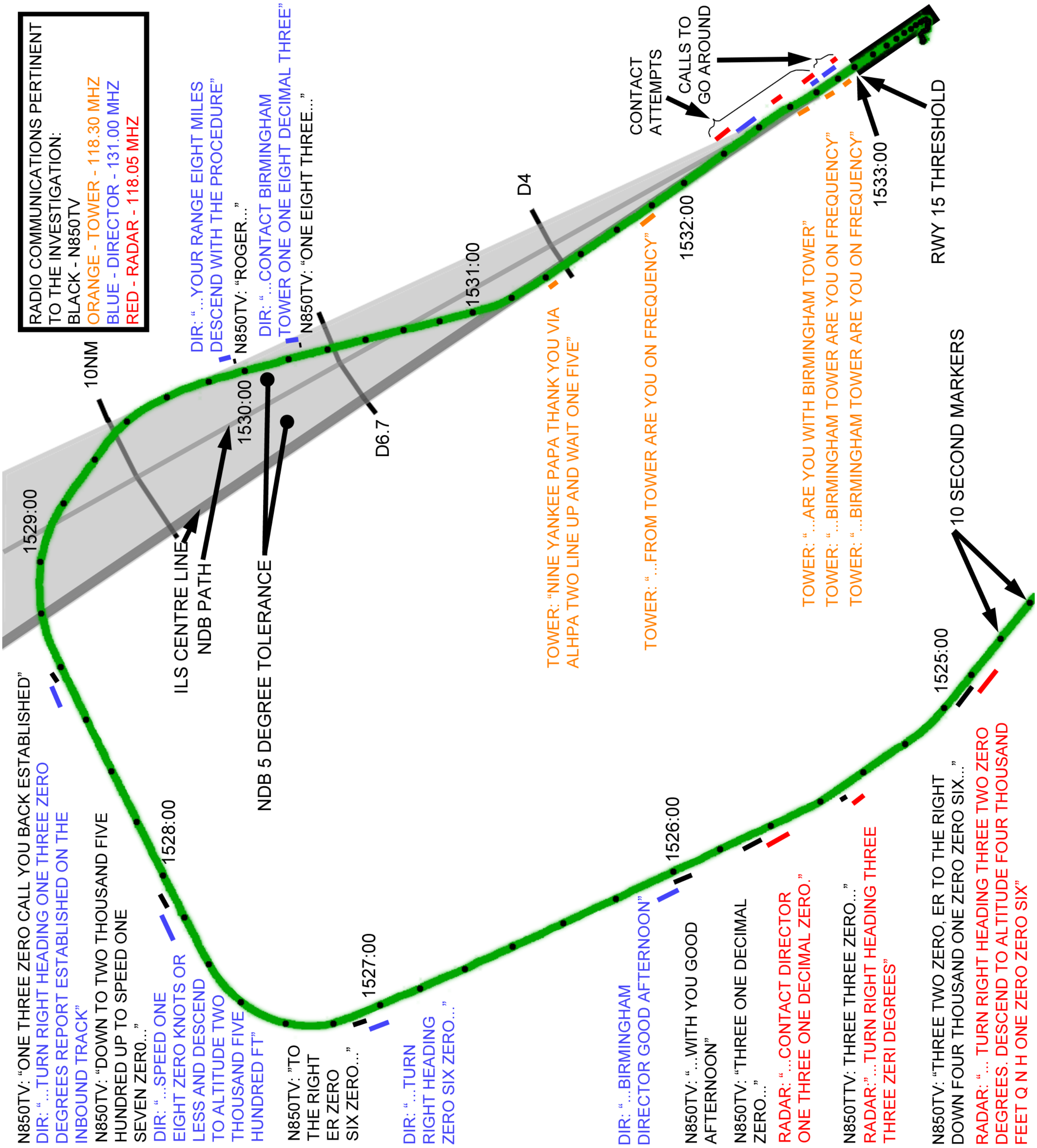

Figure 1

Aircraft track and radio communications, with pertinent procedural track information

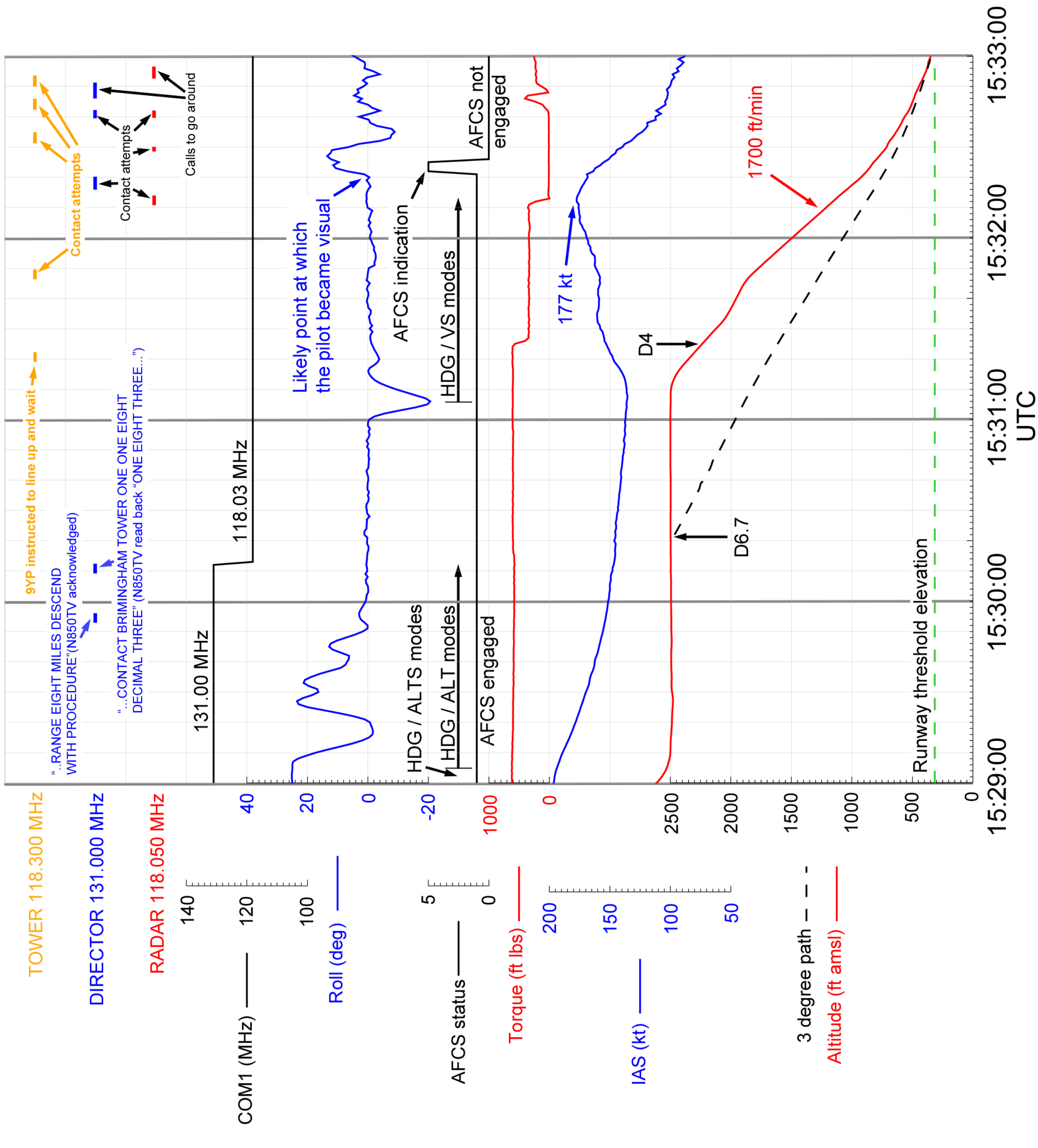

Figure 2

Pertinent recorded data for the four minutes prior to crossing the runway threshold use was "TRANSMITTING FOR TEST PURPOSES ONLY". When he contacted Birmingham Approach at 1514 hrs, the pilot was advised to expect a "NDB/DME RUNWAY 15" approach. He tuned the ADF for the approach and reviewed the approach plate on the aircraft's built-in Electronic Flight Bag (EFB). This EFB was displayed on the aircraft's central Multi-Function Display (MFD). MFD selections are not recorded and it is unclear if the pilot used other functions between this initial review and finally selecting the relevant plate to be displayed when conducting the approach. The aircraft was being operated with the autopilot engaged with the pilot manually selecting heading and vertical speed.

The pilot was given radar vectors to downwind right at 4,000 ft and handed over from Approach Radar on 118.050 MHz to Director on 131.000 MHz. The Tower controller had requested that, in order to allow a DHC-8-402 (Q400), which was just leaving the terminal, to depart, Director achieve 6 nm spacing between arrivals. Director therefore vectored the TBM behind a B737-700 (737) with a gap of about 6 nm[1]. At 1527:50 hrs Director instructed N850TV to slow to less than 180 kt and descend to 2,500 ft.

Director vectored the TBM towards the Final Approach Track (FAT) for the NDB with the instruction "NOVEMBER ZERO TANGO VICTOR TURN RIGHT HEADING ONE THREE ZERO DEGREES REPORT ESTABLISHED ON THE INBOUND TRACK." The pilot acknowledged, replying with "ONE THREE ZERO CALL YOU BACK ESTABLISHED TANGO VICTOR." The FAT for the NDB approach is 154° which is offset 5° from that of the track for an ILS approach (149°) and the runway extended centreline.

The pilot later reported disconnecting the autopilot at or near this point. However, the recorded data indicates that the aircraft continued with the autopilot engaged until the aircraft became visual.

The turn took the TBM through the final approach track of 154°. The pilot adjusted the heading on to an intercept heading (closing the track from the east), still at the platform altitude of 2,500 ft. The pilot did not report established on the FAT and at the time the TBM completed the turn Director was talking with another aircraft.

At 8 nm Director passed a range check and cleared the TBM to "DESCEND WITH THE PROCEDURE." This was acknowledged by the TBM pilot.

As the TBM reached 7 nm the Director instructed the pilot to contact "BIRMINGHAM TOWER ONE ONE EIGHT DECIMAL THREE" which the pilot acknowledged saying "ONE EIGHT THREE TANGO VICTOR, THANK YOU."

This occurred about 10 seconds before the aircraft reached the FAT and about five seconds before the final descent point. However, the aircraft did not turn to track the FAT inbound, nor did it commence descent at the final descent point of 6.7 nm DME from the Runway 15 threshold.

The pilot believed he had pre-selected 118.300 MHz on the #1 radio standby position and pressed the frequency transfer button to move it to the active position. The recorded data shows that, at this point, 118.030 MHz became the active frequency. He then attempted to call the tower but received no reply. He decided to wait before calling again in case the tower controller was on the telephone. About 30 seconds later the pilot attempted to call the tower but again received no reply. The press to transmit (PTT) switch activations were not recorded

Footnote

[1] Spacing was to be achieved at 4 nm from the runway, the last point at which speed control normally applies.

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and it is unclear exactly where on the approach these calls were made. Due to the lack of response from the tower, the pilot decided that his radio had failed and did not attempt to analyse this further. The pilot later stated that he had considered selecting 7600 on the transponder but, due to the position of the selectors being behind the control yoke, had felt unable to do so.

As the 737 was landing the tower controller checked the air traffic monitor[2] and, with the TBM about 5 nm from the airfield, cleared the Q400 to "VIA ALPHA TWO, LINE UP AND WAIT" on Runway 15. The controller then waited for the 737 to vacate the runway at Charlie, a 75° exit, in order to clear the Q400 for takeoff.

The TBM continued in level flight until intercepting the track of the extended runway centreline (149°) at about 4.7 nm from the threshold. Based on a nominal 3° glidepath the TBM was about 700 ft high at this point. The pilot selected a vertical descent speed of about 1,400 fpm while continuing to track approximately along the runway centreline. Shortly after starting the final descent the engine torque reduced from approximately 610 ft lbs to approximately 340 ft lbs.

At 1531:46 hrs, with the TBM approximately 3 nm from the threshold and the Q400 approaching A1, the controller called the TBM to establish communications and transmitted "NOVEMBER EIGHT FIVE ZERO TANGO VICTOR FROM TOWER ARE YOU ON FREQUENCY?" There was no reply to this call. The controller contacted Director by intercom to alert him to the developing situation. Tower called N850TV again with the same question at 1532:31 hrs, with the TBM now 0.8 nm from the runway, and twice more before the TBM landed, but in each case there was no reply. At no time did the tower controller transmit a go-around instruction. Both Approach and Director attempted to contact the TBM on their respective frequencies and transmitted go-around instructions.

The 737 had vacated the runway at 1532:10 hrs. The tower controller did not clear the Q400 to depart in front of N850TV and focused attention on trying to establish two-way contact with the TBM. The controller assessed that there was no option that would allow the Q400 to depart or safely clear the runway and that holding it in its current location on the Runway 15 starter extension posed the least risk.

Data recorded on the TBM suggests that the pilot became visual with the runway at about 600 ft aal (900 ft amsl) and at a range of about 1.3 nm from the threshold. When interviewed, he was unsure of the point at which he became visual but the position indicated by the data appears to be reasonable. He configured the aircraft for landing with the gear and first stage of flap, waited for the speed to reduce below the full flap limit speed of 122 kt and then selected landing flap. He visually checked that the runway was clear while correcting the aircraft's flightpath and then landed. The tower controller assessed that the TBM touched down abeam the Bravo intersection, about 270 m from the displaced threshold and 170 m short of the main touchdown markers. A 'follow me' vehicle was assigned to escort the TBM to its parking position. On vacating the runway the TBM pilot contacted Ground on the #1 radio without difficulty.

Aircraft and Garmin G1000 description

The TBM 850 is a single engine turboprop powered by an 850 hp engine. It is certified for single pilot operations and has a total of six seats. It is equipped with Garmin G1000 avionics comprising two 10.4 inch Primary Flying Displays (PFDs) and one central 15 inch

Footnote

2 A simple radar display mounted in the tower.

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Multi-function Display MFD. The G1000 is controlled by a combination of soft keys and dedicated controls. N850TV was equipped with an ADF, which is an optional fit.

The communication (COM) radios are integrated into the G1000 system. Information relating to the active and standby frequency of the #1 radio is displayed on the top right of the PFD with the active frequency being to the left of the standby frequency. The #2 radio is displayed immediately below the #1. The frequency in use is highlighted in green. Should the radio tuning system fail then the system will automatically tune 121.5 MHz. Depending on the failure mode a red 'X' may appear on the frequency display.

It is possible to load frequencies from the FMS database directly into the COM standby position using the 'nearest airport' function. This database held the correct tower frequency for Birmingham.

In March 2010, during an approach to Malaga, N850TV had a failure of the #1 COM radio. This failure was accompanied by an audible warning and the presentation of the red 'X' on the COM 1 display on the G1000. The pilot commented that on that occasion he was operating with another qualified pilot and it had been relatively straightforward to deal with the problem. The COM 1 radio was subsequently replaced.

The transponder Mode A code is altered by selecting the XPDR soft key on the PFD, then selecting CODE and entering the required code. The XPDR soft key is the eighth key from the left of the PFD and is therefore located behind the control yoke (shown in Figure 3 below).

The G1000 system is capable of flying autopilot coupled approaches. The MFD of the G1000 on the TBM850 can display electronic versions of paper approach charts. N850TV was using a database from a major international chart supplier. The G1000 overlays the aircraft position

Figure 3

Position of transponder controls

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onto the electronic chart as an aid to situational awareness but this is not approved for primary navigation use. The charts are selected by pressing the SHW CHRT soft key then pressing the FMS knob to activate the cursor and entering the airfield identification. The FMS knob is then used to select an approach and a dropdown box with the chart options appears. Turning either FMS knob will scroll through the available charts and enter selects the chart. The electronic menu uses the same identifiers as the paper charts; the ILS for Runway 15 at Birmingham is therefore listed as the NDB ILS DME Rwy 15 (plate number 11-1), while the NDB approach is NDB DME Rwy 15 (plate number 16-1). The chart display can zoom into the chart at a user-set level. The default user-set level set for N850TV displays the top two-thirds of the chart but cuts off the vertical profile at the bottom (see Figure 4 below).

The pilot stated that, during the incident, he had placed a paper copy of the NDB chart in a chart holder which he used to follow the vertical profile of the approach. He also stated that he had selected, on the G1000, a NAV page which he used to monitor his lateral profile.

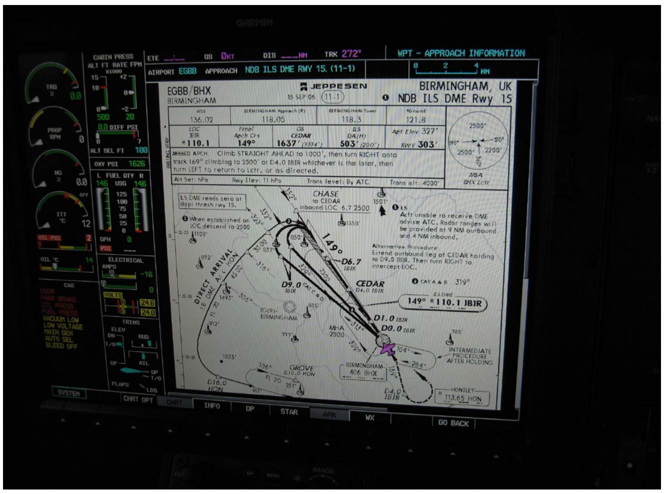
On the day following the incident the pilot was asked to demonstrate selecting the NDB approach chart for Runway 15 on the system. However, the chart he selected for display was the ILS chart for Runway 15.

Recorded data

N850TV was not required to be equipped with flight recorders. However, the installed Garmin G1000 avionics system records flight parameters once a second to a file on a Secure Digital (SD) memory card if one is inserted in the top SD card slot of the central display. An SD card was found in the appropriate slot and it retained the recordings of three flights flown on the day of the incident. The otherwise comprehensive list of recorded parameters did not include flap or gear selections, data relating to the EFB or radio Push-To-Talk parameters.

Recorded radar returns from the aircraft, including some Mode S parameters, were provided as well as the ATC recordings active at the time of the event.

Birmingham ATC uses surface movement radar which is overlaid onto a display of the airport map along with



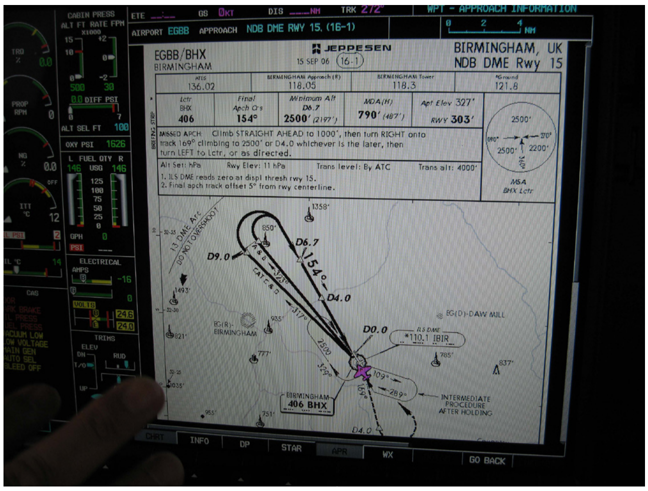


Figure 4

Presentation of ILS and NDB plate images on G1000

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UTC and aircraft identifiers. The displayed image was recorded and subsequently analysed. The pertinent information from the recordings is given in Table 1.

Two minutes and eleven seconds elapsed between the first returns of the 737 and N850TV appearing on the surface movement radar display. The G1000 recordings show that N850TV was 5.7 nm away from threshold when the 737 landed.

TBM pilot

The TBM pilot had originally held an Italian PPL (A) and had an FAA private pilot certificate issued on the basis of that licence. However, his Italian licence lapsed and he gained a stand alone FAA Private Pilot's certificate in the USA in December 2006. He completed his Instrument Rating (IR) at the same time and last renewed it in June 2010 in Italy. He was required to fly an NDB approach during his initial flight test but was not required to fly one during his renewal test. The TBM pilot could not recall flying an NDB approach between his initial IR test and the incident.

No type rating is required to fly a TBM 850 on a FAA licence, nor is a specific endorsement for glass cockpit aircraft required. However, a pilot is expected to be proficient in the use of the equipment installed in the aircraft. In February/March 2010 the pilot completed

Surface movement radar displayed time (UTC)	Comment
1530:45	First sign of 737 surface movement radar return on landing.
1531:55	Q400 radar return started crossing the A1 hold point.
1531:57	Box[3] popped up showing N850TV against a 60 second marker.
1532:05	N850TV ident moved to 45 second marker.
1532:10	737 radar return cleared C1.
1532:21	N850TV ident moved to the 30 second marker and highlighted in amber[4]. Q400 also highlighted in amber and on the runway.
1532:37	N850TV ident moved to the 15 second marker and highlighted in red. Q400 also highlighted in red.
1532:55	N850TV ident and Q400 marker returned to normal colours.
1532:56	First sign of N850TV surface movement radar return, just behind Q400, ie while still airborne.

Table 1

Pertinent information from the Birmingham surface movement radar recording

Footnotes

[3] The box has four times, 60, 45, 30 and 15 seconds. An approaching aircraft is shown against the 60 second marker 60 seconds before the estimated touch down time, and moves to the 45 second marker 45 seconds before the estimated touch down time and so on for 30 seconds and 15 seconds.

[4] Changes in colour indicate a change in the level of hazard predicted by the system.

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a two-week ground and flying training course at the aircraft manufacturer. The manufacturer reported that:

'The aim (of the course) *is neither to give nor to give again Instrument Rating (IR) training. The manufacturer requests from the pilot as prerequisites, a valid Instrument Rating certificate (IR), but it is not mandatory from FAA or JAA rules point of view.*

During the training this pilot flew 8.10 hours in 6 flights of which 2.20 hours (were) *under IFR flight. He totalizes 20 landings, 4 go-around, 6 instrument approaches of which 2* (were) *NDB approaches.*

During training, to perform an instrument approach the instructor asks to use the autopilot (to teach the pilot to use it), but may also ask the pilot to perform instrument approaches without the autopilot to train for a possible system failure.

There are no specific instructions for (an) *NDB approach. The pilot can use or not use the autopilot.*

If the autopilot is chosen for (an) *NDB approach, we advise (but the PIC remains the only one to decide and there are no written operational instructions):*

- *for a DESCENT (approach or normal descent): to engage "heading -HDG" mode and, either "vertical speed - VS" mode or "pitch" mode*
- *During CLIMB: to use "flight level change - FLC" mode to avoid all risks of stall*

While using the autopilot, the instructor emphasizes limitations given in POH section 2 - page 2.6.2 and particularly on:

- *the autopilot and yaw damper must be OFF during takeoff and landing*
- *do not engage autopilot below 1000ft above ground level during cruise or climb*
- *do not use autopilot below 200ft during approach*
- *do not use autopilot with airspeeds below 85 KIAS'*

Tower controller

Three staff were on duty in the visual control room at the time of the incident. Two air traffic controllers (ATCO) in the Tower and Ground roles and an assistant. The ATCO in the Tower position had qualified as a controller in 2003, held current tower and radar validations, had been on shift since 1000 hrs and in position for 25 minutes before the incident.

Meteorological conditions

The METAR for Birmingham at the time of the incident reported a wind from 210° at 9 kt, visibility of greater than 10 km, light rain with cloud scattered at six hundred feet and broken at nine hundred feet temperature +11°C dewpoint +10°C and the QNH 1006 HPa.

Airfield information

Birmingham Airport is a major international airport located in the West Midlands. Runway 15 was in use which is of black coloured asphalt construction measuring 2,279 m from the displaced threshold. There is a starter extension of 290 m, the first 160 m of which is constructed of beige-coloured concrete. The

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runway is equipped with high intensity approach lights, runway lighting with 15 m spaced centreline lighting, touchdown zone lighting and PAPI set to 3°. Figure 5 below shows the area around the threshold of Runway 15 and identifies the holding points at that end.

The runway is normally equipped with an ILS certified to CAT III. However, because it was being tested after it had been replaced, the ILS was unserviceable; this fact was identified in NOTAMs. The NDB DME approach to Runway 15 was in use. The NDB is located on the airfield and the DME used is the same as for the ILS giving a reading of 0.0nm at the threshold. On the day of the incident the ILS was in the process of being re-commissioned which required calibration flights to be operated intermittently. The Air Navigation Service Provider (ANSP) responsible for the ILS stated that, at the time of the incident, it was believed that the ILS was switched off but no detailed records of power on and off times were available. Due to the calibration work ATC were using CAT II/III holding points for departing traffic. The aircraft being used for the ILS calibration was on the ground at the time of the incident and was not a factor in the event.

ATIS

CAA CAP 493: Manual of Air Traffic Services (MATS) Part 1, Section 3, Chapter 1 states that:

> *'The ATIS message is intended to provide a pilot with a range of information to enable him to make a definite decision about his approach and landing…The message should, whenever practicable, not exceed 30 seconds'*

and additionally in the same section:

> *'The ATIS should contain…Type of approach to be expected'*

In addition to the normal weather information, the ATIS being broadcast had four messages appended; that the ILS was transmitting for test purposes, that delays could be expected due to calibration work, that a ground stop bar had a fault and that there was increased bird activity, specifically wood pigeons. These messages alternated between human and synthetic voice, included the repetitive phrase "PILOTS ARE TO BE ADVISED THAT…". The total duration of the ATIS message was 56 seconds. The ATIS broadcast did not include the type of approach to be expected.

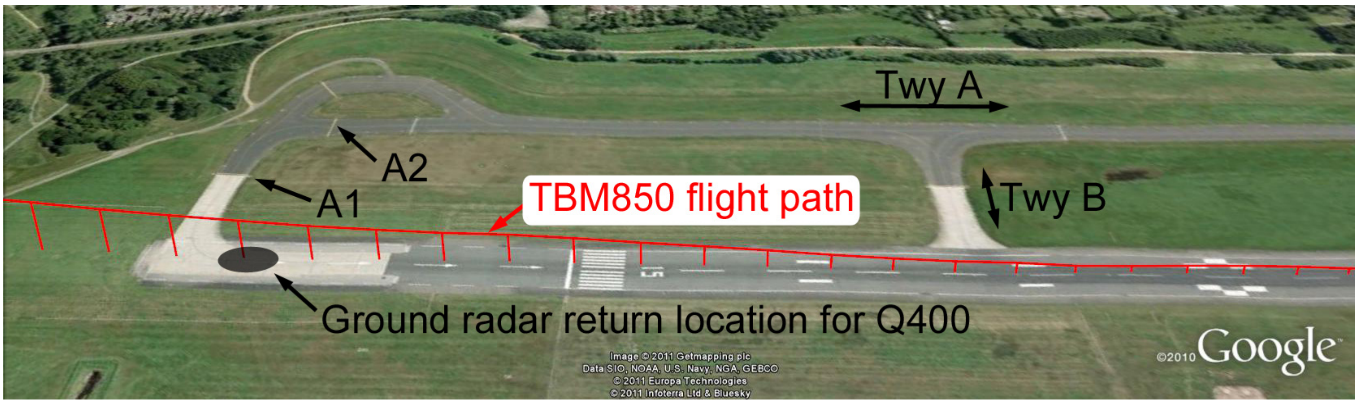

Figure 5

Runway 15 threshold

Approach vectoring

The *CAA MATS Part 1*, Section 3, Chapter 2 states that:

> *'9.3.3 Except when Continuous Descent Approach (CDA) procedures are in operation or in an emergency, aircraft shall be positioned so as to maintain a period of stabilised level flight before commencing descent on the glide path, on descent profile of a pilot interpreted approach…*
>
> *9.6.1 …Non-precision approaches rely on the pilot being in a position to cross the published Final Approach Fix at the specified altitude/height in order to safely complete the approach.*
>
> *9.6.2 Controllers shall vector aircraft onto the final approach track, or onto a heading to close the final approach track at an angle not greater than 40° offset from the final approach track. Whenever practicable, the aircraft is to be established on the final approach track before the Final Approach Fix to enable it to cross the Final Approach Fix at the altitude/height specified in the notified procedure.*
>
> *9.6.4 For procedures that are supported by DME, the controller shall pass a range check and clear the aircraft for the approach when the aircraft is established on the final approach track.'*

Loss of communications

ICAO Doc 4444 Procedures for Air Navigation Services - Air Traffic Management - Section 15.3.3 states that, following a loss of communications a pilot should, if in visual meteorological conditions:

> *'1) continue to fly in visual meteorological conditions; 2) land at the nearest suitable aerodrome…'*

If in instrument meteorological conditions a pilot should:

> *'.....complete a normal instrument approach procedure as specified for the designated navigation aid or fix; and land….'*

The *UK Aeronautical Information Package* (AIP), section ENR 1-1-3-4, paragraph 4.2.4 details the actions to be taken following radio failure. The procedures in ENR 1 state:

> *'4.2.4.1 A flight experiencing communication failure in IMC shall*
>
> *(a) Operate secondary radar transponder on Mode A, Code 7600 with Mode C.*
>
> *…*
>
> *(f) Carry out the notified instrument approach procedure as specified for the designated navigational … When practical, pilots should take account of visual landing aids and keep watch for instructions that may be issued by visual signals from the ground.'*

However, specific airfield instructions, detailed in AIP, section AD 2, may differ from or amplify those procedures. The charting system used by the pilot for Birmingham Airport accurately reflected the entry published in the *UK Aeronautical Information Package (AIP)* for Birmingham (on chart AD 2-EGBB 5-1) and stated, on plate 18-2, the loss of communication procedure as:

> *'Intermediate and Final Approach – Continue visually or by means of an appropriate final approach aid. If not possible follow the Missed Approach Procedure to Birmingham Lctr.'*

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The procedure has been adopted as standard throughout the UK and reflects *ICAO Doc 4444* practice.

The *UK Air Navigation Order - The Rules of the Air Regulations 2007* (ANO) also address the issues of communications and communication failure and states under Rule 45 that:

> *'(6) The commander of an aircraft flying within the aerodrome traffic zone of an aerodrome shall:*
>
> *(a) cause a continuous watch to be maintained on the appropriate radio frequency notified for communications at the aerodrome; or*
>
> *(b) if this is not possible, cause a watch to be kept for such instructions as may be issued by visual means;'*

Signal lamps

The *UK Civil Aviation Publication (CAP) 670* requires[5] that:

> *'A signal lamp with interchangeable coloured lenses (white, red and green) and spare bulb shall be provided and must be accessible to the controller. The lamp must enable control of aerodrome traffic as laid down in the Rules of the Air Regulations 2007 (incorporating The Rules of the Air (amendment) Regulations 2009). The light must be visible from all points of the manoeuvring area and from all points within the aerodrome visual circuit. NOTE: Shining the lamp through tinted glass or blinds can affect the perceived colour of the signal.'*

The ANSP at Birmingham, in common with several other major UK airfields, had applied to the CAA to remove their signalling lamp approximately six to ten years before the incident. This application was supported by a study which showed that signal lamps had limited effectiveness at those airfields. The CAA acknowledged that they had given permission for the signal lamp to be removed but neither they nor the ANSP could locate a copy of the application, permission or the supporting study.

Landing without clearance – previous events

The UK CAA MOR database was interrogated for incidents relating to loss of communications on final approach which had resulted in landing without clearance. Although the database produced numerous examples, a considerable number of non-relevant results were returned as well. Where examples were highlighted, the database coding was not sufficiently robust to allow a quantitative analysis of events occurring over a wide date range to be conducted with any confidence. However, 17 occurrences were positively identified in the 12 months to March 2011. To ensure data validity the search was constrained to multi-pilot, public transport, passenger aircraft.

ANSP safety notice

Following a number of incidents at various airfields of aircraft landing without clearance, or aircraft not going-around when instructed, the ANSP issued *Safety Notice (SN001.10 NATS) Runway Safety – Landing without clearance* (Safety Notice) on 22 December 2010. Although titled *'Safety Notice'* it provided advice for controllers rather than a mandatory operating instruction. The Safety Notice stated that:

Footnote

[5] CAP 670 provides a detailed means of compliance with the ANO and EU Regulations that is acceptable to the CAA.

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> *'Advice from UK based airline crew is that, normally commercial crews not in receipt of a landing clearance will execute a standard missed approach. Occasionally an aircraft will complete an approach and land without clearance….'*

The Safety Notice included advice relating to '*Aircraft failing to execute a missed approach when instructed.*'

It stated:

> *'A significantly more serious situation arises when an ATCO has issued the instruction for an aircraft to execute a missed approach and the aircraft crew fail to carry out/acknowledge the "go-around" instruction or they indicate their intention to land regardless. Controllers should be aware that the instruction to execute a missed approach represents a significant dislocation of the pilots' expectation that they will land, particularly if the instruction is issued when the aircraft is within 4 miles from touchdown.'*

The Safety Notice then observed that:

> *'the options available to mitigate the severity of this situation are extremely limited, but the following actions should be considered:*
>
> - *Continue to transmit the "go-around" instruction to the aircraft*
> - *Transmit essential aerodrome information relating to the hazard / reason for the "go-around"*
> - *Initiate an "aircraft accident imminent" in accordance with local procedures*
> - *Alert other controllers in the vicinity*
> - *Use an Aldis lamp to signal the aircraft*
> - *Alert the supervisor'*

The Tower controller was aware that an aircraft may land if its radio had failed and the runway was clear, but was not aware of this Safety Notice before the incident and thus had not read the advice that it contained.

ATCO briefing process

At Birmingham a group briefing was conducted for each ATC watch on the first afternoon shift of a week. Between these group briefings ATCOs were required to self-brief at the start of each shift, before commencing controlling. In common with all the ANSP's units, an electronic briefing system was provided which should have flagged any instructions, safety notices or similar documents that had been uploaded since the last time the ATCO logged on to the system. The ATCO could then read the document on the screen and/or print it. The ATCO could also electronically acknowledge the document as having been read. The system logs the amount of time a controller views each document and whether it is printed. The system also generates reports for managers to allow them to track that their staff have acknowledged the latest documents. If the electronic system was unavailable the ATCO could self-brief from hard copies of the relevant documents.

The Tower controller had logged onto the briefing system after the Safety Notice had been issued but had not seen or acknowledged it. It was subsequently determined that the Safety Notice had been removed in error and thus was not available for the controller to view or acknowledge at that time.

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After it became apparent that the controller had not read the Safety Notice, the AAIB asked the unit air traffic manager to interrogate the system and provide a list of staff who also had not electronically signed as having read or printed it. The system generated a list that included this controller but also included members of staff who were not licensed controllers and were therefore not expected to have read it. It also listed controllers who for various reasons were no longer at the unit.

UK controller – pilot mutual training

To improve mutual understanding of the controller and pilot roles, several airlines conduct training with the ANSP involved in the incident. This training includes flight crew and controllers attending each others classroom and simulator training courses. For flight crew the ANSP encourages the observation of live operations involving tower, radar and the Swanwick and Prestwick Control Centres. Several airlines offer controllers the opportunity to observe flights from the jumpseat as a way of significantly improving controllers' understanding of flight procedures. In order to satisfy insurance requirements controllers may be issued with a flight ticket, although the ticket itself is normally provided by an operator at no cost. This mutual training has the full support of the CAA and the ANSP.

UK Air Passenger Duty (APD)

In the UK, APD is a duty of Excise which is levied on the carriage of chargeable passengers on chargeable aircraft from a UK airport. The duty is payable by the operator of the aircraft. Certain categories of persons are exempt from APD but it had been considered that Air Traffic Controllers on mutual training flights did not fit in one of these categories and so were not exempt. During the investigation a number of controllers and other safety staff commented that the costs, including APD, act as a discouragement from conducting familiarisation flights.

Analysis

Human Factors: operational context

The TBM pilot had relatively limited total experience and low experience on type. The level of experience in a particular activity changes the likelihood of particular types of error being made. Low experience increases the probability of errors in skill and rule-based behaviour[6]. The pilot stated that he last flew an NDB approach four years before the incident and could not recall flying one in the TBM 850 even though he was reported to have accomplished two during his TBM course.

The TBM pilot was also subject to subtle pressures which may have reduced his probability of making good decisions. He had flown three sectors over seven hours and, with five and a half hours airborne as single pilot, may have been experiencing some fatigue. His passengers were his employees and they were all going to a business meeting. It is likely that the pilot felt a certain amount of pressure to land at Birmingham in order that he and his colleagues could attend the meeting on time.

Plan continuation bias - explanation

The theory of plan continuation bias is described in '*The Field Guide to Understanding Human Error*', (Dekker 2006) as *'sticking with the original plan while the situation has actually changed and calls for a different plan.'*[7] In it he goes on to suggest that amongst the reasons for this are that early cues

Footnotes

[6] Reason- Human Error p57 section 2.4

[7] Dekker – The field guide to understanding human error 2006

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suggesting that the initial plan is correct are usually very strong. However, later cues suggesting the plan should be abandoned are less compelling. Stress and fatigue make it more difficult to project a situation into the future by mentally simulating possible outcomes. The evidence of a need to change the plan may not become compelling until seen in hindsight. Anyone, including pilots and ATCOs, can be affected by plan continuation bias.

Approach vectoring

The timing of Director's call to turn right to intercept the FAT would have enabled the TBM to become established at about 10 nm, albeit with a very short intercept leg, if the TBM had executed a similar rate of turn to that of the previous vectoring instruction. However, a reduced rate of turn resulted in the aircraft passing through the NDB inbound track while still heading south east. The aircraft continued for 1.5 nm before the pilot turned more southerly to intercept. Despite overshooting the FAT there remained sufficient distance and time to re-establish on the NDB final approach track before commencing descent at 6.7 nm. The effect of the late interception on pilot workload was further compounded by the frequency change from Director to Tower occurring at 7 nm.

The TBM passed through the NDB final approach track again at 5.9 nm. This position was already within the final descent point for the approach and thus an unstable approach became more likely. The aircraft eventually became established on the runway extended centreline at just less than 5 nm but still at the platform altitude of 2,500 ft.

Although the vast majority of instrument approaches flown in the UK involve radar vectors to an ILS, the NDB approach remains approved for use in the UK. The NDB lateral element is pilot-interpreted requiring a high cognitive demand to complete and the vertical element relies on a stable starting platform. As a consequence, it is considered likely that pilot-interpreted non-precision approaches require additional time to plan and execute.

Approach

The TBM pilot had maintained the platform altitude of 2,500 ft until intercepting the extended runway centreline at 4.7 miles. Based on the weather and pilot reports, it was unlikely that he would have been visual with the runway at this point and, with the ILS out of service, the pilot needed to use another navigation aid to achieve this track. While the pilot maintains that he was simply flying the NDB to the best of his ability, there is the possibility that he was flying the approach by using the G1000 aircraft position overlay to support his tracking. It is also possible that the pilot had displayed the ILS lateral profile on the MFD instead of that for the NDB.

The TBM's lateral track remained within the limits for the NDB procedure.

Vertical profile

The TBM pilot was operating a private flight and was not obliged to operate to the stable approach criteria or continuous descent final approach used by commercial air transport operators. However, these techniques are referenced here as a benchmark for the approach profile. His approach would be legal so long as he did not go below minima without the appropriate visual references. While with Director, the TBM had been given a speed control of not more the 180 kt. Any speed control would normally cease to apply within four miles of landing.

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The TBM did not cross the NDB final approach track until it was 6.1 nm from the threshold. Although the pilot could have commenced descent when within 5° of the inbound track he would be unlikely to do so until he had turned to track inbound. At 6.1 nm the aircraft was 212 ft above the profile.

The TBM continued in level flight until it was 5° right of the published FAT where it turned to track inbound on 149°. At this point it was 700 ft above the nominal approach path. The pilot flew a rate of descent of about 1,400 fpm, approximately double the rate required on a normal 3° approach. Just inside 4 nm, torque was reduced from approximately 610 ft lbs to approximately 310 ft lbs but the aircraft's speed continued to increase, peaking at 177 kt at 1,130 ft (1.6nm). This was 1 kt below the gear limiting speed.

The approach had become unstable; the aircraft was close to the ground with a high rate of descent and a high speed (almost 90 kt above its threshold speed). Landing clearance had not been received. The cloudbase was close to the approach minima and, as the approach had become destabilised, it is likely there would be an aversion to return to an uncomfortable environment. Likewise the runway represented an area of safety and thus the psychological 'push' from the cloud and the 'pull' from the airfield made a go-around, once visual, more unlikely. Plan continuation bias would also have reduced the likelihood of the pilot electing to go around.

At no point on the approach did the TBM's vertical profile exceed the limits of the NDB procedure.

Loss of communications

On being instructed to change to 118.300 MHz the pilot had selected 118.030 MHz. The number sequence is visually very similar and once the error had been made, detection of it without an additional cue would be highly unlikely. The cue provided by the failure to establish communications could have led the pilot back to the radio frequency selection. However, as discussed above, by the time the pilot had been alerted to the loss of communications, his task loading had increased significantly and it is possible that the need to establish communications was lost amongst the competing priorities of operating the aircraft. There is no evidence to suggest that the pilot tried to diagnose the apparent radio failure. A previous radio failure on the aircraft may have made the pilot more likely to assume that it had failed again, even when there was no evidence to support this assumption.

Failure of visual search

On becoming visual with the runway at about 600 ft aal the pilot stated that he looked at the runway but did not see the Q400. It is likely that he did look to check that the runway was clear before landing, with his probable area of focus having been the touchdown zone of Runway 15 (the point at which he was aiming).

Although the Q400 had a white strobe light on its tail, white strobes are sometimes used as location aids at European runways and as such may not have been as effective in attracting the pilot's attention. The approach lighting embedded into the surface of the starter extension created a brightly lit area which would have reduced the contrast between the white coloured Q400 and the runway surface. This, combined with the likelihood that any visual search would have been focused on the runway itself and not the different coloured concrete of the starter extension, would have reduced the probability of a successful detection of the Q400.

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The approach ended in a cognitively busy situation and any pilot has limited attention to divide between all the necessary tasks. In this approach the required number of tasks at the point of breaking cloud had increased and, due to the high approach speed, the time available to complete those tasks was substantially shorter than normal. High workload can lead to a narrowing of the visual field, as well as reducing the time available for visual search.

Regardless of the reasons, the pilot did not see the Q400 and thus assumed that the runway was clear for him to land.

Tower controller's options

The tower controller had intended on using the 6 nm spacing between landing aircraft to allow the Q400 to line up and depart. After the landing 737 had passed the threshold, the Q400 was cleared to line up from holding point A2. Once the 737 had vacated the runway the controller planned to clear the Q400 to depart, before then clearing the TBM to land. There were four prospective outcomes that could have affected the controller's plan:

a if the 737 was slow to vacate the controller would have to keep the Q400 on the ground and send the TBM around,

b if, after the 737 vacated, the Q400, despite reporting ready for departure, was slow to commence its takeoff roll the controller would have to send the TBM around and then co-ordinate the departing Q400 and the TBM going around,

c if the Q400 conducted a rejected takeoff the controller would have to send the TBM around and,

d if the TBM had a higher groundspeed than the controller had anticipated then the controller would have to keep the Q400 on the ground and send the TBM around.

All the scenarios above are routine occurrences in the UK and require, in order to ensure a successful outcome, an effective channel of communication from the controller to the aircraft involved.

As stated during a subsequent interview, the controller would normally plan on a 6.5 nm spacing between arrivals, but with a light turboprop the spacing could be smaller as they tend to be much slower within 4 nm of the runway. At normal speeds the controller's plan would have allowed a small but workable gap to clear the Q400 to depart. The controller had reduced risk by confirming that the Q400 was "ready for departure" and so would be able to depart as soon as the 737 had vacated. If the plan did not work as intended, the contingency was for the TBM to go-around. Based on the controller's knowledge at that time and without the benefit of having seen the guidance in the Safety Notice, the expectation was that, in the event of a loss of communication, the TBM would be likely to go around.

However, instead of slowing down when within 4 nm, N850TV accelerated and was considerably faster than normal. This reduced the time available for the Q400 to depart by about 20 seconds. It is considered likely that the controller's first call to the TBM of "ARE YOU ON FREQUENCY?" was a confidence check that two-way communications with the TBM could be established and that the plan to depart the Q400 could still be achieved. This call occurred synchronously with the Q400 approaching the A1 holding point and entering the runway and a positive reply from the TBM might have given the controller confidence in the original plan. With the controller's focus of attention being on establishing contact with the TBM, the opportunity to allow the Q400 to depart, was lost.

The lack of response from the TBM presented the controller with a choice, to clear the Q400 to depart against non-communicating traffic of unknown intentions but which, based on the controller's expectations, would probably go-around, or to change the plan that had already been embarked upon. The controller's options for changing the plan were very limited. The Q400 was entering the runway and communications had already been lost with the TBM. There was no way for the Q400 to taxi clear of the runway before the TBM arrived so the controller's only option was to keep the Q400 obstructing the runway and rely on the TBM pilot either going around or seeing and avoiding the Q400.

The tower controller had not read the recent Safety Notice which contained specific advice for dealing with this type of situation, but did alert the other controllers on duty and the supervisor that N850TV had not checked in on the tower frequency and instructed them to try to call the aircraft to send it around. The tower controller called the TBM a total of four times in an attempt to make contact but at no time issued a 'blind' go-around instruction to N850TV. Blind go-around instructions were issued by Approach Radar and Director. Due to the specific nature of the loss of communications this did not alter the outcome of this event but, had N850TV simply had a transmitter failure, the pilot would have been alerted to the need to conduct a go-around and may have been prompted to do another visual search to determine the reason: the presence of the Q400.

One possible way to instruct the TBM to go-around would have been by visual signal using a signal lamp. However, as the lamp had been removed, this option was not available to the controller.

Loss of communication – controller and pilot expectations

The *Safety Notice (SN001.10 NATS)* states that '*normally, commercial crew not in receipt of a landing clearance will execute a standard missed approach*'. However, the instances of landing without clearance recorded in the CAA MOR database suggest that this is not always the case. ICAO Doc 4444, the UK AIP and the specific instructions for Birmingham, in common with most other UK airfields, require a crew having lost communications on intermediate or final approach to *continue visually or by means of an appropriate final approach aid*. As the pilot of N850TV had lost communications, albeit through a frequency mis-selection, this is the situation in which he found himself.

In summary it is likely that air traffic controllers assume that a loss of communications will probably result in a go-around while pilots are expecting that they will land if they are able. This disparity could lead to conflict between the controller and pilot mental models. Therefore:

Safety Recommendation 2011-073

It is recommended that the Civil Aviation Authority resolve the conflicting expectations of flight crews and air traffic controllers following a loss of communications during approach.

An expectation that aircraft without a landing clearance will probably go around will form the basis for any risk assessment associated with lining up an aircraft for departure ahead of it. In light of the fact that, contrary

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to controller expectation, some aircraft will land without having received clearance, it is possible that that risk assessment is flawed. Therefore:

Safety Recommendation 2011-074

It is recommended that the Civil Aviation Authority review the risk assessment of the hazards associated with clearing aircraft to line up ahead of landing traffic.

Controller / pilot joint training

Improving ATCO and pilot understanding of each other's operating environments would help improve mutual mental models. Several UK airlines conduct joint ATCO/pilot training, and pilot visits to local towers and en-route facilities are encouraged by the UKs major ANSPs. Several airlines welcome controllers on flight deck observation trips which are designed to improve this mutual understanding.

Controllers may be issued with a flight ticket for such trips. Although the tickets are free of charge, UK Air Passenger Duty is levied which, as these trips are generally arranged for short-haul multi-sector trips, can be required to be paid multiple times. This application of APD acts as a disincentive to conducting mutual training gained through flight deck visits.

With the assistance of the Department for Transport's Head of International Aviation Safety and Environment Division the issue was highlighted to HM Revenue and Customs (HMRC) - transport taxes team. After consideration HMRC stated that:

'There is a provision in the Finance Act 1994 that exempts from APD passengers carried on board an aircraft who are not carried for reward and who are there for the sole purpose of inspecting the aircraft or flight crew (section 31(5)(b)). We consider that air traffic control officers on officially sanctioned operational training flights.... would fit this description provided they were not required to buy a ticket.'

ATIS

The ATIS broadcast by Birmingham at the time of the incident did not include the type of approach to be expected by pilots, contrary to the information provided in MATS (Part 1). Furthermore the ATIS included repetitive phrases and a mix of human and automated voices that could make the ATIS difficult to receive over a radio and could be overly complex for non-native English speakers. The ATIS also significantly exceeds the recommended MATS (Part 1) length. Therefore:

Safety Recommendation 2011-075

It is recommended that NATS review the content of the Birmingham Airport Automated Terminal Information System to ensure that it is clear and concise, and includes the type of approach to be expected.

Signal lamps

CAP 670 requires the tower to have available a signal lamp capable of being visible from all points in the visual circuit. However, a study showed the lamps to be ineffective at some airfields (including Birmingham) and so their withdrawal from service was permitted by the CAA. The inability to provide the supporting paperwork for this withdrawal means that the considerations taken into account when making this decision are unavailable. However, Rule 45 of the ANO requires pilots to cause a watch to be kept for visual instructions. At Birmingham, at the time of the incident, a means for issuing visual instructions was not provided.

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Given the weather conditions on the day and the workload of the TBM pilot it is considered unlikely that issuing a visual instruction by means of a signal lamp from the tower would have affected the outcome of this incident. However, as a means of providing visual signals is inferred to be required by the ANO, an effective alternative to the now-withdrawn signal lamp should be sought. Therefore:

Safety Recommendation 2011-076

It is recommended that the Civil Aviation Authority review the most appropriate means of providing the visual instructions for which pilots are required to maintain a watch in accordance with Rule 45(6)(b) of the UK Air Navigation Order.

Conclusions

The pilot met the currency requirements of his IR. However, lack of recent practice at NDB approaches combined with other factors, led to a short term peak in workload. Despite this, his approach was in compliance with the lateral and vertical limits for the NDB DME 15 but the high workload led to peripheral tasks being dropped and his decision-making process being degraded. This led, without further fault diagnosis, to the misidentification of a frequency selection error as a radio failure. From that point on, the pilot's actions from his perspective, although based on continuation bias, were in compliance with regulations. The same human factors that led to the misidentification of the radio problem probably also led to the failure of his visual search of the runway before he landed.

The air traffic control procedures in use were compliant with the appropriate MATS and are standard practice throughout the UK. The controller's planning assumption, supported by previous training, that aircraft should and probably will go around following a loss of communications, was widely shared throughout ATC management and the regulator. However, the controller's plan provided little room for manoeuvre and included a single point, albeit unlikely, that could lead to it being disrupted.

Following a loss of communications, ICAO Doc 4444 and the UK AIP require aircraft to continue visually and at least 17 multi-pilot public transport passenger flights have landed without clearance in the UK in the 12 months to March 2011. In those cases the runway was clear.

Safety action

By the pilot

The pilot commented that subsequent to this event he had reappraised the risk of both operating the aircraft and attending business meetings. As such, whenever travelling to meetings, he now operates with a safety pilot who is not involved with the business.

By NATS

The ANSP conducted a review of the central briefing process used to deliver the safety notice SN001.10. They reported that issues in the way the notice had been processed onto the electronic briefing system had meant it may not have been highlighted to all relevant members of staff, including the tower controller. This issue did not affect operating instructions and similar mandatory notices. The process for uploading safety notices has been altered to ensure appropriate distribution.

An ALDIS lamp was installed at Birmingham by the ANSP and tested in detail to determine its effectiveness. However, this study indicated that the ALDIS lamp is ineffective at the current tower location and its use could hinder rather than help pilots.

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The trial concluded that, while a white lamp could be seen at a range of about 1 nm, a red or green filter would make the lamp impossible to detect. The study concluded:

> *'The effectiveness of an Aldis Lamp in being an aid to a controller at Birmingham to an aircraft flying at a range of more than a mile is probably nil.'*

The results of this study have been communicated to the CAA.

The ANSP is trialling modified arrival procedures at Birmingham: no traffic will be lined up ahead of any aircraft on a non-precision approach once it is within 6 nm unless it has established communications with the tower controller. Further, to provide a more predictable traffic flow for the tower controller; speed control of 160 kt to 4 nm will be mandatory; a standard gap of 6 nm between traffic will be used unless certain circumstances, such as wake vortex, require a different gap; and all traffic will be transferred to Tower by 6 nm.

By HMRC

During the investigation the AAIB made HMRC aware of the issues surrounding this incident. Having considered the matter HMRC stated that, on condition that the controller does not pay for a ticket, they will in future consider Air Traffic Controllers on officially organised mutual training flights to be exempt for the purpose of Air Passenger Duty.

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SERIOUS INCIDENT

Aircraft Type and Registration:	MD 900 Explorer, G-SASH
No & Type of Engines:	2 Pratt & Whitney Canada PW206E turboshaft engines
Year of Manufacture:	2000
Date & Time (UTC):	11 June 2011 at 0828 hrs
Location:	Leeds Bradford Airport
Type of Flight:	Commercial Air Transport (Non-Revenue)
Persons on Board:	Crew - 2 Passengers - 2
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	50 years
Commander's Flying Experience:	5,973 hours (of which 298 were on type) Last 90 days - 25 hours Last 28 days - 6 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further investigations by AAIB

On lifting to the hover, the downwash from the helicopter pushed one parked light aircraft into another.

The helicopter, an Air Ambulance, was on a routine positioning flight from Leeds Bradford Airport to Bagby Airfield, North Yorkshire. It had been positioned, by ground handling staff, on a designated helicopter landing spot which was 18 m away from, and upwind of, the West Apron on which several light aircraft were parked. Shortly after the pilot lifted the helicopter into the hover, the downwash caused a parked light aircraft to begin moving. After the parked aircraft had turned through 180°, its port wing wedged under the wing of an aircraft parked next to it, causing minor damage to both aircraft. The pilot, and the Duty Airside Safety Unit Officer who attended the incident, both reported that none of the light aircraft on the West Apron were chocked at the time of the incident.

Since this incident, aircraft parking arrangements at Leeds Bradford Airport have been reviewed and air ambulance helicopters no longer use the West Apron area.

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ACCIDENT

Aircraft Type and Registration:	Beech 76 Duchess, G-WACJ
No & Type of Engines:	2 Lycoming O-360-A1G6D piston engines
Year of Manufacture:	1980
Date & Time (UTC):	10 July 2011 at 1030 hrs
Location:	Wycome Air Park, Buckinghamshire
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to aircraft underside, propellers and nacelles, both engines shock-loaded
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	48 years
Commander's Flying Experience:	4,144 hours (of which 660 were on type) Last 90 days -136 hours Last 28 days - 53 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The student and instructor had completed several Engine Failure After Takeoff (EFATO) drills in the local area (these drills involved raising the flaps and the landing gear immediately after selecting full power to climb away). They then returned to Wycombe to complete a few circuits.

The instructor recalled checking for "three greens" on the final approach for a touch-and-go. The aircraft touched down normally and the student then applied full power. As the aircraft accelerated the nose started to drop and the instructor thought that the nose gear had collapsed. He took control, shut down the engines and electrics and the aircraft slid to a halt on the runway. There were no injuries. The instructor subsequently noticed that the gear lever was in the UP position. He believes that the student had inadvertently raised the gear immediately after selecting full power, this being the sequence of actions performed earlier in the flight during the EFATO drills.

As a result of this accident the training centre has initiated a safety review of touch-and-go exercises.

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ACCIDENT

Aircraft Type and Registration:	Cessna 152, G-BSZO
No & Type of Engines:	1 Lycoming O-235-L2C piston engine
Year of Manufacture:	1977
Date & Time (UTC):	26 June 2011 at 1207 hrs
Location:	Southend Airport, Essex
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to nosewheel, propeller and left wingtip
Commander's Licence:	Student
Commander's Age:	48 years
Commander's Flying Experience:	22 hours (of which 22 were on type) Last 90 days - 5 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The student pilot had performed three dual circuits with his instructor "to a good standard". The instructor disembarked, briefing the student to carry out three solo circuits. The first two circuits were performed successfully but after the third circuit the touchdown was fairly heavy and the aircraft bounced. On the second touchdown the aircraft bounced again causing damage to the nosewheel, which collapsed on the third touchdown, allowing the nose and left wingtip to strike the ground. The student admitted that he should have gone around after the first bounce but that, after the second bounce, it was too late.

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ACCIDENT

Aircraft Type and Registration:	Jabiru J430, G-RCST, amateur-built
No & Type of Engines:	1 Jabiru Aircraft PTY 3300A piston engine
Year of Manufacture:	2006
Date & Time (UTC):	5 June 2011 at 1704 hrs
Location:	Gloucester Lodge Farm, Northumberland
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to engine, nose landing gear, firewall
Commander's Licence:	Private Pilot's Licence
Commander's Age:	53 years
Commander's Flying Experience:	885 hours (of which 495 were on type) Last 90 days - 26 hours Last 28 days - 13 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional AAIB investigation

Synopsis

Whilst flying in the Newcastle area, the pilot reported smoke and fumes in the cockpit and noted that the engine oil pressure was dropping rapidly. He conducted a successful forced landing, although the aircraft sustained some damage. The problem was found to be a loss of oil via a split in a seam in the engine oil cooler; this component had been fitted immediately prior to the accident flight, the previously fitted unit having developed a 'weep'. It was found that a manufacturing fault had led to the oil cooler splitting as a result of being subjected to the normal engine oil pressure.

History of the flight

The aircraft took off from Eshott in Northumberland for an intended flight to a farm strip in Norfolk. The engine temperature and pressure indications were all normal as the aircraft entered the eastern part of Newcastle Control Area at an altitude of 1,200 ft. Whilst overhead Blyth wind farm Visual Reporting Point, smoke suddenly appeared inside the cockpit and the pilot noticed that the engine oil pressure was dropping rapidly. He made a MAYDAY call to Newcastle ATC, who were able to monitor the aircraft on radar and subsequently alerted the emergency services. The pilot turned the aircraft towards the west and prepared to conduct a forced landing. However, during the approach to his chosen field, the pilot noted a number of people were in the

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landing area. Consequently, he was forced to land, with a tail wind component, in an adjacent field where the surface consisted of a series of ridges and furrows. The landing was successful although the rough nature of the field resulted in some damage to the nose landing gear and the firewall to which it was attached.

Investigation

Upon investigation, it was immediately apparent that a large quantity of oil had been lost via a split along a seam at the rear of the engine oil cooler. In fact this was a new component that had only just been fitted following a 'weep' that had been discovered in the previously fitted unit. Some of the oil had dropped onto the exhaust system, thus generating the smoke that had entered the cockpit.

The owner/pilot noted that the lower plate of the oil cooler had developed a "bulge" since being fitted to the aircraft and the leak appeared to be associated with this.

Both the incident oil cooler (see Figure 1) and the previously fitted component were examined by a metallurgist. After cleaning, an air pressure test revealed that there was a leak along an approximate 40 mm length of the lower plate, on the aft side as fitted to the aircraft. Both coolers were sectioned, (Figure 2) and the bulging in the lower plate of the incident unit could be seen. The cooling channels in the lower chamber were formed from corrugated sheet metal sandwiched between horizontal plates. However, it was apparent that there was an absence of solder between the lower plate and the corrugated channels, meaning that the plate had remained attached only around the periphery. As a result, the oil pressure within the chamber had caused the lower plate to bulge and had overloaded the sheet metal sidewalls of the chamber. The leak was due to a longitudinal fracture of the sheet metal sidewall, immediately adjacent to the soldered joint between it and the lower plate; this can be seen in Figure 3.

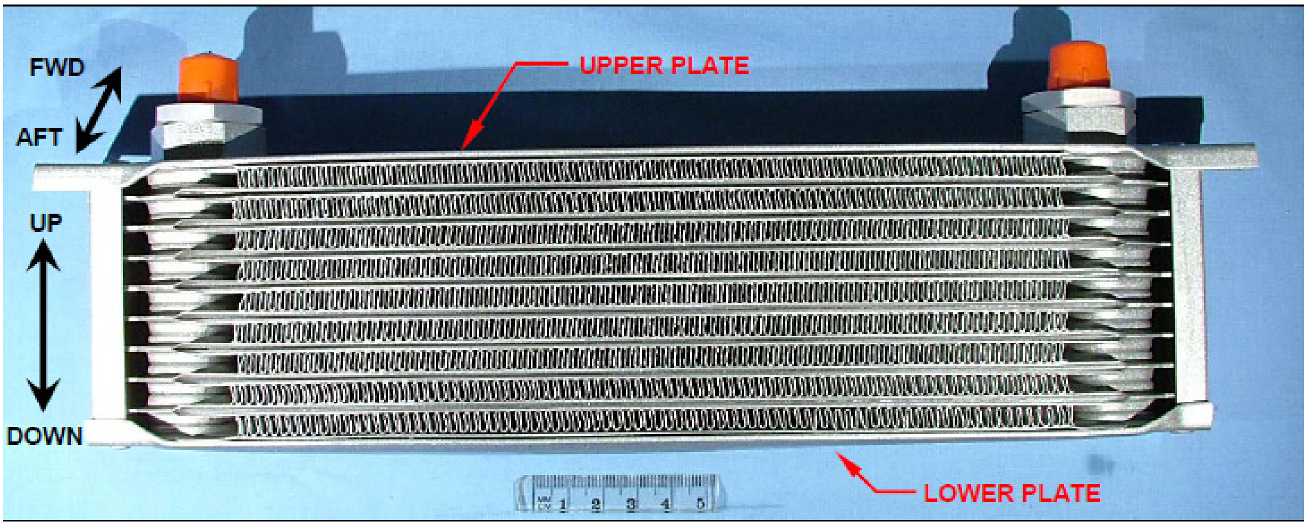

Photo: ms4i

Figure 1

View of the incident oil cooler, as received

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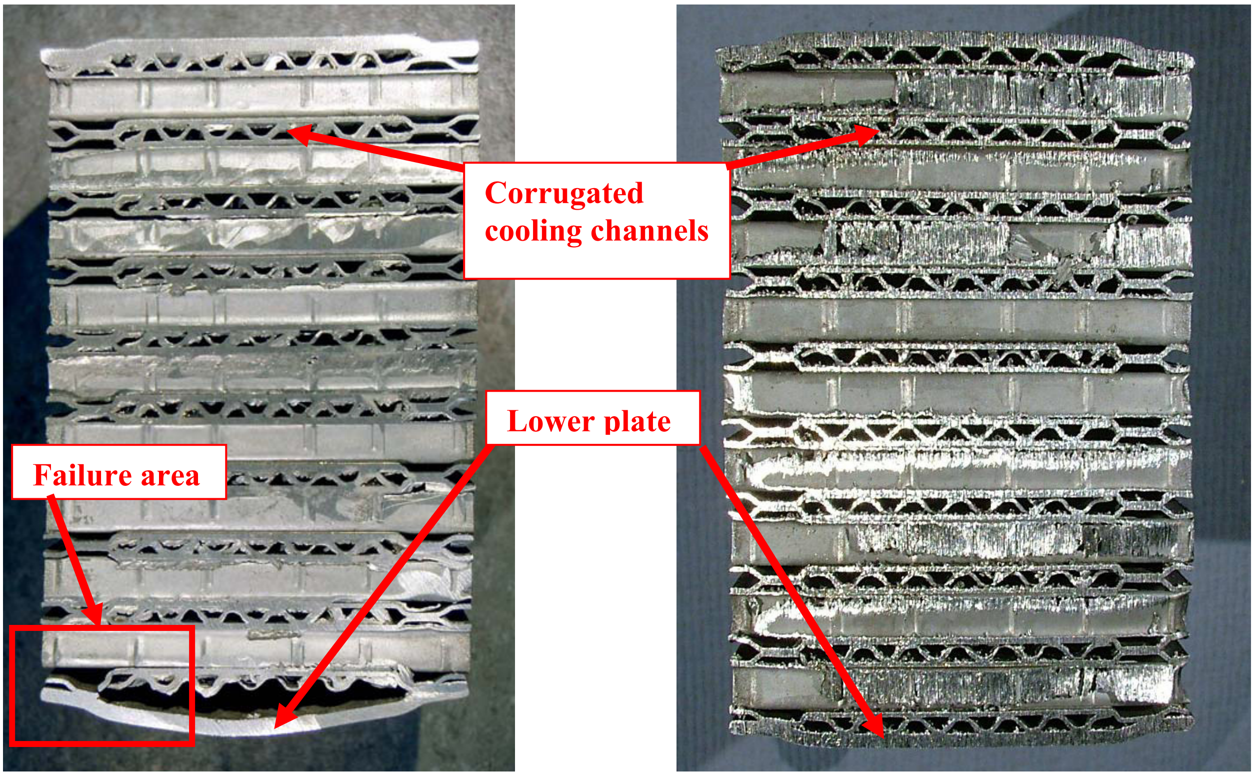

Photo:ms4i *Photo:ms4i*

Incident oil cooler Previously fitted oil cooler

Figure 2

Oil coolers after being sectioned. Bulge in lower plate of incident unit is clearly visible

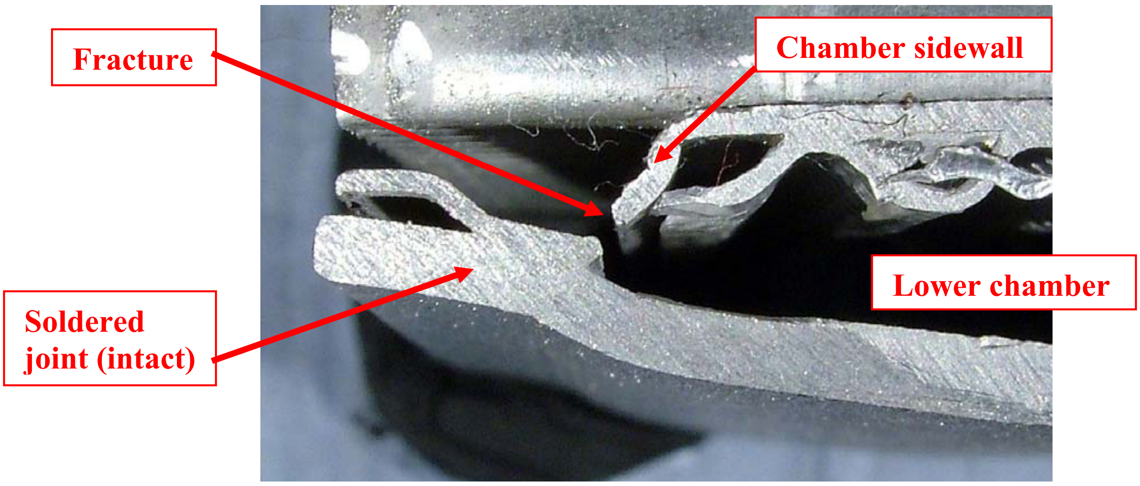

Photo:ms4i

Figure 3

Enlarged view of area of failure

Examination of the fracture surface indicated that the failure was consistent with overload; there was no evidence of slow crack growth mechanisms, such as fatigue.

As part of the investigation, the lower plate of one half of the previously fitted oil cooler was deliberately torn from the matrix. In contrast to the incident unit, the corrugated cooling channels were found to be securely joined to the lower plate such that the removal process caused the channel material to fail (Figures 4 and 5).

It was therefore concluded that the oil cooler failed as a result of the corrugated channels not being joined to the lower plate. This was in turn due to the omission of solder that should have been applied during the manufacturing process.

Previously fitted oil cooler

The 'weep' in the previously fitted cooler, which had achieved 94 hours since fitment, was also investigated, and it was found that two fatigue cracks had developed in the corners of the lower plate sidewall. The remaining half of the lower plate was deliberately torn off in order to expose and examine these features, which are indicated in Figure 4 (note: a conventional leak test could not be conducted due to the cooler having already been sectioned).

Both the fatigue cracks were approximately 25 mm in length and had penetrated through the full thickness of the chamber sidewall. These are shown on a photograph of the lower plate at Figure 5. The fatigue cracks were visually distinguishable from the deliberate

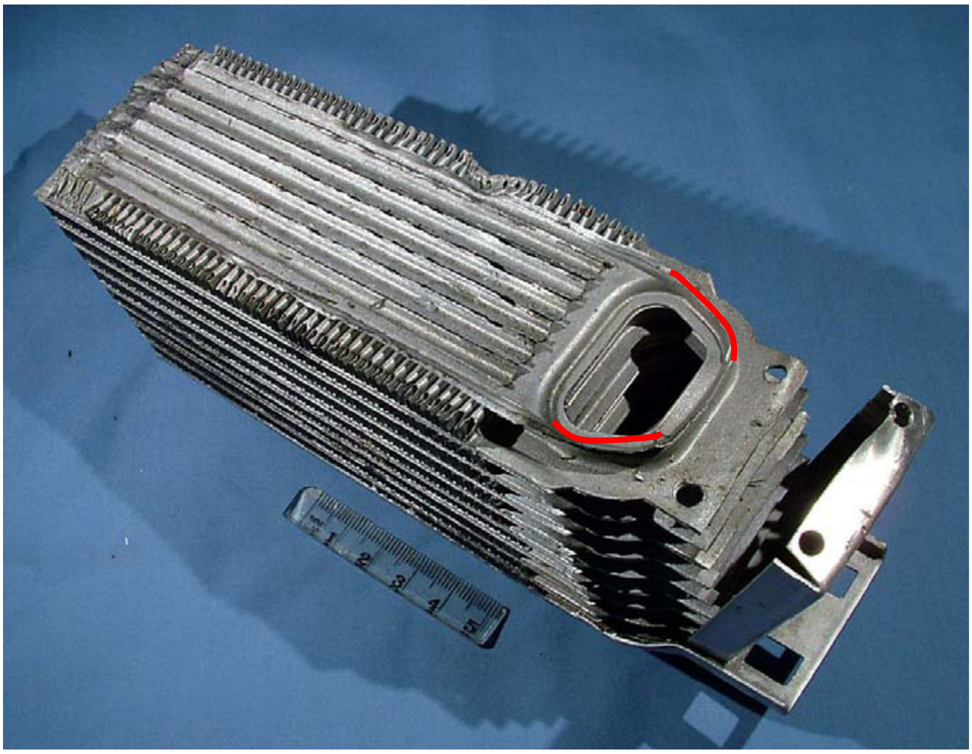

Photo: ms4i

Figure 4

View of underside of previously fitted oil cooler, with lower plate torn off. Remains of channels can be seen; fatigue crack regions are highlighted

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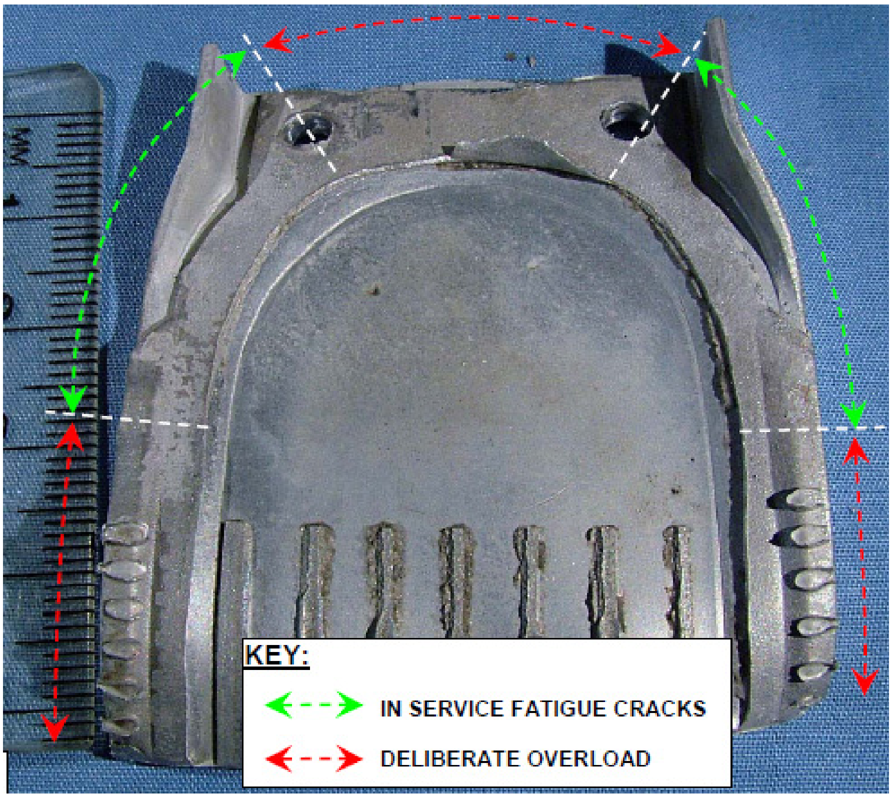

Photo: ms4i

Figure 5

View of lower plate after removal, with areas of pre-existing fatigue indicated.
Note remains of oil channels, which had been attached to those seen in Figure 4

overloading of the sidewall, since they were darker in appearance, due to oxidation and staining during stable crack growth. The nature of the fracture surface indicated that the fatigue crack had initiated from multiple sites on the internal surface of the chamber sidewall. It was not possible to establish a figure for the amount of time taken for the crack to progress from initiation to failure.

Other information

This type of oil cooler, which is sold primarily into the automotive market, is used on a number of Jabiru J400/430 aircraft and the owner of G-RCST was aware of concerns among other owners over their continued use.

The manufacturer's data sheet for the oil cooler states that:

> *'Every cooler is pressure checked to 175 psi. Periodic samples are burst tested to 350 psi.'*

However, the aircraft owner stated that there was no documentation that accompanied this, or any other cooler, that indicated what checks had been conducted prior to release from the manufacturer.

The oil pressure generated by a Jabiru engine is reported to be typically around 45 psi, with the pressure sensor located immediately upstream of the oil cooler. As a result of the damage observed on the failed oil cooler from G-RCST, notably the bulge in the lower plate,

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it seems unlikely that the unit would have been able to withstand the 175 psi test pressure applied after manufacture and it is thus possible that this test may have been omitted. The USA-based manufacturer has not been able to provide an explanation for lapses in the manufacturing process, although they did note that some coolers had developed leaks as a result of pressure spikes being generated by some types of oil pump.

The Light Aircraft Association (LAA), who provide airworthiness services and oversight for this aircraft type, are to conduct a survey of owners to establish the extent of oil cooler problems, whilst at the same time evaluating other available oil coolers.

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ACCIDENT

Aircraft Type and Registration:	Nipper T.66 RA45 Series 3, G-AVKI
No & Type of Engines:	1 Sauer SE 1800 E2S piston engine
Year of Manufacture:	1967
Date & Time (UTC):	6 August 2011 at 1130 hrs
Location:	Honington, Suffolk
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to propeller, canopy, top of fin and nose leg
Commander's Licence:	Private Pilot's Licence
Commander's Age:	44 years
Commander's Flying Experience:	290 hours (of which 22 were on type) Last 90 days - None Last 28 days - None
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot took off from RAF Honington to practise circuits. He had completed his downwind checks, which included selecting the carburettor heat to hot. After turning onto the base leg and throttling back, the engine cut out. He checked the fuel selector and the magnetos, which were both ON. As the engine did not have an electric starter and given the height and distance to the runway threshold, the pilot had no option other than to make a forced landing. He selected a field short of the runway and then made a MAYDAY call.

The aircraft touched down, mainwheels first, approximately a third of the way down the large ungrassed field. Soon after the nosewheel touched down the aircraft flipped over, coming to rest inverted and trapping the pilot. Passers-by helped to right the aircraft so that the pilot could free himself. The Suffolk Police Air Support helicopter, the local and RAF Honington fire services and an ambulance also attended the scene. The pilot was uninjured.

No obvious explanation could be found for the engine failure. The pilot considered that his frequent practising of forced landings and ensuring that the straps on his harness were tight prior to touchdown contributed to the safe outcome of this accident.

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ACCIDENT

Aircraft Type and Registration:	Piper PA-25-235 Pawnee, G-BSTH
No & Type of Engines:	1 Lycoming O-540-B2C5 piston engine
Year of Manufacture:	1969
Date & Time (UTC):	11 May 2011 at 2100 hrs
Location:	Portmoak Airfield, Kinross
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Landing gear shock struts
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	66 years
Commander's Flying Experience:	310 hours (of which 65 were on type) Last 90 days - 17 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The landing gear shock struts failed after the aircraft stalled and landed heavily on rough ground. The pilot attributed the event to the loss of visibility whilst approaching into a low sun with rainwater droplets on the screen.

History of the flight

The tug pilot had already carried out six glider aero-tows to 2,500 ft that day without incident. Although the flight conditions were somewhat turbulent, the pilot reported that he soon became accustomed to these and was not experiencing any difficulty. On the seventh tow he encountered rain at 2,000 ft. Because of the difficulty of seeing through a rain-affected windscreen, he decided to land as soon as possible and signalled the glider pilot to release from the cable. This was accomplished successfully. The tug pilot had previously been landing across the field, as had the gliders. On this occasion, however, he chose to land long on the grass runway. As he turned onto the final approach, the combination of the low sun and the rain-affected windscreen restricted his vision.

The final approach was carried out with the aircraft crabbed to allow for the wind, which was blowing across the runway from the left. The aircraft nevertheless failed to maintain the centreline and drifted to the right. It then stalled from a height of about 5 ft and fell firmly onto rough ground to the right of the prepared strip, causing the landing gear shock struts to fail. The pilot shut down

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the engine as quickly as possible and exited the aircraft.

The pilot considered that although he had landed successfully into the sun many times before, on this occasion the combination of the low sun and the wet windscreen had affected his vision more than he had expected.

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ACCIDENT

Aircraft Type and Registration:	Piper PA-28-161 Cherokee Warrior II, G-EDGA
No & Type of Engines:	1 Lycoming O-320-D3G piston engine
Year of Manufacture:	1985
Date & Time (UTC):	6 July 2011 at 1505 hrs
Location:	RAF Halton, Buckinghamshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Left wing outer leading edge, anti-collision and navigation lights damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	280 hours (of which 102 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 had completed an uneventful transit from Coventry Airport to RAF Halton, Buckinghamshire. The weather conditions at Halton were described as bumpy, with thunderstorms in the area and "gusty" wind conditions - the forecast was for a surface wind of 180°/15 gusting 25 kt. The pilot positioned his aircraft for a flapless landing on grass Runway 20, with the windsock showing a strong wind straight down the runway.

As the aircraft approached trees on final approach it was "swatted violently downwards and left", the left wing dropped and made contact with the trees. The pilot levelled the wings and noticed, from the windsock, that the wind had veered significantly, almost 90º. He turned towards the wind and landed across the runway, stopping in the long grass beyond the side of the strip. The aircraft was taxied back to the apron and shut down normally. A subsequent inspection revealed damage to the left wing.

The pilot considered that the accident was caused by a sudden and violent change in the wind direction, perhaps caused by a nearby thunderstorm to the north.

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ACCIDENT

Aircraft Type and Registration:	Piper PA-38-112 Tomahawk, G-OTFT
No & Type of Engines:	1 Lycoming O-235-L2C piston engine
Year of Manufacture:	1978
Date & Time (UTC):	8 April 2011 at 1043 hrs
Location:	RAF Henlow, Bedfordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - 1 (Serious)
Nature of Damage:	Engine possibly shock-loaded
Commander's Licence:	Private Pilot's Licence
Commander's Age:	37 years
Commander's Flying Experience:	144 hours (of which 118 were on type) Last 90 days - 2 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

Synopsis

The passenger's arm was struck by the propeller when she vacated the cockpit and stepped off the leading edge of the wing. The aircraft was stationary with its engine at idle power[1].

History of the flight

The aircraft was stationary with the engine running at idle power when the passenger got out of the cockpit and onto the right wing intending to collect a headset that had been left in the control tower. She closed the door, moved towards the leading edge of the wing and stepped off onto the grass manoeuvring area. As she moved off the leading edge, her arm was struck by the propeller.

Information from the pilot

During her initial inspection of the aircraft the pilot briefed the passenger on how to enter and exit the aircraft. When she had completed her inspection, she taxied the aircraft to the refuelling location and came to a halt near the fuel bowser pointing towards the control tower beyond. After she shut down the engine, she went to the control tower intending to complete her pre-flight preparation and collect a headset for the passenger. When she returned she gave a pre-flight briefing to the passenger before starting the engine.

Footnote

[1] Idle power is the power produced by the engine when the throttle control is in the IDLE position, which for a stationary aircraft results in a lower propeller speed than if the throttle control were advanced.

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After starting the engine the pilot noticed that the passenger did not have a headset on and realised that it had been left in the control tower. She instructed the passenger to get the headset from the tower and "re-stated how to exit the aircraft and the route to follow". The pilot had been told during training that, in order to protect the engine, she should not shut down immediately after start and so, instead, she reduced the power to idle before the passenger stepped onto the wing. As the passenger moved towards the front of the aircraft, the pilot knocked on the windscreen and pointed towards the rear of the aircraft and believed that her gesture had been seen. She shut down the engine when she saw the passenger step down from the wing.

Information from the passenger

This was to have been the passenger's first flight in a light aircraft and, before boarding from behind the trailing edge of the wing, the pilot told her to step only on the black walkway that ran along the inner section of the wing. This was the only briefing she received from the pilot apart from being told to fasten her seat belt when the pilot returned from the control tower.

When asked to get a headset, the passenger was not told how to exit the aircraft and the route to follow to the control tower, nor that she was to walk around the rear of the aircraft. When she stepped out onto the wing and closed the door, she saw the control tower ahead of the aircraft and walked towards it ensuring she remained on the black walkway. She did not believe that the pilot tried to gain her attention as she walked forwards. She stepped off the front of the wing and did not notice the propeller.

Air Navigation Order

Article 88 of the Air Navigation Order (ANO) states that the commander of an aircraft must take reasonable steps to ensure that passengers are made aware of the position and method of use of the safety equipment on the aircraft. The Article does not specify additional briefing requirements with respect to specific types or classes of aircraft, such as single engine piston aircraft.

Published guidance

Safety Sense Leaflet 2 - '*Care of Passengers',* published by the CAA, provides advice to aircraft captains on how to fulfil their responsibilities for the safety and well-being of their passengers. The leaflet advises pilots to:

'a) Point out that propellers and helicopter rotors are extremely hazardous and should be avoided at all times, even when stationary. Rotating propellers…may be hard to see, especially from the side or at night. The hazard may not be noticed if nearby aircraft have engines running.

b) Always shut down the engine(s) when passengers are boarding or leaving…..unless they are escorted by properly briefed helpers.

c) Advise passengers that when going to and from a propeller-driven aeroplane, they must approach/depart from behind the wing.

d) Ensure that even if the engine is stopped passengers do not step forward off the wing leading edge towards the propeller.'

Discussion

The differences between the two accounts of events were not reconciled by the investigation. Nevertheless, the accident demonstrated the danger represented by propellers, highlighted the importance of pre-flight safety briefings and reinforced the points from Safety Sense Leaflet 2, any one of which had the potential to prevent this accident.

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ACCIDENT

Aircraft Type and Registration:	Reims Cessna F152, G-BJKY
No & Type of Engines:	1 Lycoming O-235-L2C piston engine
Year of Manufacture:	1981
Date & Time (UTC):	21 March 2011 at 2000 hrs
Location:	Ingleborough, North Yorkshire
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - 2 (Serious) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	55 years
Commander's Flying Experience:	1,615 hours (of which 400 were on type) Last 90 days - 22 hours Last 28 days - 7 hours
Information Source:	Aircraft Accident Report Form submitted by the instructor and further telephone inquiries by the AAIB

Synopsis

During a dual night cross-country navigation training flight the aircraft deviated from its planned track and flew into rising ground. The crew were seriously injured but survived the accident. Using a mobile phone, they were able to contact the emergency services and were rescued after an extensive search.

Background

The flight was part of the training towards a night qualification for a PPL holder with about 60 hrs flying experience. The route included pre-planned legs from Blackpool to Clitheroe followed by a practice 'diversion' to a nominated point. The instructor briefed the student that he would provide him with the waypoint to divert to during the flight.

History of the flight

The aircraft departed Blackpool Airport in good visibility. The instructor reported that the first three planned legs of the exercise (see Figure 1) were completed satisfactorily and, during the leg to Clitheroe, he told the student that after Clitheroe he would like him to divert to Kirkby Lonsdale, a town which was often used by the flying school as a turning point during PPL VFR navigation training. The student plotted the diversion leg on his chart, calculated the wind-corrected heading and time for

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the diversion leg and successfully identified Clitheroe. He then turned the aircraft onto the heading for Kirkby Lonsdale and climbed to the calculated safe altitude. The instructor could not recall the heading that the student had selected or the exact altitude flown but believed the latter was either 2,800 or 3,000 ft amsl.

The instructor reported that, initially, the student had some difficulty maintaining the intended heading but subsequently managed to regain it. He also stated that they could see nothing, describing the leg from Clitheroe as a "black hole". He could not ascertain whether this was because they were in cloud. To back up their visual and dead-reckoning navigation, the instructor used the aircraft's single navigation receiver to obtain bearings from the Wallasey (WAL) and Pole Hill (POL) VORs, to the south-west and south-east of the aircraft respectively. From these bearings, which were not plotted on the chart, he concluded that the aircraft was slightly to the right (east) of track. He reported that there was still nothing visible outside the aircraft. The instructor then saw some lights to the right of the aircraft and concluded that this was Ingleton, a small town which he had expected to see to the right of the planned diversion track. He confirmed this with a "rapid reading" of the VOR bearings.

From this point on, the instructor had limited recollection of the flight and the student could remember nothing. The instructor thought that he then asked the student to alter course on to a heading of about 300°M, towards lower ground, and commence a gentle descent to 2,000 ft amsl "to gain more ground visibility". He believed that this altitude would enable them to maintain at least 1,000 ft clearance above the highest obstacle within 5 nm.

The instructor and student's next recollections were of regaining consciousness after the aircraft had crashed on high ground. They had both sustained serious injuries and remained with the aircraft which, although destroyed, did not catch fire.

Search and rescue

The instructor and student used a mobile phone to contact Blackpool ATC who then alerted the Distress and Diversion Cell (D&D) at NATS Swanwick. An extensive air and ground search was initiated, initially using the Lancashire Police Air Support Unit (ASU). The ASU was directed to the last known position of the aircraft which, based on radar data, was about 8 nm south of the crash site. The ASU was able to search the lower ground between Settle and Kirkby Lonsdale but considered it too hazardous to search the higher ground due to the weather and light conditions. The ASU crew were also aware that a Night Vision Goggle (NVG) equipped RAF Sea King SAR helicopter was en route and elected to leave the search of the high ground to them.

Meanwhile, the police used mobile phone location techniques in an attempt to pinpoint the position of the injured crew. However, in the rural location, the accuracy of these techniques did not significantly refine the search area.

Once in the search area, the Sea King crew phoned the injured crew and, over a period of about thirty minutes, the instructor directed them to his location, based on whether the helicopter was getting louder or quieter. At about 2330 hrs the instructor could see the lights of the Sea King. However, attempts to effect a rescue were thwarted by poor visibility and low cloud. Having located the crew to within a radius of about 300 m, the Sea King returned to its base.

At about 0010 hrs the Clapham Cave Rescue Team and the Kendal Mountain Rescue Team, using search dogs, located the wreckage and crew. When found, the crew

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Figure 1

Reconstructed chart showing planned and actual aircraft track

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were beginning to suffer from exposure, in addition to the serious injuries they had sustained in the accident. The crew were both wearing denim jeans and a shirt. In addition, the instructor had on a "relatively thick" jacket. They were carried, on stretchers, to the nearest vehicle access point and were admitted to hospital at 0530 hrs.

Meteorology

The UK Low Level Forecast (Metform 215), relevant to the time of the accident, forecast isolated areas of scattered or broken cloud with a base at 1,500 ft amsl. It also forecast a possibility of isolated hill fog.

In an aftercast, the Met Office calculated that the wind at 2,000 ft amsl would have been from 250° at 15 to 20 kt. This compared to the 'planning' wind of 220°/12 kt used by the instructor and his student.

On the evening of the accident, moonrise was at 2148 hrs and the moon was 97% full.

Radar data

The aircraft was equipped with a transponder but did not have an altitude reporting capability. A portion of the flight was recorded by three separate radars and was transposed on to a 1:500,000 chart (see Figure 1). The track information stopped about 4 nm south-west of the town of Settle, probably due to the aircraft being below radar coverage in the hilly terrain. This position was approximately 8 nm south of the accident site.

Accident site and wreckage

The accident site was located in an area of remote terrain at an elevation of approximately 1,970 ft, within 0.5 nm of the summit of Ingleborough (elevation 2,376 ft) (see Figure 2). It was 6 nm east of the direct track from Clitheroe to Kirkby Lonsdale, in an area noted for its lack of cultural lighting, 8 nm from Kirkby Lonsdale. The accident site was 3.7 nm to the south of Whernside, elevation 2,414 ft, the highest point within 25 nm.

The aircraft's insurers reported that, when they arrived at the site, the dome light, navigation lights and beacon switches were on. The landing light switches were off. The VOR Omni Bearing Selector (OBS) was set to 330° but it was not possible to determine the frequencies selected on the NAV and COM radios.

Flight planning

The night qualification for the PPL requires a minimum of one hour of dual night cross-country navigation flying. The instructor had briefed the student to plan a route from Blackpool Airport to Southport, then to the M6/M58 motorway intersection Visual Reporting Point (VRP) before routing to Clitheroe. The student calculated that the flying time for these three legs would be 28 minutes, in total, with the leg to Clitheroe being 13 minutes. Thereafter, the student was briefed that he would be instructed to conduct a diversion to a nominated point, to be specified when they were on the third leg to Clitheroe. The instructor was familiar with the route, having used it before, and had chosen it and the diversion, Kirkby Lonsdale, in part, to demonstrate the difficulties of night visual navigation in an area with few visible ground features.

Following the accident, a chart showing the planned route (replicated in Figure 1) and a wind reference of "220/12", but no other markings, was recovered from the aircraft. Also recovered was a knee board with the pilot's log for the flight legs to Clitheroe. The chart included a line joining Clitheroe and Kirkby Lonsdale.

The flight was being conducted under IFR, in VMC, at night. The route was planned, initially, at an altitude below 3,000 ft amsl, to remain clear of the Manchester

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Figure 2

Accident site looking south

Terminal Manoeuvring Area (TMA). When the aircraft was north of the TMA, it was intended that it would be at an altitude that was 1,000 ft above the highest obstacle within 5 nm of the aircraft's track.

The distance from Clitheroe to Kirkby Lonsdale is 21 nm, on a track of 343°M. Settle is 12.5 nm to the north-north-east of Clitheroe and Ingleton is 17 nm to the north-north-west.

Approximately halfway along the direct track from Clitheroe to Kirkby Lonsdale, an aircraft would pass within 0.5 nm of White Hill, elevation 1784 ft. At Kirkby Lonsdale an aircraft would be 4 nm to the west of Gragareth, high ground which rises to an elevation of 2,057 ft amsl.

Procedures

Civil Aviation Publication (CAP) 393, *Air Navigation: The Order and the Regulations, Section 2, The Rules Of The Air Regulations 2007* state that an aircraft flying at night shall:

> *'(a) be flown in accordance with the Instrument Flight Rules [IFR] outside a control zone.'*

IFR require that:

> *'An aircraft shall not fly at a height of less than 1,000 feet above the highest obstacle within a distance of 5 nautical miles of the aircraft unless: … (d) the aircraft flies at an altitude not exceeding*

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> *3,000 feet above mean sea level and remains clear of cloud and with the surface in sight and in a flight visibility of at least 800 metres.'*

They also require that:

> *'an aircraft in level flight above 3,000 feet above mean sea level or above the appropriate transition altitude, whichever is the higher, shall be flown at a level appropriate to its magnetic track.'*

Levels (Flight Levels (FL)) appropriate to magnetic track above 3,000 ft (and below 19,500 ft) are referred to as quadrantals. On a north-westerly track, the appropriate quadrantals are 'even thousands of feet + 500 feet [on an altimeter pressure setting of 1013.2 HPa]'.

CAA Safety Sense Leaflet 3, *Winter Flying*, advises pilots to:

> *'Dress sensibly (you should spend some time outside whilst pre-flighting the aircraft), and have additional warm clothing available in case of heater failure or a forced landing.'*

Safety Sense Leaflet 5, *VFR Navigation*, contains guidance which would have been applicable to this flight. On the subject of navigation aids, it states:

> *'Radio aids and GPS are to assist visual navigation, NOT substitute for it.'*

CAA Safety Sense Leaflet 1e, *Good Airmanship*, gives the following advice under the heading *Lost*:

> *'if any **2** of the items below apply to you, you should call for assistance quickly, **'HELP ME'**:*

> ***H*** *High ground/obstructions – are you near any?*
>
> ***E*** *Entering controlled airspace – are you close?*
>
> ***L*** *Limited experience, low time or student pilot (let them know).*
>
> ***P*** *Position uncertain, get a 'Training Fix' in good time; don't leave it too late.*
>
> ***M*** *MET conditions; is the weather deteriorating?*
>
> ***E*** *Endurance – fuel remaining; is it getting short?*

It advises pilots to:

> *'Transmit first on your working frequency. If you have lost contact on that frequency or they cannot help you, then change to 121.5 MHz and use Training Fix, PAN or MAYDAY, whichever is appropriate (see CAP 413 'Radiotelephony Manual'). If you have a transponder, you may wish to select the emergency code, which is 7700. It will instantly alert a radar controller.'*

Discussion

The evidence highlighted the aircraft's departure from its intended track and descent below a safe level, resulting in Controlled Flight into Terrain (CFIT).

The aircraft's track from Clitheroe to Kirkby Lonsdale should have been 343°M. However, the radar data indicated that it initially tracked east before turning left on to a track of approximately 009°M, maintaining this track for at least 9 nm. It is not clear why the aircraft did not follow the correct track (it was over 25° to the east of the intended track) and the crews' recollection of this part of the flight was incomplete. The light conditions were poor and there were few visible features, if any, that the crew could use to confirm their position and any track error.

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In a candid report, the instructor later concluded that he made a "classic HF [human factors] mistake", making the information available to him fit his assumption of their position. He deduced that the town they had identified as Ingleton was in fact Settle, which has terrain rising to the north-west. This is supported by the radar data.

The time to fly from Clitheroe to abeam Ingleton, en route to Kirkby Lonsdale, would have been approximately 35% longer than the time it should have taken to fly to abeam Settle. However, the aircraft's initial track from Clitheroe, to the east, may have increased the time it took to reach Settle, adding to the confusion.

The gentle descent "to gain more ground visibility", the forecast cloud conditions and the visibility experienced by the search and rescue helicopters suggest that remaining clear of cloud, with the surface in sight and in a flight visibility of at least 800 metres was difficult to achieve. Hence, remaining 1,000 ft above the highest obstacle within a distance of 5 nm of the aircraft would seem to have been appropriate.

Within 5 nm of Kirkby Lonsdale, 1,000 feet above the highest obstacle would have been 3,100 ft amsl, to the nearest 100 ft. IFR would require the aircraft to have been at a quadrantal, which in this case was FL045 (4,500 ft on an altitude setting of 1013.2 HPa). At that level, the aircraft would have been well above the highest obstacles within 5 nm of the aircraft's track, both intended and actual. Whether the meteorological conditions at that level would have precluded the successful completion of the exercise is not known, but possible.

It appears that three of the items in the CAA Safety Sense Leaflet 1e list, under the heading *Lost,* were probably present when the aircraft was near Settle. Namely, high ground/obstructions, position uncertain (although the instructor believed that he knew where they were, he had little information on which to base his position) and deteriorating weather. In those circumstances, a request for assistance on the ATC frequency in use, or 121.5 MHz, could have confirmed their location, identifying the inaccuracy in the crew's navigation and enabling them to decide on the best level to fly.

The instructor surmised that the aircraft probably struck the gentle upslope of the surface at a groundspeed of approximately 90 kt. Having survived the accident, albeit with serious injuries, the crew were both beginning to suffer from the effects of exposure when they were eventually rescued. CAA Safety Sense Leaflet number 3, *Winter Flying*, provides advice on the clothing to consider taking on a flight. It was fortuitous that the crew had a mobile phone with them and were able to call for help from their remote accident site.

Conclusion

It was not possible to determine the navigation error that resulted in the aircraft being approximately 25° to the right of their intended track. The instructor acknowledged that he incorrectly identified the aircraft's position, citing the human factors error in which a person makes the information available to them fit their assumption. This led to the instructor initiating a descent which he believed would be over lower ground and therefore safe.

The description of the meteorological conditions, both forecast and actual, indicate that, under IFR, it would have been appropriate for the aircraft to be at FL045 on the diversion leg to Kirkby Lonsdale. At this level, it would have been clear of any obstacles within 5nm of its intended or actual tracks. A call to ATC on the

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frequency in use, or 121.5 MHz, could have confirmed the aircraft's position when it was near Settle. Based on that, the crew would have been able to refine their intentions.

The aircraft struck the surface at an estimated ground speed of 90 kt. The crew were both seriously injured but the outcome could have been worse.

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ACCIDENT

Aircraft Type and Registration:	Reims Cessna FA152 Aerobat, G-LEIC
No & Type of Engines:	1 Lycoming O-235-L2C piston engine
Year of Manufacture:	1985
Date & Time (UTC):	19 May 2011 at 1400 hrs
Location:	Field near Kilby, Leicestershire
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Minor) Passengers - 1 (Minor)
Nature of Damage:	Nose gear leg separated, damage to propeller, upper wing surface and vertical tail
Commander's Licence:	Commercial Pilot's Licence with Flight Instructor rating
Commander's Age:	26 years
Commander's Flying Experience:	972 hours (of which 527 were on type) Last 90 days - 73 hours Last 28 days - 33 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

Synopsis

Shortly after takeoff the engine lost power. The pilot pumped the throttle, which produced brief bursts of power but this was insufficient to maintain level flight. The pilot made a successful forced landing into a field but during the ground roll the nosewheel hit a furrow causing the aircraft to invert.

History of the flight

Shortly after the aircraft departed Leicester Airport and was climbing through about 1,700 feet, the engine suddenly lost power. The pilot reported that all engine indications had been normal until the engine rpm suddenly dropped from about 2,450 rpm to a near-idle rpm. He tried pumping the throttle and this produced brief bursts of power of up to 2,400 rpm but it was insufficient to maintain level flight. He checked that the mixture was rich, and that the fuel and magnetos were selected ON. He also selected carburettor heat ON. This had no effect so he selected a field and proceeded to set up for a forced landing. The aircraft made a normal touchdown in the field but during the ground roll the nosewheel hit a furrow causing the nose leg to separate and the aircraft to invert. The pilot and his passenger sustained minor injuries and were able to exit the aircraft via the side doors.

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The pilot reported that carburettor heat had been applied for a minimum of 15 seconds during the engine run-up checks. He said that he had experienced carburettor icing before and that the sudden loss of engine power in this incident was very different.

Weather

The Met Office estimated the surface air temperature in the area at the time of the accident to be about 15°C and the dew point 4°C. According to the CAA's Safety Sense Leaflet 14 in LASORS[1] 2010 on '*Piston engine icing*' this placed the risk of carburettor icing as 'moderate' at cruise power and 'serious' at descent power.

Aircraft Examination

The aircraft was recovered and examined by an aircraft maintenance organisation (AMO). The AMO reported that there was sufficient fuel onboard, in excess of about 50 litres. Because the aircraft had inverted they could not easily check for water in the fuel, but the aircraft had flown earlier that day and had not been refuelled so water in the fuel was considered unlikely. The fuel gascolator was removed and found to be clear of debris. The carburettor had been damaged in the impact so it no longer contained any fuel. The engine had not seized and there were 4 quarts of oil onboard. The magnetos were found to be secure. Under the observation of the insurance loss adjuster the carburettor bowl was removed and examined. The float bowl was clean with no evidence of a sticking float.

The Lycoming O-235-L2C engine had accumulated 18 hours since its last overhaul in March 2011. The Precision Airmotive MA-3PA carburettor was overhauled in July 2010 and was fitted to the engine in March 2011, so it had also accumulated 18 hours.

Analysis

The examination of the engine by the AMO did not reveal any evidence of an engine fault or fuel issue. The meteorological conditions at the time raised the possibility of carburettor icing but the symptoms reported by the pilot were not consistent with carburettor icing. The fact that the pilot was able to momentarily regain some power by pumping the throttle suggested that the accelerator jet in the carburettor was functioning and that this fuel was reaching the cylinders. This raised the possibility that there was a fuel delivery problem from the main carburettor jet and this caused the initial loss of power. The damage to the carburettor prevented it from being rig tested.

Footnote

[1] 'LASORS 2010' is a CAA publication containing information on Licensing, Administration, Standardisation, Operating Requirements, and Safety.

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ACCIDENT

Aircraft Type and Registration:	Aerotechnik EV-97 Eurostar, G-IDOL
No & Type of Engines:	1 Rotax 912-UL piston engine
Year of Manufacture:	2007
Date & Time (UTC):	9 April 2011 at 1230 hrs
Location:	Damyns Hall Airfield, Essex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to propeller, wings, fuselage, left landing gear, fin, nosewheel fairing, engine shock-loaded. Damage to parked car
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	65 years
Commander's Flying Experience:	217 hours (of which 157 were on type) Last 90 days - 7 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and aditional AAIB inquiries

Synopsis

During the takeoff roll, the nosewheel struck a bump on the runway surface, causing the aircraft to lift off prematurely, at a low airspeed. The engine torque and propeller slipstream effects, in combination with a crosswind component, caused the aircraft to turn to the left. The pilot was unable to correct this deviation using the rudder, so he closed the throttle and applied the brakes. Nevertheless, the aircraft eventually collided with a car at the end of a row of vehicles that were parked to the left of the runway.

A subsequent flight test on a similar example of this aircraft type confirmed that it met the requirements of the appropriate design code used to assess its suitability for the issue of a UK Permit to Fly.

History of the flight

The aircraft lined up on Runway 14 and commenced the takeoff roll. After covering approximately 50 m the nosewheel struck a bump on the runway surface, which caused the aircraft to lift off prematurely, without having gained normal flying speed. The aircraft then turned to the left and, although the pilot applied right rudder, it was ineffective in correcting the heading. The pilot closed the throttle and applied the brakes, but the aircraft continued to travel towards the left

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side of the runway, beyond which was a row of parked cars. The aircraft was now heading in a direction that left the pilot no option but to apply full left rudder in an attempt to avoid the vehicles; this resulted in the aircraft turning through almost 180º from the takeoff direction. However, the tailgate of the vehicle at the end of the row was open, which allowed the right wing tip to contact the inside of the 'C pillar', causing the aircraft to swing round to the right and collide with the side of the car.

The pilot attributed the accident to the aircraft having become prematurely airborne at a low airspeed, where there was insufficient rudder authority to maintain directional control. He noted that the wind at the time was 110º at 12 kt.

A similar crosswind-related incident occurred to another EV-97 Eurostar aircraft, G-CFVI, at Peterborough on 3 April 2010. This was reported in AAIB Bulletin 9/2010, file reference EW/G2010/04/01.

Flight test

The original investigation of the amateur-built EV-97 type, to assess its suitability for the issue of a UK Permit to Fly, was carried out by the Light Aircraft Association (LAA). The LAA remain the body responsible for the continued airworthiness monitoring of amateur-built examples of the type.

Following the accident to G-IDOL the LAA conducted a flight test on a similar example of the type. The aircraft was evaluated against CS-VLA, which is a European Aviation Safety Agency design code (or Certification Standard) for Very Light Aircraft. It is similar to other codes used around the world and is the most common code for LAA aircraft.

Part 143 General of CS-VLA states that:

> '(a) *The aeroplane must be safely controllable and manoeuvrable during: –*
> *(1) Takeoff*
> *(2) Climb*
> *(3) Level flight*
> *(4) Descent*
> *(5) Landing (power on and power off) with the wing flaps extended and retracted.*
>
> *(b) It must be possible to make a smooth transition from one flight condition to another (including turns and slips) without danger of exceeding the limit load factor, under any probable operating condition.'*

For the purpose of the test flight, the aircraft was flown solo, with half fuel and no baggage, creating a mid centre of gravity (CG)/mid weight condition, with the lateral CG displaced to the left (the critical direction) due to the pilot occupying the left seat.

The test itself was conducted at an altitude of between two and three thousand feet, with an air temperature of around 20ºC. The aircraft was configured with the flaps retracted and full power, in climbing flight at 70 mph indicated airspeed (IAS). The airspeed was then progressively reduced by raising the nose, while noting the amount of right rudder required to maintain the slip ball in the centre, together with the adequacy of the lateral and directional control. It was found that the amount of right rudder required increased steadily with reducing airspeed, reaching full deflection at 40-42 mph IAS, which was the approximate speed of the power-off stall in this configuration. There was no sign of rudder stall at large deflections and the rudder response was judged to be linear up to full deflection.

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Raising the nose higher to reduce the airspeed further led to the slip ball moving to the left, together with a tendency to bank further to the left. However, this could be countered by the use of right aileron up to the onset of the stall at around 35 mph IAS. The behaviour in the stall was not explored due to the possibility of a spin developing with the aircraft in this extreme configuration.

Whilst at full power, at airspeeds of around 40-42 mph, the aircraft was allowed to develop a yaw to the left by using less right rudder than was required to centre the slip ball. It was found that yaw angles up to the maximum slip indicator amplitude could be reduced to zero by using additional right rudder. Throughout this manoeuvre there was no sign of fin stall at high yaw angles, or of rudder stall at high rudder deflections.

The above test was repeated with the flaps at the takeoff and landing settings; it was found that there was no detectable change in the lateral and directional control characteristics except that the stall speeds were slightly reduced compared with the flaps retracted condition. In consequence, greater aileron angles were required to level the wings at the point of stall.

The takeoff behaviour was also assessed, using full power, takeoff flap and a rotation speed of 45 mph rather than the 47 mph recommended in the Pilot's Operating Handbook. This test was conducted on a hard runway in nil wind conditions. There were no directional or lateral control difficulties and the aircraft showed no willingness to be 'hauled off' the ground at airspeeds of less than 45 mph. The effect of crosswinds on takeoff handling was not assessed, although clearly a crosswind from the left would require the application of right rudder.

Finally, the flight test report noted that the aircraft accelerated quickly between 30 and 60 mph on takeoff. However, in view of the risk of departure from controlled flight at low airspeeds, it would not be sensible to attempt to fly out of a bounce or premature takeoff at speeds below 45 mph IAS. The report suggested that, in the event that the aircraft is 'thrown into the air' below this airspeed, the aircraft should be allowed to sink back onto the runway, whereupon it would accelerate to a safe climb-away speed of 45+ mph in a few seconds.

Discussion

Any aircraft with a tractor-mounted Rotax 912 series engine will tend to swing to the left at low airspeed and full power, due to the effects of torque and the propeller slipstream. A crosswind from the left would exacerbate this tendency due to the aircraft 'weather-cocking' into wind. On the day of the accident to G-IDOL the wind was from approximately 30º to the left of the runway heading; any strengthening or backing of the wind vector would, in combination with the aircraft hitting the bump, have added to the pilot's difficulties in controlling the aircraft. Whilst it is not known if full right rudder was applied, the LAA flight test demonstrated that the aircraft is controllable, at least under flight test conditions, at low airspeeds providing full use is made of the rudder.

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ACCIDENT

Aircraft Type and Registration:	Aerotechnik EV-97 Eurostar, G-NIDG
No & Type of Engines:	1 Rotax 912-UL piston engine
Year of Manufacture:	2000
Date & Time (UTC):	8 February 2011 at 0900 hrs
Location:	Oldbury-on-Severn, Gloucestershire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Both wings, slight buckle in fuselage rear spar carry-through member
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	74 years
Commander's Flying Experience:	6,693 hours (of which 1,300 were on type) Last 90 days - 23 hours Last 28 days - 10 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The engine suffered a loss of power at a height of approximately 10 ft after the pilot inadvertently attempted to take off with the fuel selector in the OFF position. He landed ahead but was unable to stop the aircraft from overrunning the strip, passing through an electric fence and striking obstacles some 30 metres further on.

The pilot attributes the oversight to being in a hurry and allowing himself to come under unnecessary pressure. The cold and humid weather had caused problems of persistent canopy misting, requiring the use of a fan heater to achieve clear vision, and difficulty in engine starting, requiring use of the choke. The use of the latter culminated in the mixture becoming excessively rich, so he started the engine by selecting the fuel off (to give a leaner mixture) and then turning the fuel on again. He then taxied to the threshold, whereupon the canopy misted up again, forcing him to return to the hangar to repeat the process. He was eventually able to clear the canopy misting and proceed with the takeoff. However, he had forgotten to select the fuel on again after starting the engine and it cut out during the takeoff.

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ACCIDENT

Aircraft Type and Registration:	Cameron O-120 hot air balloon, G-BVXF
Year of Manufacture:	1994
Date & Time (UTC):	1 January 2011 at 0947 hrs
Location:	Midsomer Norton, Somerset
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Fatal) Passengers - 1 (Fatal)
Nature of Damage:	Balloon destroyed
Commander's Licence:	Private Pilot's Licence (Balloons and Airships)
Commander's Age:	42 years
Commander's Flying Experience:	194 hours on balloons Last 90 days - 2 hours Last 28 days - 0 hours
Information Source:	AAIB Field Investigation

Synopsis

The pilot was attempting to climb to an altitude of 6,000 m (approximately 19,700 ft). Having reached an altitude of 21,500 ft the balloon descended for about 80 seconds at approximately 1,500 ft/min. It then entered a rapid descent of approximately 5,500 ft/min from which it did not recover. In the latter stages of the descent the envelope was seen in a collapsed, 'streamered' state. There was a post-impact fire, which damaged much of the balloon basket and envelope.

The British Balloon and Airship Club (BBAC) and the balloon manufacturer actively assisted in the AAIB investigation. As a result of the accident the BBAC will be issuing guidance information for operation of hot air balloons at high altitudes.

Background information

One of the elements for award of the BBAC Gold Badge is to achieve a flight to an altitude of over 6,000 m amsl. The pilot was attempting this element. There have been 23 successful Gold Badge flights over 6,000 m altitude in the UK, and additionally there have been numerous flights over 4,000 m made by British balloon pilots in the Alps.

Members of the ground crew recalled that the pilot started planning for the attempt in October 2010. During the following months the pilot spoke to other balloonists experienced in high altitude flights, seeking advice from them. They all commented that, from the pilot's questions, they considered his preparation was thorough. The pilot acquired the Cameron O-120 from a leasing company on 19 December 2010; this was his first

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flight with a Cameron O-120 with a 'lock top' fitted. To reduce mass a smaller basket from another balloon was used. The pilot and passenger had flown together in this basket several times before.

The pilot obtained written approval for this altitude attempt in the form of an Airspace Co-ordination Notice from the CAA on 21 December 2010. This stated a 'launch window' from 27 December 2010 to 4 January 2011, with an estimated flight duration of 90 minutes, and '*vertical limits from the surface to FL210'*. The pilot was required to phone Bristol ATC 24 hours before the launch and on the morning of the flight, to discuss anticipated rates of climb and descent; this he did.

Aircraft description

The envelope was a Cameron O-120 which has a volume of 120,000 cubic feet (Figure 1). This type of envelope has a 'parachute valve' which allows the controlled release of hot air (venting) and, for landing, the complete deflation of the envelope. It takes the form of a circular parachute-style panel that seals on a circular opening in the top of the envelope (Figure 2). The parachute valve is held in place by a combination of the internal pressure of the hot air and a set of centralising lines inside the balloon (12 for this design of balloon). For venting, a red line is pulled in the basket and the valve is held open for a few seconds, whereas for deflation it is pulled further and held open until the envelope deflates.

This balloon envelope was fitted from new with a 'lock top' landing deflation system. This is a modified parachute valve, fitted to larger envelopes. The centralising lines are longer and allow the red vent line, and thus the parachute valve, to be pulled down further for faster final deflation. At the top of the envelope there is a large metal ring called the 'crown ring' and to

Figure 1

Envelope, G-BVXF

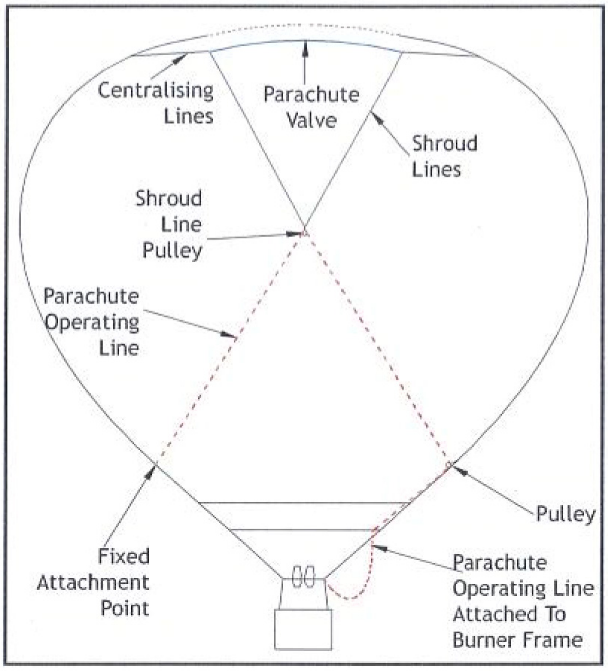

Figure 2

Parachute valve

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which the 'crown line' is attached; the other end of the crown line is free and is used for ground handling. The centre of the parachute valve is attached, on a lock top system, to the crown ring by a snap shackle (Figure 3). With the connection rings from the crown ring and the parachute valve secured inside the snap shackle the parachute valve can only be partially opened; this is to prevent the deflation mechanism operating without an additional control decision to arm the system.

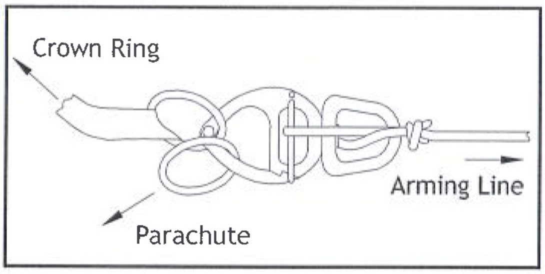

Figure 3
Release shackle assembly

On the final approach to land a yellow and black 'arming line' is pulled to release the snap shackle and a flag marker appears inside the envelope to indicate visually that the system is armed. With the system armed, the red vent line can then be pulled down to a position where the hot air will vent rapidly. Shortly after this point, re-inflation of the envelope will not be possible.

In preparation for launch the yellow and black arming line, and the red parachute valve operating line, are normally stowed by attaching their free ends to the burner frame.

This balloon was fitted with two burners. Each burner had a pilot light, a main burner and a 'whisper' burner. For this flight four gas cylinders were carried, with two connected to the burners at any time. The system featured a cross-flow valve, allowing both burners to be fed from one cylinder. Each cylinder had a pressure relief valve, which would activate in the event of elevated pressure, from exposure to a fire for example. Vertical control of the balloon in flight is achieved by a combination of use of the burners, natural cooling and by venting hot air through the parachute valve.

Two temperature sensors were fitted to the balloon. A 'temperature streamer' was fitted insider the top of the envelope and was held in place by a solder designed to melt at 127°C; if the temperature exceeds this value the solder melts and the streamer falls down through the mouth of the envelope alerting the crew. There was also a 'tempilabel' indicator, which is mounted in the top of the envelope and which has temperature-sensitive areas that change colour at different temperatures between 90°C and 150°C, thus providing a permanent record of the maximum temperature that the fabric has reached.

Two radios were carried, one for communication with ATC and one for use with the ground crew. A variometer/altimeter, which measures altitude and rate of climb and which belonged to the pilot, was fitted to the burner support frame. A transponder was also used which informed ATC of their altitude, and a barograph was carried to ratify the attempt.

This balloon type has been certificated to EASA.BA.013 which includes requirements for the ability to control the balloon safely during all phases of the flight.

History of the flight

The pilot, passenger and ground crew arrived at the launch site at Chelwood, 7 nm east-south-east of Bristol International Airport at approximately 0800 hrs on 1 January 2011. A BBAC observer was also present to ratify the flight.

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The rigging of the basket and the envelope proceeded under the supervision of the pilot. Just before cold inflation of the envelope it was noticed that the crown line was tangled around some of the crown webbing lines. This was untangled before cold inflation commenced. At about the same time, one of the ground crew, who was manning the line attached to the crown ring and who was also a trainee balloon pilot, noticed the lock top. Not knowing what it was he asked the pilot, who explained its usage, adding it was only to be used on the ground; he was heard doing so "in a confident manner". The same member of the ground crew also witnessed the pilot clip the lock top snap-shackle closed with at least one, and possibly two, of the rings required. Cold inflation was then completed without further event.

The pilot and passenger were both seen to don their supplementary oxygen system and test it (see the 'Personal equipment' section below for detailed description). They were heard to say they had set the flow rate to 4 litres/min. It is believed that the cylinder was then turned off to preserve oxygen.

After cold inflation the pilot inspected the balloon externally (twice) and internally, before hot inflation commenced. Hot inflation commenced using an external cylinder, which was subsequently disconnected and left on the ground as planned. This was to ensure the maximum amount of fuel from the four cylinders in the basket was available for the flight.

The pilot got into the basket first and the passenger then joined him whilst the balloon was still attached to a recovery vehicle by a tether. Witnesses observed that a parachute valve check was completed successfully by the passenger pulling on the parachute valve operating line and saying "parachute released", to which the pilot replied "yeah ok".

The pilot then coiled up the end of the lock top arming line and secured it under a Velcro tape, out of the way on top of the uprights on the burner frame and said "we don't touch that". It is believed, from photographs taken at the launch, that the lock top arming line had not been secured to the 'lower tie point' within the balloon envelope, leaving the possibility of the lock top being accidentally armed before the line was secured.

The end of the parachute valve operating line was attached to a cylinder and the end of the crown line was clipped to the frame.

At this point the pilot made a radio call to Bristol ATC requesting takeoff clearance. After takeoff the balloon was seen to rise quickly before it disappeared into the cloud.

The ground crew cleared the launch site and drove off in a south/south-easterly direction towards Radstock/ Midsomer Norton. The ground crew driver believed the flight would last at least one hour as the pilot had suggested that the descent would be at approximately 500 ft/min and hence would take around 40 minutes from 20,000 ft.

At about 0936 hrs the ground crew received a call from the passenger saying they were at 4,000 m and that they had burnt the fuel in the 60 litre cylinder , more than they had expected, and were not sure if they would achieve their objective. At the same time the pilot transmitted to Bristol ATC that they had a "small problem" with the balloon and were descending. The balloon was then observed on radar to continue climbing. About 2 minutes later the pilot transmitted to ATC that they had fixed the problem and were continuing the climb.

At 0940 hrs there was a short exchange between the pilot and ATC as he sought confirmation from the radar of

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their current passing level. After he was informed that the balloon was at FL205 he told ATC that they were "now descending". ATC transmitted their level as FL215 at 0942 hrs. This was the highest altitude indicated on the radar; there was no reply to this transmission. The ATCO later commented that he was not concerned when he saw the balloon pass FL210 in the climb. He added he would have questioned the pilot's intentions if he saw it climbing through FL250.

The ground crew heard from the passenger at about 0942 hrs when he transmitted that they were at 6,600 m (21,780 ft amsl) and were starting their descent. Nothing further was heard from the balloon by the ground crew or ATC. There was a carrier wave transmission at 0943 hrs, though its source could not be verified. There was no sign of stress in the voices of the balloon occupants during any of the transmissions.

The balloon was 'heard' by several witnesses and then seen in a 'streamered' condition by several witnesses as it appeared below the cloud falling vertically down at speed. Some of the witnesses believed they saw the burners lit during the final moments of the flight, which might have been indicative of attempts to re-inflate the envelope. The balloon crashed in Midsomer Norton, Somerset, on a bowling green, after which an intense post-impact fire ensued. Video footage of the fire on the ground was captured by a passer-by, in which intense vertical flames were visible from the location of the basket on the ground. Both occupants died as a result of the accident.

Weather information

An aftercast was provided by the Met Office for the period of the flight. In summary it stated that at the time of the accident the Midsomer Norton area was dominated by a ridge of high pressure. This maintained a fairly uniform sheet of broken or overcast cloud with a base of approximately 2,000 to 2,500 ft and a cloud top of 3,500 to 4,000 ft. Above this level the aftercast indicated that there was likely to be little or no cloud.

At the surface, the aftercast indicated that the visibility was 11 to 13 km and with a 5 to 10 kt westerly surface wind. The ground air temperature was approximately +4ºC. Through the depth of the atmosphere, the temperature fell with height to -34ºC at FL240, with the temperature at FL210 being -30ºC.

Wreckage site

The wreckage was located on a bowling green. The envelope had collapsed on top of the basket and there was significant fire damage. The crown ring had not fallen on top of the basket; instead it was approximately 8 m from the basket in a direction consistent with the wind direction. A fire had consumed most of the basket and most of the envelope within a radius of approximately 6 m from the basket. The parachute valve, which would normally be underneath the crown ring and inside the envelope, was found in a position consistent with the parachute valve having been above and outside the main envelope when the envelope struck the ground. The snap shackle was found in the open position and with the cord tangled around it several times. All the wreckage was found within the boundary of the bowling green club, and there was no evidence of an in-flight break-up.

The two burners were found intact and still attached to the burner frame; the latter was severely deformed, probably as a result of the landing forces. The pilot light on each burner was in the ON position, and on one of the burners the whisper burner control was in the half open position. Such a position would not be unusual and might have indicated that the whisper burner was effectively being used as a pilot light. At higher altitudes, where there

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is a reduced level of oxygen, problems with pilot lights can occur. Two of the propane cylinders were attached to the burners with both vapour and liquid hoses consistent with normal operation. There were two other cylinders. All four cylinders were found empty and fuel remaining in any of the cylinders would probably have vented out as a result of the pressure relief valves operating during the fire. There was significant heat damage to the cylinders' seals and the aluminium hand wheels on each of the main valves had melted.

The supplementary oxygen cylinder was found in the wreckage of the basket. It was badly fire damaged and the hand wheel on the main valve was missing. The short rod that connected the hand wheel to the main valve was found approximately 10 m from the cylinder and on an area of the bowling green away from other items of wreckage. There were scorch marks on the grass around the rod.

Aircraft mass

The Cameron O-120 envelope has a volume of 120,000 cubic feet, for which the flight manual specifies a Maximum Take Off Mass (MTOM) of 1,088kg. The Cameron Flight Manual (Issue 10, amendment 8) states:

> *'For balloons of 105,000 cubic feet and above the Minimum Landing Mass (MLM) for normal operations must not be less than 50% of the Standard MTOM. For special flights, record attempts etc., with only necessary crew on board, lower masses may be used at the pilot's discretion.*
>
> *The maximum rate of climb for balloons with a volume of greater than 105,000 cubic feet and less than 340,000 cubic feet is 1,000 ft/min.'*

The pilot had elected to fit a smaller basket from another balloon to reduce mass and hence give better climb performance. The estimate of the mass of the balloon at the apogee of the accident flight and at zero fuel is contained in Table 1.

	Mass at apogee (kg)	**Mass with zero fuel** (kg)
Envelope	145	145
Burner	24	24
1 x 60 litre cylinder (empty)	22	22
3 x 40 litre cylinders	102 (assumed 2 full cylinders)	60 (3 empty cylinders)
Basket	75	75
2 pilots + kit	180	180
Other equipment	27	27
Total	575 (53% of MTOM)	533 (49% of MTOM)

Table 1

Estimate of balloon mass

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Typical balloon operation tends to be at around 70-80% MTOM. This balloon was being operated close to the 50% of the MTOM limit, and as such would have had handling qualities that were slightly different from those at higher masses.

Flight Manual information for the parachute valve

The Flight Manual contains the following information in the Normal Procedures section for lock top operation:

> *'To release hot air during the flight the venting line should be pulled. Great care must be taken not to stall the parachute valve when the arming line is not used.*
>
> *Warning: in the unlocked state an extended pull on the parachute operating line beyond the limits in section 2.11 may cause the parachute to 'stall'. The parachute will not then re-close.*
>
> *Note: when the take-off mass of the balloon exceeds half of the standard MTOM, it is no longer necessary to arm the vent prior to use. It is therefore not necessary to rig the arming line after the parachute has been tabbed into place. Great care must be taken however not to stall the parachute when the arming line is not used.'*

And in Section 2.11 Limitations:

> *'The parachute valve must not be held open for periods longer than 3 seconds during flight. The envelope must be allowed to re-inflate fully and the envelope mouth must be seen to be fully open before subsequent operations of the vent.'*

Flight manual information for hard landings

The Flight Manual contains the following information in the Emergency Procedures section:

> *'If the rate of descent cannot be controlled, consider jettisoning all disposable ballast, including fuel cylinders which are not in use, if it is possible to do so without endangering people or property on the ground.*
>
> *A burner or envelope failure results in a 'heavy' landing where the speed is mostly vertical…*
>
> *In a heavy landing the occupants should brace themselves against vertical compression, with their knees only slightly bent. The rope handles or cylinder rims should be firmly held.…*
>
> *Extinguish the pilot light(s), shut off at all cylinders in use and empty the hoses if time permits.'*

Maintenance records

The balloon envelope had recently had its annual inspection and had been issued with a Certificate of Release to Service on 18 December 2010. The accident flight was the first flight of the envelope after the inspection. The envelope material had passed a 'grab test' to check the structural integrity of the material, 110°C was the recorded tempilabel value and the envelope had flown for a total of 270 hours at the time of the accident.

Recorded information

Radar

Recorded radar data from Clee Hill and Burrington radar heads, giving positional information for G-BVXF during the accident flight, were available for the investigation. The radar ground track is illustrated in Figure 4. The track starts at 0923:10 hrs just to the south-east of the launch site with the first altitude returns starting 4½ minutes later as the balloon passed through 6,300 ft amsl (probably when the transponder was switched on). The track ends at 0946:30 hrs north-east of the accident site with the balloon at 2,000 ft amsl (ie about 1,600 ft agl), descending rapidly.

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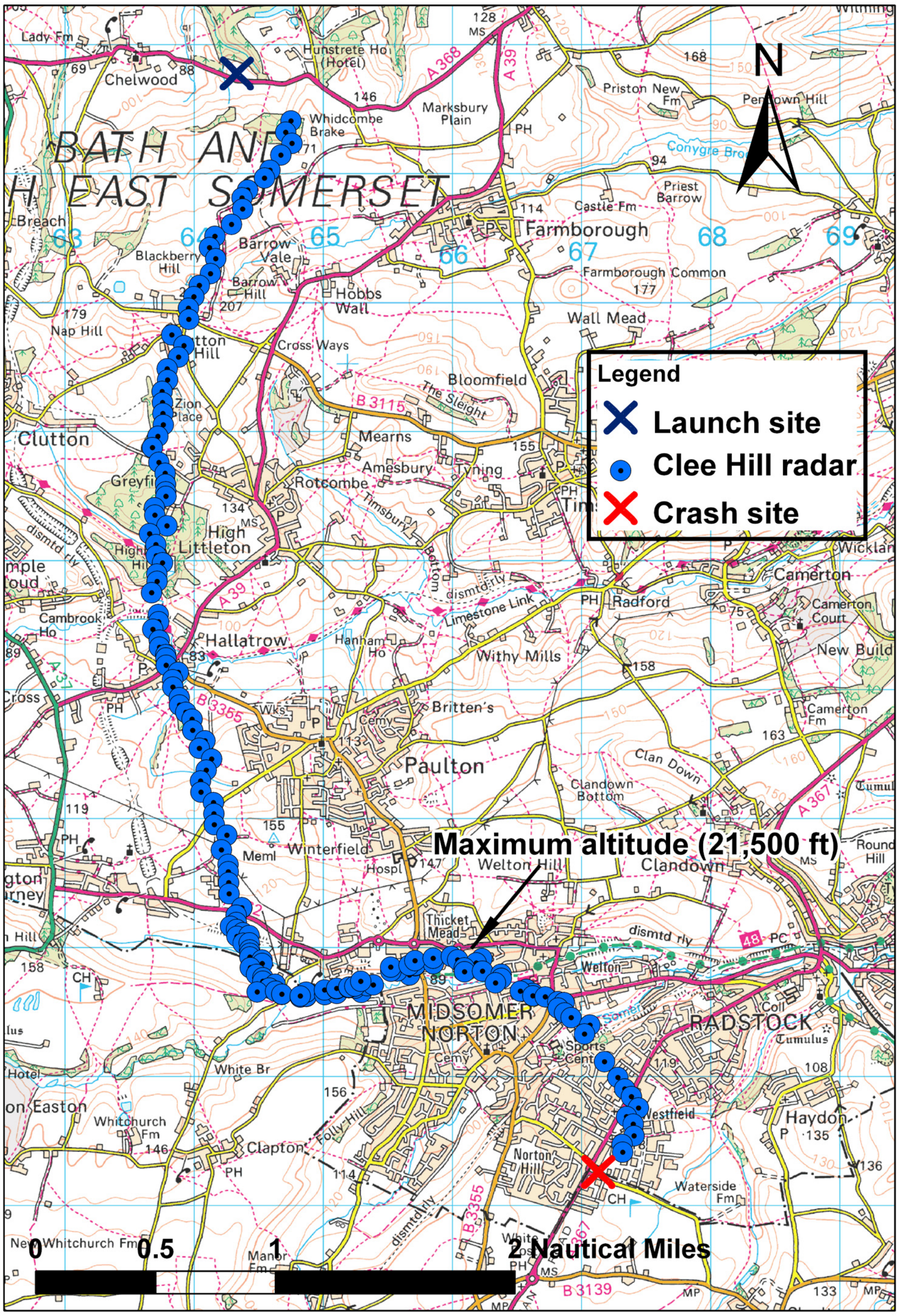

Figure 4

Accident track of G-BVXF from radar information

The altitude profile of the accident flight, near the top of climb, is shown in Figure 5 and shows that a maximum altitude of 21,500 ft amsl was reached just before 0942 hrs. The vertical climb rate and acceleration, calculated from the altitude and time information is also shown. During the ascent the rate of climb exceeded the 1,000 ft/min maximum specified in the Flight Manual.

The figure also compares the accident flight to a successful Gold Badge flight from a different, but similarly sized, balloon as well as to the non-fatal accident flight of N61ZL in the USA in August 2008. During the flight of N61ZL part of the top of balloon was destroyed by heat from excessive use of the burners and as a result the envelope deflated and 'streamered'[1].

Of note is that the transition from climb to descent for G-BVXF was more marked than the gradual transition on the comparison Gold Badge flight, which was made by turning off the burners and waiting for cooling to initiate a 'cold descent' and was without any venting.

There are broad similarities between the data for the G-BVXF and N61ZL accident flights. In the case of G-BVXF there were approximately 80 seconds of descent (after the maximum altitude) at approximately 1,500 ft/min before it commenced a high-speed descent at around 5,500 ft/min. This high-speed descent from 19,750 ft to the ground took approximately 3½ minutes. It was confirmed by calculation that the gradual decrease in rate of descent was consistent with the air density increasing closer to the ground and hence the balloon was almost certainly 'streamered' for these 3½ minutes.

Footnote

[1] Source: National Transportation Safety Board - August 2008 Aviation Accidents

GPS and loggers

A number of GPS units and flight data loggers were recovered from the accident site; however, these were damaged during the post-impact fire such that no recorded data was recoverable. No meaningful information could be obtained from the memory in the variometer/altimeter.

Detailed examination of the wreckage

The envelope was inspected. Approximately 40% of the area of the envelope had been destroyed by fire and there was no evidence of a significant tear in the remaining panels. The panels that were fire damaged were those closest to the basket at the wreckage site, which was consistent with fire damage occurring on the ground. Several panels were 'grab' tested by an experienced BBAC inspector to assess the material strength of the canopy; all panels that were tested passed the test.

The tempilabel indicated that 121°C had been reached on the accident flight, as this was the first flight since the envelope inspection (when the tempilabel was noted as 110°C). The tempilabel was sufficiently far from fire damaged panels that it was unlikely to have been affected by heat from the post-impact fire. The temperature streamer was missing (it was present before flight), indicating that 127°C had been reached. Whilst the solder attachment for the streamer was within a metre of part of the envelope that had been heat damaged, there were no traces of solder close to the attachment location and hence it was concluded that the temperature streamer had dropped during the flight. Although the envelope had exceeded 127°C during the accident flight, this slightly elevated temperature was not considered a factor in the accident.

A detailed inspection was made of the top of the envelope, including the parachute valve, and approximately 30% by

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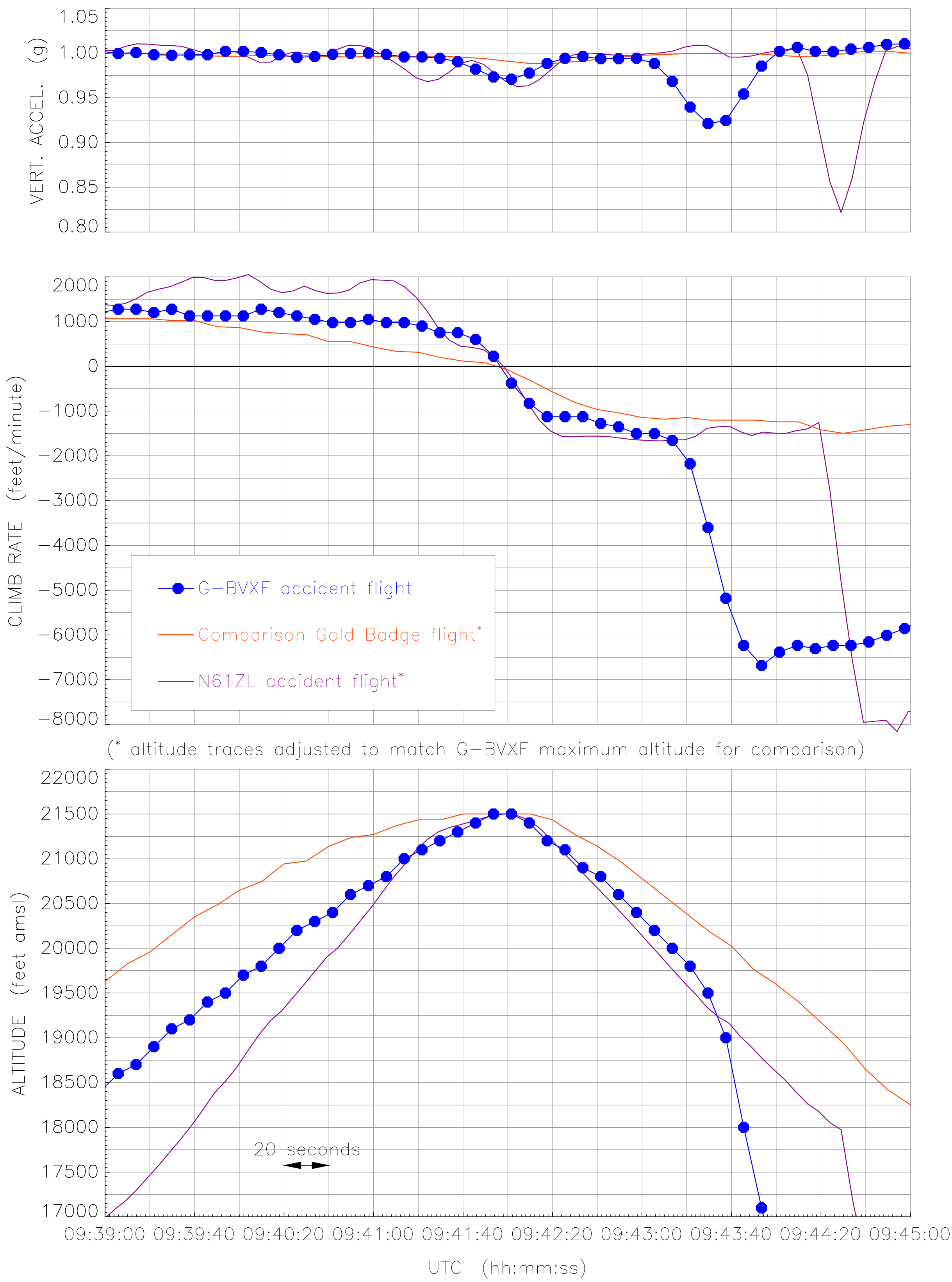

Figure 5

Altitude, climb rate and acceleration comparison at top of climb of G-BVXF, 'Gold Badge' flight and accident flight of N61ZL. Climb rate and accelerations calculated from altitude and time information

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area of the parachute valve had been destroyed by fire. There was a small tear, approximately 35 cm long, across the central circular panel, a complicated tangle of line around the snap shackle and several areas of damage to the loading tapes. All these areas of damage could be explained by turbulent aerodynamic forces on the collapsed envelope taking place over a significant period of time, possibly several minutes. The snap shackle was found to operate correctly, and it was concluded that for the complicated tangle to occur the snap shackle would have to have been open for a significant portion, if not most, of the descent. It was also concluded that the parachute may have exited through the crown aperture during the descent, the mechanism for this being the parachute capturing a small amount of air and the main envelope 'concertina-ing' in the turbulent flow.

The four propane and the oxygen cylinders were inspected and filled with water to check for leaks; no leaks were found.

Personal equipment

The pilot had hired a supplementary oxygen system which supplied oxygen from a single bottle which was connected to individual pulse dose meters and then to nasal cannulae (Figure 6). The oxygen bottle had a hand wheel to open and close the main valve, mounted at the top of the cylinder, and next to the valve was a regulator. The regulator had a rotary flow control, with an integrated dial for flow settings 1-6. The nasal cannulae were mounted in a circular length of tubing placed over the wearer's head, and this circular tube was connected to the output of the individual pulse dose meters.

The system was hired a few days before the accident with a cylinder pressure of 200 bar, which was sufficient oxygen for approximately 4 hours for two adults. The equipment that was hired included four nasal cannulae; two had an additional in-line indicator mounted 100 mm from the end of the circular length of tubing, such that each time oxygen is supplied a bright green indication is made, and two cannulae were without the inline indicator. A review of photographs taken just prior to the flight confirmed that the supplementary oxygen system appeared to have been set up correctly; however, both occupants were wearing the cannulae without the in-line indicators. The passenger was wearing the oxygen bottle in a bespoke rucksack, with the hand wheel valve and regulator exposed at the top of the rucksack behind his neck, in this position the valves would not have been readily accessible to the passenger.

Neither occupant was wearing a parachute.

Inspection of supplementary oxygen system

The remains of the supplementary oxygen system were inspected. The two pulse dose meters and nearly all of the tubing were not found and would have been destroyed in the fire. The oxygen cylinder was inspected with the manufacturer present. Whilst the hand wheel for the valve was missing, probably consumed in the fire, it was possible to determine with high confidence that both the

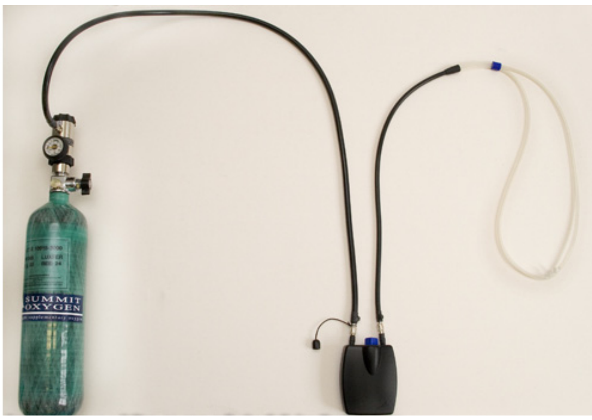

Figure 6

Supplementary oxygen system similar to that carried on the accident flight (one pulse dose meter and one nasal cannula attached) main valve and the regulator were closed. Either one of these being closed would result in no oxygen being supplied to either pulse dose meter.

There was no oxygen left in the cylinder and there was damage to the housing for the main valve. This damage, and the fact that the connecting rod for the hand wheel had been found approximately 10 m from the oxygen cylinder at the wreckage site, was strong evidence that the oxygen cylinder had contained gas at pressure when the balloon struck the ground, and that the pressure had been released as a result of the post-impact fire.

Medical information - hypoxia

A lack of oxygen in the blood and ultimately the brain is a condition known as hypoxia. The effects of hypoxia on the individual are related to altitude and are for practical purposes negligible under 10,000 ft for a healthy individual. As altitude increases then the effects of hypoxia become more pronounced although there is considerable variation between individuals. At between 10,000 and 15,000 ft symptoms in resting individuals are likely to be minimal, but mental performance is likely to be impaired. At between 15,000 and 20,000 ft mental performance deteriorates further, with loss of critical judgement and mood changes, and a lack of awareness of the adverse effects. Above 20,000 ft the symptoms are markedly worse and unconsciousness can rapidly occur.

At 22,000 ft (just above the peak altitude of the accident flight) the time of useful consciousness is around 10 minutes, although there is great variation depending on the individual. This figure also relates to sudden exposure to that altitude. A gradual increase in altitude, as happened during this flight, would mean that the effects of hypoxia would build up during the ascent, so the time of useful consciousness at the peak altitude would be considerably less than this figure.

Medical information - pathology

The post-mortems were carried out by a consultant aviation pathologist. He concluded that the pilot was killed as a result of the injuries sustained in the impact. The passenger, while severely injured in the impact, died in the post-impact fire. There were no signs of drugs or alcohol in either occupants' blood.

The pathologist reviewed the photographs taken before the flight to assess the suitability of the occupants' clothing. Both occupants appeared to have been wearing warm clothing suitable for use at or around sea level in the UK on a cold day in winter. Physical activity and exposure to a cold environment increases the body's demand for oxygen. Whilst it is unlikely that the occupants would have been engaged in strenuous physical activity, they would have been exposed to an outside air temperature of -30°C at the peak altitude. The pathologist commented that, if the occupants' clothing did not keep them thermally neutral, then they would have had an increased susceptibility to hypoxia.

Pilot's and passenger's experience

The pilot gained his PPL(B) in November 2001. He had logged a total of 194 hrs, of which 160 hrs were in command, in various types and sizes of envelopes. While some of the types listed had a rapid deflation system none of them had a lock top fitted.

He worked for the balloon manufacturer from April 1995 until June 1997 and again from May 1998 until 2004. During that time he was employed principally as a mechanical engineer working on burner units. However, he also often acted as a member of the team taking balloons out for test inflations where he may have helped to operate some of them on test and gained some knowledge about lock tops.

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The passenger had completed his PPL(B) General Flying Test (GFT) on 14 April 2010 and had a total of 39 hours under training. As he had not completed his ground exams he had not applied for his licence to be issued. His log book showed that he had predominately flown with the accident pilot since he had completed his GFT. He had no experience of lock tops.

The pilot had used a nasal cannula on a flight to approximately 12,000 ft amsl in 2003, albeit using a different supplementary oxygen system from that on the accident flight. The other occupant on that occasion noticed that the accident pilot was breathing through his mouth for the majority of the time.

There was no evidence that either occupant had experience of flying in controlled airspace at altitude.

Analysis

There were several items that require analysis to determine the causal or contributory factors in this accident.

Radar information

A key piece of evidence was the height profile from the radar, Figure 5. Comparing the altitude profiles of the accident flight with another Gold Badge flight (for which the descent was initiated by not using the burners and not venting) strongly suggests either the envelope of G-BVXF was vented or there was a significant leakage of hot air due to an envelope failure. The high rate of ascent, which reduced only slightly prior to the apogee at 21,500 ft, is indicative of an intact balloon envelope at that stage; it is likely that the CAA approval to FL210, already passed, could have led the pilot to decide to initiate a more rapid descent than he had originally planned.

Supplementary oxygen system

Another key piece of evidence was that the main valve, and the regulator, on the oxygen cylinder were found in the closed position. It is possible that these had been opened at high altitude but were closed during the descent. However, given that both valves were found closed, that the valves were located in a rucksack and hence not readily accessible, and that the pilot and passenger were probably focussed on trying to re-inflate the envelope during the rapid descent, the closing of the valves during this descent is unlikely.

There was evidence from the communications with Bristol ATC that both occupants were conscious and not in distress just prior to the descent. The radio call suggested that the descent was being initiated, which implies that a pull on the parachute valve line was planned, rather than simply turning off the burners and allowing time to transition to a cold descent. If the supplementary oxygen was not being used during the flight then the occupants would have been subjected to conditions where hypoxia would have had the potential to affect their decision making, their performance and, ultimately, the ability of the pilot to control the aircraft safely.

Envelope inspection

The inspection of the envelope did not reveal any abnormality that could have contributed to the accident. The tear in the parachute valve, which probably occurred after the balloon was 'streamered', was in itself too small to cause the envelope to deflate rapidly and would not have significantly affected flight performance. The temperature indicator revealed that the balloon had been hot, but not excessively so, and hence any heat-induced failure of the envelope is unlikely. There was significant fire damage to the envelope, which could readily be explained by the proximity of these areas of the envelope to the basket where video evidence confirmed there was an intense ground fire. If there was a large tear at the top of the balloon, the evidence could have been destroyed by ground fire. However, such a tear would have to have occurred shortly after the radio call informing that the descent was commencing, which, whilst possible, is very unlikely.

Post-impact fire

The pilot lights and burners were found in positions that were reasonable for normal operations. At high altitudes pilot lights are susceptible to going out and a partially open whisper burner being used as a pilot light is not unusual. Given the 3½ minute duration of the descent with the envelope collapsed, the pilot and passenger did, in theory, have enough time to shut off the cylinders and switch off the pilot lights; however, they were probably focussed on trying to re-inflate the envelope. Whilst it was not possible to determine precisely how the ground fire started, the pilot lights and/or the whisper burner would appear to be the most likely ignition source, with propane (either through fuel pipes or through a leak or rupture sustained when the system struck the ground) being the most likely fuel source. Once the fire took hold, propane in the remaining cylinders would have been vented through the pressure release valves, supplying additional fuel to the ground fire.

Pilot's experience

The pilot had flown several types of balloon and was familiar with the basket and burner systems used on the accident flight. However, he might have found this flight challenging given that:

a) This was the first flight he had made with a lock top deflation system

b) This flight was made with a large balloon, at a low mass and at a high rate of climb, which probably handled differently from other combinations he had flown

c) He had not used this type of supplementary oxygen system before

d) He may have been concerned about exceeding his altitude clearance with ATC.

It was not possible to determine accurately how much the pilot knew about the lock top deflation system, but he did have 194 hours on all balloon types and had significant experience with parachute valve systems. The evidence from the ground crew suggests that the lock top was correctly rigged prior to flight. The comments the pilot made about the lock top arming line suggests that he was aware that care was required when using it.

Parachute valve operating and lock top arming lines

The parachute valve operating line was attached to a cylinder prior to launch. This is not the normal location and there is a possibility that it did not allow sufficient slack in the line to accommodate changes in the envelope shape during the climb. However, it is considered very unlikely that this was a factor in the accident.

Witnesses observed that the lock top arming line was secured to the burner frame prior to launch, although the line had not been secured to the 'lower tie point' within the envelope. There is, therefore, a possibility that the lock top might have been inadvertently armed before the line was secured. However, had this occurred, a flag marker would have appeared within the envelope and it is considered unlikely that an inadvertent arming was a factor in the accident.

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Summary

There was no evidence of a technical defect in the balloon or of an in-flight structural failure. It is likely that the accident occurred as a result of some combination of a mishandled parachute valve, inexperience of lock tops, inexperience with a large balloon at high rates of ascent, degraded human performance due to some level of hypoxia and pressure to descend as the approved Flight Level was about to be breached. However, it was not possible to determine which factors were most applicable in this accident.

Safety advice and safety actions

The advice and warnings in the Flight Manual about use of the lock top deflation system and venting line are considered valid and hence no additional safety action or Safety Recommendation is appropriate.

The post-mortem revealed that one of the occupants survived the ground impact, but not the post-impact fire. Both pilot lights were found in the ON position, and one of the whispering burners was partially open. Had the valves on the propane cylinders been closed and the pilot lights extinguished, the accident might have been survivable. The advice in the Flight Manual is considered valid and is as follows:

'If the rate of descent cannot be controlled, consider jettisoning all disposable ballast, including fuel cylinders which are not in use, if it is possible to do so without endangering people or property on the ground.

A burner or envelope failure results in a 'heavy' landing where the speed is mostly vertical…

In a heavy landing the occupants should brace themselves against vertical compression, with their knees only slightly bent. The rope handles or cylinder rims should be firmly held.…

Extinguish the pilot light(s), shut off at all cylinders in use and empty the hoses if time permits.'

It was apparent during the investigation that the pilot of G-BVXF had prepared for this flight over several months. However, it is possible that relatively small changes in the conduct of the flight, such as initiating a cold descent near the apogee, might have resulted in a safe outcome and as a result of this accident the BBAC is producing guidance information for high-altitude flights. This will cover, for instance, changes in balloon handling qualities at high rates of climb and low mass, use of burners and pilot lights, clothing, planning, use of oxygen systems, ATC and wearing a parachute.

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ACCIDENT

Aircraft Type and Registration:	EV-97 TeamEurostar UK, G-CEDV
No & Type of Engines:	1 Rotax 912-UL piston engine
Year of Manufacture:	2006
Date & Time (UTC):	20 June 2011 at 1510 hrs
Location:	Private Strip, Grove Farm, Wolvey, Leicestershire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	The right main landing gear and right wing were damaged
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	48 years
Commander's Flying Experience:	191 hours (of which 43 were on type) Last 90 days - 10 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The aircraft joined a right hand circuit pattern for grass Runway 11 at a private landing strip. The runway was 350 m in length and 14 m (45 ft) wide. On each side of the runway was a standing crop of oilseed rape, some 4 ft high. The surface wind was light and variable in direction, mainly along the runway or slightly from the right.

The approach and touchdown were reported as normal. When the nosewheel was on the ground, the pilot applied the brakes but, as the speed reduced, the aircraft drifted to the left. The pilot was looking ahead along the runway and did not appreciate the proximity of the vegetation to his left. The left wing made contact with the crop and the aircraft immediately slewed round to the left. Its nose entered the crop and the engine stopped.

There was a small drop at the edge of the runway by the cultivated area and, as the aircraft crossed this, damage was caused to the right main landing gear and the right wing. The pilot and his passenger, who were both wearing full shoulder harnesses, were uninjured and vacated the aircraft unaided after it had been shut down.

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ACCIDENT

Aircraft Type and Registration:	Magni gyroplane M24C Orion, G-CGTI
No & Type of Engines:	1 Rotax 914-UL turbocharged piston engine
Year of Manufacture:	2010
Date & Time (UTC):	28 April 2011 at 1131 hrs
Location:	North of Hilltop Way, near Old Sarum Airfield, Wiltshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Fatal) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence (Gyroplanes)
Commander's Age:	51 years
Commander's Flying Experience:	128 hours (of which 25 were on type) Last 90 days - 20 hours Last 28 days - 7 hours
Information Source:	AAIB Field Investigation

Synopsis

The pilot departed Old Sarum Airfield for a local flight in his M24C gyroplane and shortly after it became airborne the 'gull-wing' door was seen to open to the horizontal position. The pilot made a radio call that he had a problem with the door and intended to return to the airfield. The aircraft continued around the circuit until the end of the downwind leg, where the pilot appeared to position the aircraft to land in a field. At the end of the flight the engine noise was heard to reduce and the aircraft was seen to roll to the left before it crashed into the field and caught fire. The investigation established that at the start of the flight the pilot's door appeared to be closed but the latching mechanism had not locked the door in the closed position.

As a result of the findings of the investigation a number of safety actions were taken by the aircraft manufacturer's UK representative and the Civil Aviation Authority. One Safety Recommendation is made to the Civil Aviation Authority.

History of the flight

The pilot arrived at Old Sarum Airfield, Salisbury, at around 0900 hrs and conducted the pre-flight check of his gyroplane, which had approximately 40 ltr of fuel onboard. He then lent the aircraft to the instructor who had taught him to fly gyroplanes for a five-minute flight with a passenger. The instructor departed the airfield at 1033 hrs and subsequently advised the investigation

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that the aircraft had performed normally and he had no difficulty in closing and locking the aircraft doors.

The pilot completed the preparations for his flight and at 1120 hrs called Old Sarum Radio to request airfield details for a local flight to the south and was advised that Runway 06 was in use with a right hand circuit. The aircraft was then seen to taxi to the holding point where the pilot conducted the power checks and at 1128 hrs called ready for departure. The ground radio operator passed the surface wind as 030º at 10 kt and as there was no traffic to conflict with G-CGTI the pilot commenced his takeoff run. At this time there were two other aircraft in close proximity to the airfield: a fixed wing aircraft joining the circuit on the base leg and a gyroplane on the downwind leg, piloted by a student and the instructor who had flown G-CGTI earlier in the day.

The radio operator observed G-CGTI commence its takeoff run, with its doors apparently closed. The aircraft then disappeared from view and when the operator next saw it, at a height of about 15 ft, it had a marked right yaw, right roll and the left door was open in the horizontal position. The aircraft recovered to a more normal attitude and climbed to approximately 300 ft agl before turning onto the crosswind leg. It was then seen to continue to climb and fly around the circuit at what appeared to be the normal height of 600 ft for this type of aircraft. Shortly after turning onto the crosswind leg the pilot made a radio call, indicating that he had a problem with his door and he was returning to the airfield. Once the radio operator acknowledged the call, the pilot's instructor made a radio call to G-CGTI advising the pilot to "ignore the door and to concentrate on flying the aircraft." The instructor, aware that there was an aircraft joining on left base, also declared an emergency on behalf of G-CGTI to ensure he received priority to land.

The gyroplane continued along the downwind leg, at what appeared to be a faster speed than normal, and after turning onto the base leg it was seen to descend rapidly and perform a tight right turn. When the aircraft was close to the ground it appeared to flare and momentarily stopped descending before it rolled to the left and crashed. The pilot of the aircraft joining base leg observed the accident and made the radio call "the gyro has crashed, it's burst into flames". The instructor in the gyroplane, who had just carried out a 'touch-and-go' on Runway 06, saw the smoke from the accident site and flew immediately to the area, landing in the same field as G-CGTI. His student left the aircraft to offer assistance to the pilot, but the intense fire prevented him, and other individuals in the immediate vicinity, from approaching the scene.

Witnesses

In addition to two witnesses in the tower, there were a number of other witnesses at the airfield who were consistent in their reports of the flight path and attitude of the gyroplane as it flew around the circuit. However, there was inconsistency as to the direction of the final turn.

A gyroplane student observed the aircraft shortly before it crashed. He had a good view of the left side of the gyroplane and noticed that the aircraft was slightly lower and seemed to be flying faster than normal, but he did not recall seeing either of the doors open.

The pilot in the aircraft, which was joining base leg, observed the gyroplane perform a tight turn into wind (030°) over a large flat field in which it appeared that the pilot of G-CGTI was attempting to land. He then saw G-CGTI "roll to the left and it appeared to hit the ground instantly and within a couple of seconds it burst into flames".

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Witnesses in the area of the accident site describe the aircraft flying very fast and very low, in an unstable manner. They described a tight right turn, low over a housing estate, followed by a flare when the aircraft stopped descending. There was then a marked reduction in the noise produced by the engine, followed by the gyroplane rolling rapidly to the left and the nose dropping before the aircraft struck the ground. None of these witnesses could recall seeing the gyroplane's doors open.

Weather

The general situation, at the time of the accident, was dominated by high pressure, with very little or no cloud, no significant weather, and good visibility. There was a north to north-easterly wind with the surface wind at Old Sarum being 030º at 10 kt and the wind at circuit height was calculated to be 040º at 16 kt. Flying conditions at the time of the accident were described by the instructor as moderately bumpy.

Pilot's background

In June 1996 the pilot started learning to fly helicopters and was awarded his Private Pilot's Licence (Helicopters) in January 1997. His last recorded flight in command of a helicopter was in April 1997.

In July 2010 the pilot commenced his training in gyroplanes, predominantly on the Magni M16C, and in September he test flew a M24C and ordered an aircraft shortly afterwards. He was awarded his Private Pilot's Licence Gyroplanes PPL(G) in January 2011 and immediately commenced his conversion training onto the M24C, which he completed in February 2011. He then continued to fly with his instructor, completing his first solo flight in the M24C in April 2011. At the time of the accident the pilot had a total of 12:55 hrs in command of gyroplanes, with 2:35 hrs in command of the Magni M24C. The pilot's training records show satisfactory progress throughout the PPL(G) course.

Pathology

The post-mortem report concluded that the pilot died of multiple injuries sustained during the initial impact and the forces involved were such that the accident was not considered to be survivable. No evidence was found of natural disease which could have contributed to the crash. Toxicological analysis of the pilot's blood concluded there were no traces of alcohol or drugs.

Recorded information

Introduction

A portable GPS, operating a SkyDemon-manufactured flight planning software application, was recovered from the aircraft and found to contain a partial track log of the accident flight. The track log provided aircraft GPS-derived position, altitude and groundspeed recorded at a nominal rate of once every ten seconds. Track log information is automatically stored when the groundspeed exceeds 35 mph. Logging stops when the GPS is turned off, the SkyDemon software application is manually stopped, the groundspeed remains at less than 12 mph for a period of 20 seconds or the GPS signal is lost for a period of 30 seconds.

The aircraft was also equipped with an engine health monitoring system. However, the unit was severely damaged during the accident and no data could be retrieved. Recorded radar data was not available.

Interpretation of GPS data

A total of 14 data points were recorded over a period of two minutes eleven seconds. From the GPS groundspeed, an approximate airspeed has been derived based on a calculation of the wind at 600 ft being from 040° at 18 mph.

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At 1127:23 hrs, with the aircraft positioned near to the threshold of Runway 06, the first data point was logged at a ground speed of 37 mph and at a recorded altitude within 11 ft of the actual terrain altitude. The aircraft then proceeded to track the runway before climbing and making a right turn (Figures 1 and 2). The aircraft climbed steadily at an average rate of approximately 500 ft/min and an average airspeed of about 79 mph, whilst positioning onto an approximate downwind track.

At 121 seconds after the initial data point, the aircraft was at an altitude of 872 ft amsl (587 ft above nominal airfield level - the published circuit height at Old Sarum was 600 ft for this aircraft type). Ten seconds later, at 1129:34 hrs, the final data point was recorded. The altitude was the same as the previous data point, being 872 ft, although the airspeed had increased from approximately 84 mph to about 99 mph, which is faster than the typical airspeed of 60 to 70 mph. The aircraft was on a track of 291° and due to rising ground the approximate height reduced to 525 ft. The final position placed the aircraft 160 m to the west of the accident position and approximately 0.5 nm from the threshold of Runway 06.

The track log file was closed at 1130:04 hrs, indicative that the GPS signal had been lost for the past 30 seconds. The reason for the loss of the GPS signal could not be fully established. However, as no external GPS antenna was fitted, it is most likely that the aircraft entered a series of

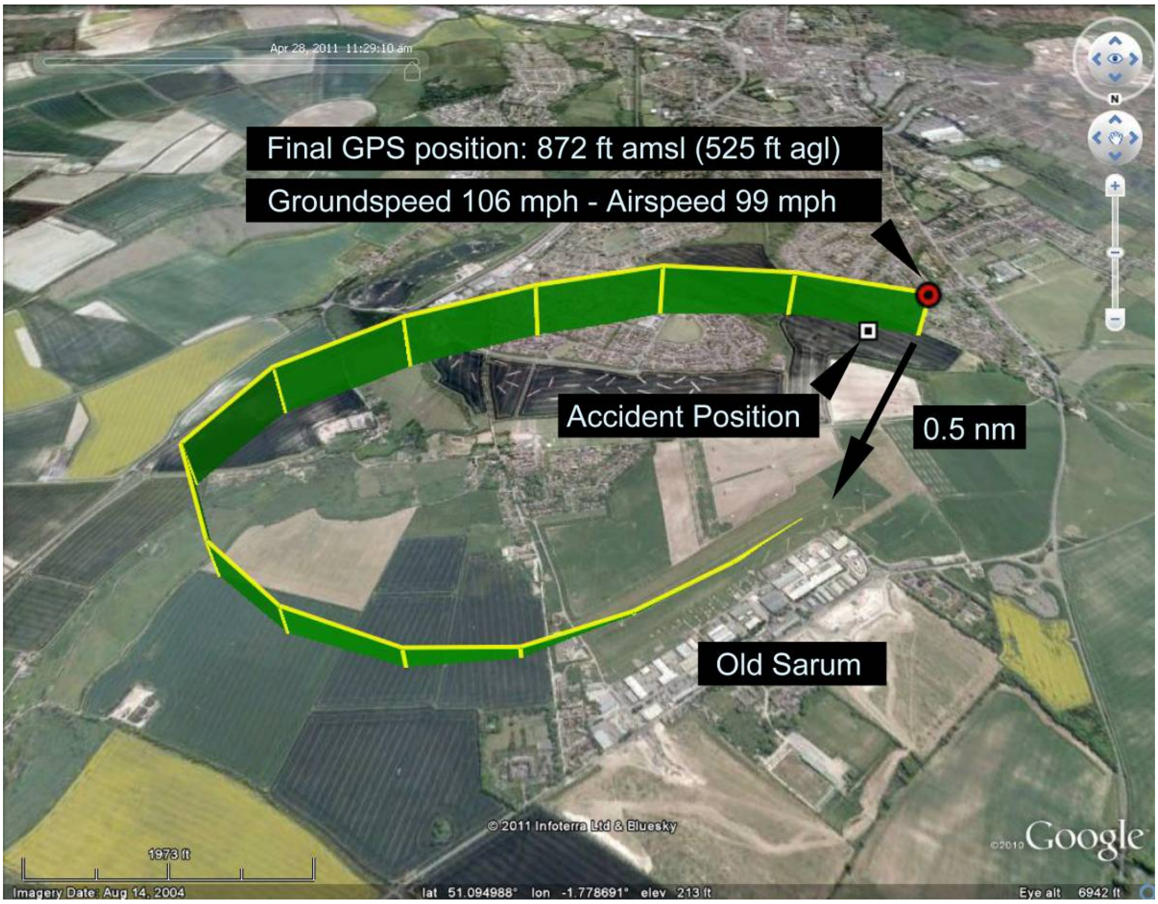

Figure 1

GPS Track from Old Sarum (view looking south)

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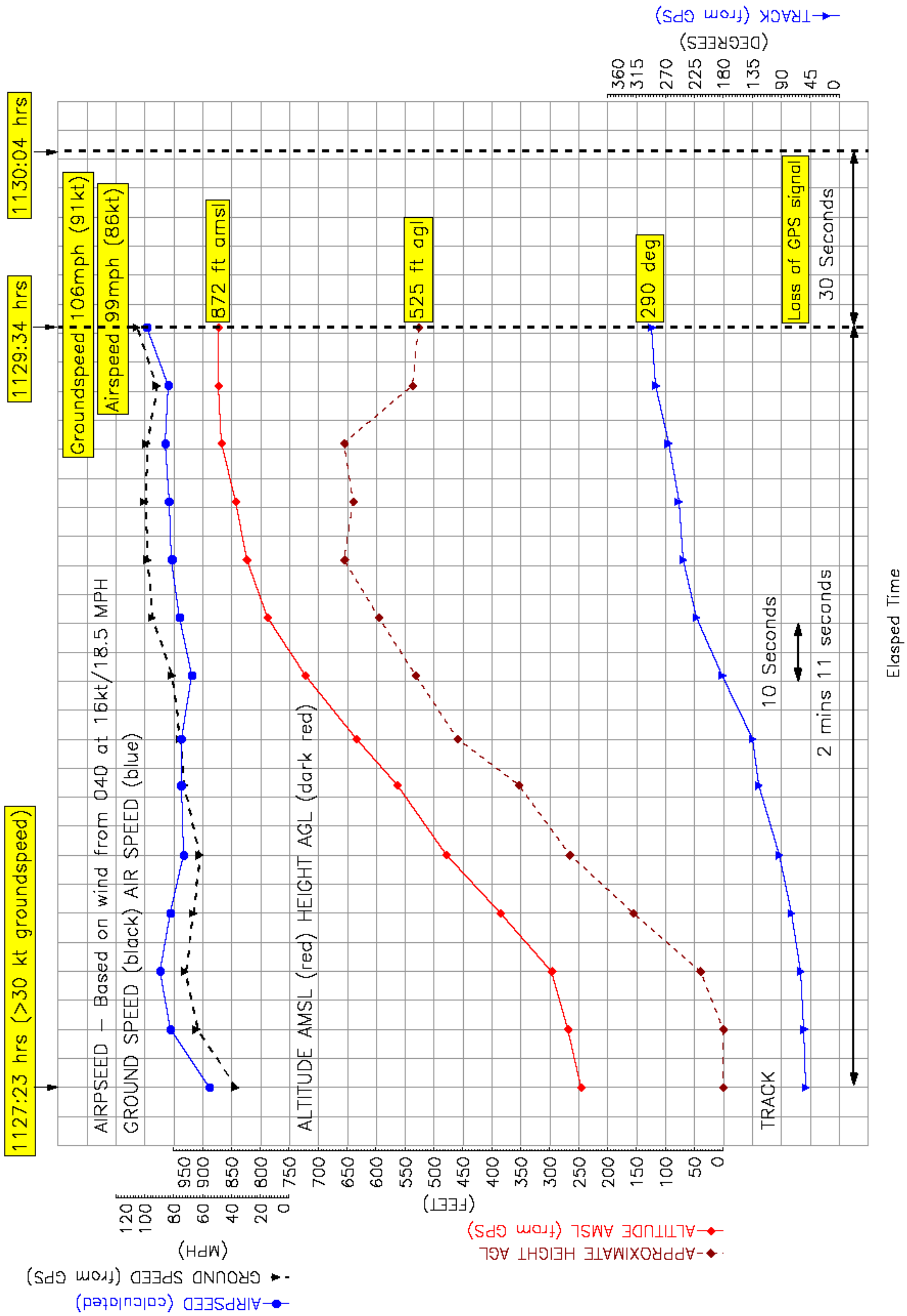

Figure 2

GPS Track points with derived airspeed

manoeuvres that resulted in the aircraft structure shielding the GPS unit from satellite signals. Further, it could not be established if the aircraft was still in flight when the track log stopped or if the unit had continued to operate after the aircraft had impacted the ground. Considering the impact forces though, it is likely that the track log was ended whilst the aircraft was still in flight.

Analysis of the data by the aircraft manufacturer indicated that the airspeeds and climb rate were consistent with maximum, or near to maximum, engine power having been selected throughout the period of the recorded data.

Aircraft information

The M24C (Orion) is a two seat, side-by-side, enclosed gyroplane powered by a 115 Hp Rotax 914 turbocharged piston engine. The aircraft is built around a steel keel and mast with the tail section, landing gear beam, 82 ltr fuel tank and rotor blades manufactured from glass fibre composite material. The cabin and door frames are manufactured from a carbon fibre composite. Both occupants are restrained by four-point harnesses and are provided with seat cushions made of energy-absorbing 35 mm CF-45 Dynaform. Ventilation of the cockpit is achieved on the ground by opening the doors and in flight by air passing through two air vents at the base of the windscreen and through a heating duct located behind the pilot's head.

A 'gull-wing' (upward opening) door is fitted to each side of the cockpit and is attached to the aircraft by a hinge fitted to the top edge of the door frame, see Figure 3. A strut is fitted to the rear of the door and holds the door open when the aircraft is on the ground; the strut also limits the upward movement of the door. The door is secured in the closed position in flight by two spigots mounted on the lower section of the door frame, which

Figure 3

Door arrangement

engage in locating blocks mounted on the inside of the door sills.

The spigots are locked in place by shoot bolts operated by the door lock levers. The bolts are in the unlatched position (open) when the internal lock lever is just aft of the vertical and in the latched position (closed) when the internal lock lever is in the forward, over-centred position, flush with the door sill, see Figure 4. A 'knob' on the lower part of the door frame allows the door to be held closed while the locking mechanism is engaged. While the doors may be open during taxi, the aircraft is not approved to fly with them in the open position.

With regard to the closing of the doors the flight manual states:

'Grab the frame of the door and lower it.

Close the door pulling on the knob.

Engage the pins of the locking system lowering the lock lever.

Visually check that both pins (front and rear) have engaged securely.'

The investigation determined that it requires two hands to close and lock the door. Moreover, it is not possible to check visually, while seated in the aircraft, that the rear spigot is latched in the locating block by the shoot bolt. The only way to check that the spigots are correctly engaged and latched is to push on the door.

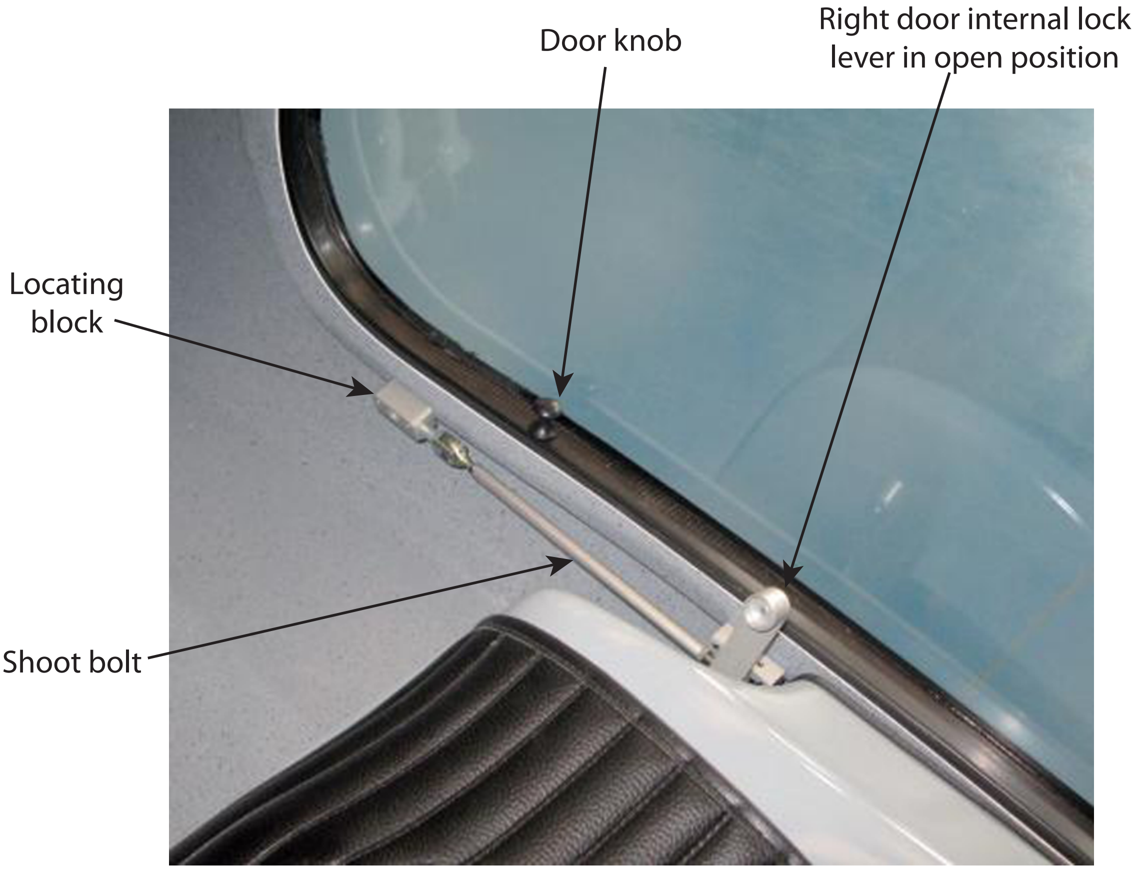

Figure 4

Right door operating mechanism

The internal locking lever on the left door is designed such that, when the locking lever is in the unlatched position, contact between the wheel brake operating lever and the internal locking lever limits the forward movement of the throttle lever, see Figure 5. On the aircraft examined by the AAIB, it was noted that with the relative positions of the levers shown in Figure 5, the shoot bolts prevent the spigots from fully engaging in the locating blocks. Thus, if an aircraft takes off with the door lock lever in the closed position, but the door spigots are not latched, the pilot would first have to close the throttle, at least partially, in order for the door lock lever to be moved rearwards a sufficient distance to allow the door to be closed and the spigots to engage fully in the locating blocks. The investigation also found that it is possible for the loose end of a lap strap to become trapped between the door sill and the door, preventing the rear spigot from entering its locating block.

Aircraft history

The Permit to Fly and Certificate of Validity for G-CGTI had been issued by the UK Civil Aviation Authority on the 20 December 2010. At the time of the accident the gyroplane had flown approximately 25 hours and had undergone a 25-hour maintenance check on the 20 April 2011, approximately one flying hour prior to the accident. There was no evidence of G-CGTI having had had any technical problems prior to the accident flight.

Previous occurrences of cockpit doors opening in flight

At the investigation's request, the aircraft manufacturer contacted their agents to determine if there had been occurrences of the cockpit doors on the M24 opening in flight. The manufacturer was advised of seven occasions and on six of these the door moved to the open position

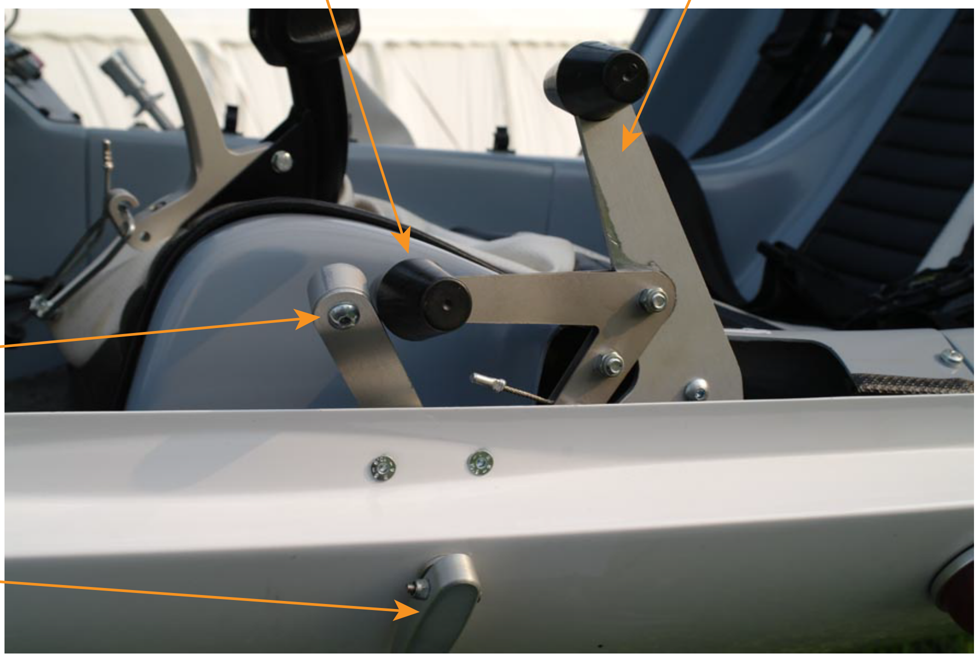

Figure 5

Throttle restricted by internal lock lever.

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as the nose came up during takeoff. However, there were no reports of any of the pilots experiencing any adverse handling effects. A summary of the occurrences follows:

- The right hand door opened on a gyroplane operating in South Africa.
- There were five occurrences in France. Three occurred over a six-month period and involved the same student and the left door. The other two occurrences involved left and right doors on different aircraft, resulting in two cracks of approximately 6 and 23 cm developing in the transparency in the left door.
- There was one occurrence in Italy when approximately ¼ of the transparency broke away from the right door and struck two propeller blades causing superficial damage.

The investigation was also advised by an owner in the UK that on two occasions he had realised once airborne that the forward spigot was not locked in the locating block.

Crash site examination

The gyroplane crashed on a heading of 280°M in a large (130 m x 1 km) flat field, approximately 900 m, and 200°M, from the threshold of Runway 06 at Old Sarum. The aircraft was destroyed in the post-impact fire, which burnt out before the emergency services arrived on the scene. An area of grass 2 to 5 m around the crash site had also caught fire.

The wreckage trail extended for 13 m from the initial impact point on a heading of 280°M. The baggage compartment access door, left anti-collision light, part of the left door sill and the bottom rear corner of the left door were all found close to the initial impact point. The left main wheel and part of its axle, the strut, lock lever, one locating block and the shoot bolts from the left door were all found in the wreckage trail. The strut and locking lever from the right door were found with the main wreckage.

There were two main rotor strike marks in the ground adjacent to the initial impact point which, when compared with the other ground marks, indicates that the gyroplane crashed on its left side with the rotor disc angled rearwards by approximately 40°. The intensity of the fire was consistent with the fuel tank rupturing during the initial impact and spilling its contents along the wreckage trail. Photographs taken shortly after the accident, indicated that the fire in the main part of the wreckage was sustained by the burning of the resin in the composite materials.

Examination of the wreckage

The intensity of the fire destroyed most of the instruments and the composite structure and aluminium components. The GPS, which had been badly damaged in the impact, had been thrown forward of the main wreckage by approximately 3 m into the burning grass. Despite the extensive damage to the aircraft, it was possible to establish that, with the exception of the control columns that were destroyed in the fire, there was control continuity from the cockpit to the rotor head and rudder. The throttle cables were also still attached to the carburettors, which had melted in the fire. There was no evidence of any pre-impact damage to either the propeller or main rotor blades. The rudder remained attached to the keel and the remainder of the empennage broke off in two parts early in the accident sequence. The fin, right horizontal stabilizer and winglet had been badly damaged by the fire, whereas the left horizontal

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stabilizer and winglet had been thrown outside the burning area and were relatively undamaged.

The beams supporting the pilot's side of the seat had been bent rearwards and the rotor mast was bent to the right. The buckles on each of the four-point harnesses were connected and in the locked position and all the seat harness attachment fittings were still attached to the aircraft structure. The nosewheel fork had failed, consistent with a force from the left side. The left main wheel and axle had detached from the aircraft and damage to the outer flange on the left hub was consistent with a force from the left side of the gyroplane. The landing gear beam had failed where it attached to the left side of the aircraft.

The majority of the door frames and the transparency in the windscreen and doors had been destroyed in the post-impact fire. Nevertheless, parts of the right door frame, strut, locking lever, both spigots and one locating block from the right door sill were recovered from the main wreckage. The bottom rear corner of the left door, which was relatively undamaged, and the strut, locking lever, shoot bolts, rear spigot, one locating block and part of the left door frame were found in the wreckage trail.

As far as could be established, there was no evidence of any pre-impact damage to the gyroplane, which appeared to have been correctly assembled and maintained.

Certification

Production of the M24 gyroplane commenced in Italy in May 2008 and at the time of the accident over 70 had been delivered with 11, of the M24C variant, on the UK register.

The M24C gyroplane is Type Approved by the UK CAA to CAP 643, British Civil Airworthiness Requirements (BCAR) Section T, Light Gyroplanes. The Airworthiness Approval Note for the M24C was issued on 4 October 2010, which allows a Permit to Fly to be issued to each aircraft that meets the requirements of the Type Approval.

CAP 643, BCAR Section T (Light Gyroplanes) has been based on CAP 482, BCAR Section S (Small Light Aeroplanes), which is applicable to microlight aeroplanes, and is intended to reflect a similar level of airworthiness. Where appropriate, requirements in BCAR Section T have been included from EASA CS 27 (Light Rotorcraft).

Compliance with BCAR Section T

The investigation reviewed BCAR Section T and the compliance document with regard to the handling qualities and the security of the cockpit doors on the M24C.

Handling qualities

- The gyroplane had been tested by the CAA flight test department, with both doors fitted and correctly latched in the closed position, and was found to have acceptable handling characteristics and could be safely controlled during any manoeuvre with normal piloting skills.
- The M24 and M24C had not been flight tested by either the manufacturer or the CAA with the doors in the open position and neither variant is approved to fly in this condition.
- BCAR Section T provides no requirement concerning handling qualities of the gyroplane when flown with the doors in the open position.

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Cockpit doors

- There is no requirement in BCAR Section T, regarding the securing of the doors, or a requirement to ensure that doors can be safely closed in flight.
- There is no evidence in the compliance document that the doors are strong enough for the M24C to be flown with them in the open position. The manufacturer confirmed that such information is not available.
- The only reference in BCAR Section T concerning the doors is that the cockpit must be so designed as to provide occupants with unimpeded and rapid escape in an emergency, which is achieved on the M24C by a simple-to-operate door locking mechanism.

The AAIB could identify no requirements in BCAR Section S, BCAR Section T or CS27 regarding the safe operation of the aircraft when a door opens in flight. Given that, if not correctly latched, gull-wing (upward opening) doors can open in flight and present a potential risk to the handling and structural integrity of the aircraft, a Safety Recommendation is made to the CAA at the end of this report.

Flight observations

The AAIB conducted a series of flights in a Magni M24C, during which it was noted that the ground cockpit ventilation is relatively poor and in strong sunlight, with the door closed, the cockpit can heat up very quickly. While the checklist calls for the doors to be latched before taxiing, it is normal practice on sunny days, to taxi with at least one of the doors unlatched in order to improve ventilation and to close and latch the door during the pre-takeoff checks. To this end, the flight manual contains the advice that:

> *'In high ambient temperatures it is possible to taxi with the doors open. In this case slow taxiing is recommended to avoid stress on the door attachment points.'*

At the time of the accident, the checklist that the pilot was using did not refer to the doors in the 'pre-takeoff' checks.

During training, pilots are encouraged to check that the aircraft is flying 'in trim' by releasing the control column for short periods of time. With two people onboard, and the aircraft correctly trimmed, the investigation observed that the aircraft attitude does not change significantly when the control column is released However, it was noted that when flying solo from the left seat there was a slight tendency for the aircraft to roll to the left when the control column was released in flight. It was also observed that if the power was reduced quickly, whilst the control column was not being held, then the aircraft tended to roll rapidly to the left. This roll to the left was quickly and easily corrected by the pilot once he took hold of the control column.

Analysis

General

The investigation established that the gyroplane had been recently serviced and had no recent fault history. There was no evidence of any pre-impact damage to the propeller or main rotor blades, or of disconnection of the engine or flying controls. There was no evidence of any structural failure in the air, although the degraded state of the wreckage meant that the possibility of in-flight damage to a door could not be entirely eliminated.

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The ground marks and damage to the aircraft indicated that it landed heavily on its left side on a heading of 280°M and was destroyed in a post-impact fire. At the time of the accident the pilot was secured by a four-point harness and as far as could be established both doors, their fittings and locking mechanisms were still attached to the aircraft.

Door security

The left aircraft door was observed to be closed when the aircraft started its takeoff run, but shortly after it rotated the door was seen to be open; the pilot also reported on the radio that he had a problem with his door. The investigation determined that it is not possible to open the throttle fully with the door lock lever in the open position; however from the speeds obtained from the GPS it is apparent that during this period the engine was probably at maximum power. Therefore the lock lever must have been in the closed position. If the door lock lever was in the closed position with either of the door spigots engaged, and latched, then it is unlikely that the door would have opened in flight. As the door was seen to be open in flight, and the aircraft performance indicates that the engine was at maximum power, then the door lock lever must have been in the closed position, but with neither of the two door spigots latched.

It is normal practice, on a hot day, to taxi with a door on the M24C open and to close and latch it during the pre-takeoff checks. The door was seen to be closed at the start of the takeoff run, which suggests that the pilot had closed the door and believed that it was correctly latched. However, from the previous seven occurrences of doors opening in flight it is known that pilots can take off with the doors closed in the mistaken belief that they are correctly latched. Tests carried out by the AAIB confirm that with the door lock lever in the closed position, the door can visually appear to be closed without either spigot being correctly latched. On this occasion the direction of the relative wind at the holding point would have assisted in holding the door in the closed position, thereby reducing the likelihood that the pilot would notice a gap between the door frame and sill, which might have alerted him that the door was not secure.

Aircraft handling

The door opened about the time the aircraft became airborne and it was then seen to roll and yaw in an unusual fashion. Thereafter the aircraft appeared to fly normally until the end of the downwind leg. Previous experience suggests that the door opening in flight should not have adversely affected the handling of the aircraft and there is no evidence that the door broke away and caused damage that would have affected the control of the aircraft.

To latch the door in flight, the pilot would first have to retard the throttle to enable the door lock lever to be moved sufficiently aft in order to withdraw the shoot bolts from the locating blocks. The data from the GPS suggests that the engine power remained at the takeoff setting for most of the flight; therefore the throttle must have remained well forward.

It is not possible, in flight, to close and lock the door with one hand. Given that witnesses who observed the last part of the flight did not see the door open, and there was no apparent reduction in engine power until the end of the flight, it is likely that the pilot continued to fly the aircraft with one hand holding the door closed and the other hand on the control column. At the end of the downwind leg, the pilot would normally reduce the engine power in order to descend and it is possible, given the witnesses reports of unstable flight, that at this point the pilot was experimenting with letting go of the control column, perhaps to reduce the engine power or latch the door.

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Latter stages of flight

The pilot of the aircraft joining the circuit at base leg and the witnesses near the accident site all described the aircraft as making an into-wind approach to the field where the aircraft ultimately crashed. While the investigation could not determine why the pilot would elect to land in a field when the airfield was so close, the field was considered to be suitable for a forced landing.

Having positioned the aircraft over the field, the pilot would normally close the throttle in order to land. This is consistent with witness reports that there was a marked reduction in the engine noise just prior to the accident. In order to close the throttle the pilot would have had two options: let go of the door or let go of the control column. However, there was no advice in the aircraft flight manual regarding flying with the door open and the pilot may have been concerned about possible damage to the aircraft or adverse handling characteristics if he let go of the door.

The throttle is relatively near the control column and from his conversion training he would have been shown that the aircraft attitude does not change significantly when the control column is released, providing the aircraft is flown in trim. He was probably unaware that the rapid closure of the throttle from takeoff to idle power setting, while not holding the control column, causes the aircraft to roll to the left.

Had the pilot released the control column and rapidly closed the throttle lever while continuing to hold the door, then a sudden roll to the left may have taken him by surprise. Close to the ground there would not have been sufficient time for him to recover the situation.

Conclusion

The investigation concluded that while the pilot's door appeared closed, it had not been correctly latched and as a consequence opened as the gyroplane took off. The throttle remained at the takeoff power setting for most of the flight and it is probable that the pilot held the door closed with one hand whilst flying the aircraft with his other hand. Evidence suggests that the pilot was attempting to land in a field at the end of the downwind leg. Reports of a reduction in engine noise and the sudden rolling of the gyroplane to the left are consistent with the pilot releasing the control column and rapidly closing the throttle. The pilot would not have expected the aircraft to roll to the left and at low level there would have been insufficient height to recover the situation.

Safety actions

As a result of the findings from this investigation, the following safety actions have been initiated by the CAA and the manufacturer:

- A Service Information Leaflet (SIL-001-2011 dated 19 May 2011) was sent by Magni Gyro UK to all owners and operators of the M24C on 23 May 2011 highlighting the importance of performing checks on the security of the door latching prior to commencing the takeoff. It also stated that a door opening in flight is unlikely to become detached or adversely affect the aircraft's handling and recommended that in such an event the airspeed should be limited to around 50-60 mph and the aircraft landed in an unhurried and controlled fashion as soon as possible.

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- A revision to the Flight Manual was issued on 18 May 2011 (Issue E) and the CAA approved the change in the M24C Type Approved Date Sheet on 19 May 2011 (Issue 3) to include the following warning:

> *'WARNING: DANGER*
>
> *It is imperative that the security of the door latching is checked prior to take-off as the door may come open on take-off, if incorrectly latched. After engaging the latching lever both the pilot's and passengers doors should be pushed from inside the cabin to ensure both forward and aft catches are secure. Should the door come open in flight it is unlikely to become detached or adversely affect the aircraft's handling. However should a door open in flight it is recommended that the airspeed be limited to around 50-60 MPH and the aircraft landed in an unhurried and controlled fashion as soon as is possible.'*

- Magni Gyro Ltd have discussed with the CAA, and intend to implement, a number of design changes to improve pilot awareness of the status of the latching mechanism. These include: microswitches to confirm the position of the aft door locking pin and shoot bolt, a red warning light to warn if a door is not correctly latched and a change to the digital rotor rpm gauge so that the display will be blanked if a door is not latched correctly.

Safety Recommendation

If not correctly latched, gull-wing (upward opening) doors can open in flight and present a potential risk to the handling and structural integrity of the aircraft. There is currently no guidance in BCAR Section T concerning the risks associated with doors opening in flight. Therefore, the following Safety Recommendation is made:

Safety Recommendation 2011-082

It is recommended that the Civil Aviation Authority amend the requirements of BCAR Section T, to minimise the likelihood of an aircraft door inadvertently opening in flight.

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ACCIDENT

Aircraft Type and Registration:	Rans S6-ES Coyote II, G-RTHS
No & Type of Engines:	1 Rotax 912-UL piston engine
Year of Manufacture:	2008
Date & Time (UTC):	26 June 2011 at 1055 hrs
Location:	Stoke Airfield, Kent
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Landing gear, propeller, wing and tailwheel assembly
Commander's Licence:	Private Pilot's Licence
Commander's Age:	54 years
Commander's Flying Experience:	490 hours (of which 78 were on type) Last 90 days - 4 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

During the takeoff run the aircraft began deviating to the left, towards a parked flex-wing aircraft, despite the pilot applying full right rudder and stick. On realising that he would not be able to avoid the parked aircraft, he deliberately lifted into the air with insufficient airspeed. Having missed the flex-wing he then tried to turn his aircraft to become parallel with the runway. During this manoeuvre, carried out with insufficient airspeed, the left wing dropped causing the aircraft to turn to the left again and head towards a mower with two people beside it. The pilot then attempted to turn sharply to the right with some success, but the left wing dropped and struck the ground, levelling the aircraft and altering its direction of travel again. The aircraft crossed the runway and a taxiway before colliding with a sea wall.

The pilot believed that the aircraft's initial deviation to the left was caused by the left wheel brake binding.

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ACCIDENT

Aircraft Type and Registration:	Rotorsport UK MTOSport, G-CGEW
No & Type of Engines:	1 Rotax 912ULS piston engine
Year of Manufacture:	2009
Date & Time (UTC):	23 April 2011 at 0945 hrs
Location:	Popham Airfield, Hampshire
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to empennage, propeller and rotor
Commander's Licence:	PPL (Gyroplane)
Commander's Age:	70 years
Commander's Flying Experience:	5,500+ hours (of which 380 were on type) Last 90 days - 18 hours Last 28 days - 8 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The student was being instructed on how to control the build up of rotor speed without the pre-rotator. He was instructed to pull the stick back gently with the rotor speed at approximately 100 rpm. He followed this instruction and gently pulled the stick fully back with the aircraft on the ground and moving forward slowly. This resulted in the rotor striking the fin.

The Pilots' Operating Handbook states:

> *'Note that it is possible to operate without the pre rotator. In this situation, start the blades by hand to about 45rpm. Taxy slowly into wind, and, holding the stick back, let the rotor speed increase. It will take about 320m to reach over 200rpm, at which stage full power can be applied and normal take off.'*

However, this is at the bottom of the page and at the top of the next page it states:

> *'WARNING! Take care! Holding the stick fully back brings the blades close to the rudder, and blade flap/ system flexibility, or bumpy surfaces could cause contact! About midway should be adequate, learn with practice!'*

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ACCIDENT

Aircraft Type and Registration:	X'Air Falcon 133(2), G-CEDO
No & Type of Engines:	1 Verner 133M piston engine
Year of Manufacture:	2006
Date & Time (UTC):	29 June 2011 at 1645 hrs
Location:	Private airstrip, Usk, Gwent
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to landing gear and pod
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	58 hours (of which 28 were on type) Last 90 days - 32 hours Last 28 days - 28 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Following normal pre-flight checks, the pilot took off and climbed to a height of between 100 and 150 ft agl, at which point the engine lost power and he could no longer maintain altitude. Due to the close proximity of power lines, the choice of location for a forced landing was limited to a field containing crops, which were approximately 1.8 m high. The pilot elected to stall the aircraft as it touched the top of the crop, resulting in damage to the nosewheel and pod assembly of the aircraft when it subsequently contacted the ground. Investigation of the engine identified a failure of the rocker arm that operated the inlet ports on one cylinder. As the engine was a twin cylinder model, the power generated by one operational cylinder alone had not been sufficient to maintain flight.

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AIRCRAFT ACCIDENT REPORT No 1/2011

This report was published on 14 September 2011 and is available on the AAIB Website www.aaib.gov.uk

REPORT ON THE ACCIDENT TO EUROCOPTER EC225 LP SUPER PUMA, G-REDU NEAR THE EASTERN TROUGH AREA PROJECT CENTRAL PRODUCTION FACILITY PLATFORM IN THE NORTH SEA ON 18 FEBRUARY 2009

Registered Owner and Operator:	Bond Offshore Helicopters Ltd
Aircraft Type:	Eurocopter EC225 LP Super Puma
Nationality:	British
Registration:	G-REDU
Place of Accident:	Approximately 300 metres southwest of the Eastern Trough Area Project (ETAP) Central Production Facility Platform helideck in the North Sea Central Area Latitude N 57° 17.49' Longitude E 001° 39.41'
Date and Time:	18 February 2009 at 1837 hrs All times in this report are UTC (coincident with local time)

Synopsis

The Aeronautical Rescue Co-ordination Centre (ARCC) notified the Air Accidents Investigation Branch (AAIB) of the accident at 1912 hrs on 18 February 2009 and the investigation commenced the following day.

In accordance with established international arrangements, the Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (BEA) of France, representing the State of Design and Manufacture of the aircraft, appointed an Accredited Representative and was supported by additional investigators from Eurocopter. The operator co-operated with the investigation and provided expertise as required.

Prior to this Final Report, the AAIB published Special Bulletins on 24 March 2009 and 23 June 2009.

Twenty-seven Safety Recommendations have been made.

The helicopter departed Aberdeen Airport at 1742 hrs on a scheduled flight to the Eastern Trough Area Project (ETAP). The flight consisted of three sectors, with the first landing being made, at night, on the ETAP Central Production Facility Platform. Weather conditions at the platform deteriorated after the aircraft departed Aberdeen; the visibility and cloud base were estimated

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as being 0.5 nm and 500 ft respectively. At 1835 hrs the flight crew made a visual approach to the platform during which the helicopter descended and impacted the surface of the sea. The helicopter remained upright, supported by its flotation equipment which had inflated automatically. All those onboard were able to evacuate the helicopter into its liferafts and they were successfully rescued by air and maritime Search and Rescue (SAR) assets.

The investigation identified the following causal factors:

1. The crew's perception of the position and orientation of the helicopter relative to the platform during the final approach was erroneous. Neither crew member was aware that the helicopter was descending towards the surface of the sea. This was probably due to the effects of oculogravic[1] and somatogravic[2] illusions combined with both pilots being focussed on the platform and not monitoring the flight instruments.

2. The approach was conducted in reduced visibility, probably due to fog or low cloud. This degraded the visual cues provided by the platform lighting, adding to the strength of the visual illusions during the final approach.

3. The two radio altimeter-based audio-voice height alert warnings did not activate. The fixed 100 ft audio-voice alert failed to activate, due to a likely malfunction of the Terrain Awareness Warning System (TAWS), and the audio-voice element of the selectable 150 ft alert had been suspended by the crew. Had the latter not been suspended, it would also have failed to activate. The pilots were not aware of the inoperative state of the TAWS.

The investigation identified the following contributory factors:

1. There was no specified night visual approach profile on which the crew could base their approach and minimum heights, and stabilised approach criteria were not specified.

2. The visual picture on final approach was possibly confused by a reflection of the platform on the surface of the sea.

Findings

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

2. The flight crew were properly licensed and qualified to conduct the flight and were well rested. Their training was in accordance with the operator's requirements and they were in recent night deck landing practice.

Footnote

[1] An oculogravic illusion is a visual illusion that affects the apparent position of an object in the visual field. A full explanation is provided in Appendix A and B to this report.

[2] A somatogravic illusion is a non-visual illusion that produces a false sensation of helicopter attitude. A full explanation is provided in Appendix A and B to this report.

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3. The flight crew had the relevant meteorological information and, although the weather was suitable for departure, the helicopter entered an area of reduced visibility in the immediate vicinity of the ETAP platform.

4. A TAWS caution caption on the CWP illuminated en-route to the platform and was announced by the co-pilot who was the non-handling pilot. The caution immediately extinguished without crew intervention.

5. The commander, who was the pilot flying, initially briefed the co-pilot for an Airborne Radar Approach due to the updated weather at the ETAP platform.

6. The flight crew visually acquired the lights and flare of the ETAP platform at a range of about 20 nm. This led to their decision to carry out an en-route descent to a height of 300 ft to position the helicopter for a visual approach and landing.

7. The helicopter entered low cloud during the initial en-route descent to a height of 300 ft, so the crew initiated a climb. On reaching a height of 400 ft, the crew regained and were able to maintain visual contact with the ETAP. Consequently, a further climb to MEA was not carried out.

8. A second descent to 300 ft was initiated at a range of 1.5 nm but, again, the helicopter entered low cloud and a climb was commenced. At 400 ft the platform lights and the flare were visible and the commander stopped the climb and continued the approach.

9. There was no specified visual approach profile providing the crew with recommended range, height and rate of descent information for the approach. Also, there were no minimum heights at which a go-around must be initiated.

10. There was no specified procedure for the 'pilot not flying' to monitor the approach using the flight instruments.

11. The co-pilot stated the opinion during the climb, thinking that it was a go-around, that a second approach would be successful.

12. The commander de-selected the upper modes of the Automatic Pilot, at a range of approximately 0.75 nm, and suspended the height alert of the radio altimeter.

13. The commander executed a 20° banked turn to the left through 62°, during which the helicopter entered a continuous descent.

14. The co-pilot identified the descent and announced it to the commander but no corrective action was taken. He also provided range and speed information.

15. The commander could see the platform flare and diffused lights but not the green perimeter lights of the helideck.

16. The co-pilot could see the flare, diffused lights of the platform and the green perimeter lights of the helideck.

17. The green helideck perimeter lights were visible from below the elevation of the helideck.

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18. The commander's attention became focussed on visually acquiring the helideck which was not visible to him.

19. The co-pilot monitored the helicopter's groundspeed and range from the platform and attempted to assist the commander in visually acquiring the helideck.

20. Both flight crew members were unaware of the helicopter's continued descent.

21. Neither pilot observed the oval shape defined by the perimeter lighting of the helideck and could not determine the helicopter's approach path angle.

22. The commander gradually pitched the helicopter's nose up in order to reduce speed. He maintained what he thought was a constant approach angle using the visual picture of the ETAP relative to his windscreen.

23. The fixed 100 ft height audio voice alert failed to activate, due to a likely malfunction of the TAWS, and the selectable 150 ft audio voice alert would also have failed to activate for the same reason, had it not already been suspended by the crew.

24. The pilots were not aware of the inoperative status of the TAWS.

25. The commander had the sensation that the helicopter was high and fast and increased the nose-up pitch attitude.

26. Both pilots thought that the helicopter was still above the level of the helideck when it impacted the surface of the sea.

27. It was probable that both pilots were subjected to the effects of oculogravic and somatogravic illusions possibly reinforced by the reflection of the platform lights in the surface of the sea.

28. The accident was survivable and all those onboard were rescued by a Search and Rescue helicopter and other surface vessels.

Safety Recommendations

Safety Recommendations made previously in Special Bulletin S4/2009 published on 23 June 2009.

Safety Recommendation 2009-064

It is recommended that the Civil Aviation Authority review the carriage and use in commercial air transport helicopters of any radio location devices which do not form part of the aircraft's certificated equipment.

Safety Recommendation 2009-065

It is recommended that the Civil Aviation Authority advise the European Aviation Safety Agency of the outcome of the review on the carriage and use in commercial air transport helicopters of any radio location devices which do not form part of the aircraft's certificated equipment.

Safety Recommendation 2009-066

It is recommended that the European Aviation Safety Agency require manufacturers of Emergency Locator Transmitters (ELT(S)s)/Personal Locator Beacons (PLBs) units to add details, where absent, of the correct use of the antenna to the instructions annotated on the body of such beacons.

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Safety Recommendation 2009-067

It is recommended that the Civil Aviation Authority ensure that all aspects of Emergency Locator Transmitter (ELT(S))/Personal Locator Beacon (PLB) operation, particularly correct deployment of the antenna, are included and given appropriate emphasis in initial and recurrent commercial air transport flight crew training, as applicable.

Safety Recommendations made in this report.

Safety Recommendation 2011-049

It is recommended that the Civil Aviation Authority re-emphasises to Oil and Gas UK that they adopt the guidance in Civil Aviation Publication (CAP) 437, entitled *Offshore Helicopter Landing Areas - Guidance on Standards*, insofar as personnel who are required to conduct weather observations from vessels and platforms equipped for helicopter offshore operations are suitably trained, qualified and provided with equipment that can accurately measure the cloud base and visibility, in order to provide more accurate weather reports to helicopter operators.

Safety Recommendation 2011-050

It is recommended that the Civil Aviation Authority encourages commercial air transport helicopter operators to make optimum use of Automatic Flight Control Systems.

Safety Recommendation 2011-051

It is recommended that the Civil Aviation Authority ensures that commercial air transport offshore helicopter operators define specific offshore approach profiles, which include the parameters for a stabilised approach and the corrective action to be taken in the event of an unstable approach.

Safety Recommendation 2011-052

It is recommended that the Civil Aviation Authority commissions a project to study the visual illusions that may be generated during offshore approaches to vessels or offshore installations, in poor visibility and at night, and publicises the findings.

Safety Recommendation 2011-053

It is recommended that the Civil Aviation Authority (CAA) amends Civil Aviation Publication (CAP) 437, *Offshore Helicopter Landing Areas - Guidance on Standards*, to encourage operators of vessels and offshore installations, equipped with helidecks, to adopt the new lighting standard, for which a draft specification has been published in Appendix E of CAP 437, once the specification has been finalised.

Safety Recommendation 2011-054

It is recommended that the Civil Aviation Authority reviews the procedures specified by commercial air transport helicopter operators as to when a crew may or should suspend a radio altimeter aural or visual height warning.

Safety Recommendation 2011-055

It is recommended that the Civil Aviation Authority reviews commercial air transport offshore helicopter operators' procedures to ensure that an appropriate defined response is specified when a height warning is activated.

Safety Recommendation 2011-056

It is recommended that the Civil Aviation Authority reviews the procedures set out by commercial air transport offshore helicopter operators to ensure that a member of the flight crew monitors the flight instruments during an approach in order to ensure a safe flight path.

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Safety Recommendation 2011-057

It is recommended that the International Civil Aviation Organisation introduces a Standard for crash-protected recordings of the operational status of Airborne Collision Avoidance System (ACAS) and Terrain Awareness and Warning System (TAWS) equipment, where fitted, on helicopters required to carry a flight data recorder.

Safety Recommendation 2011-058

It is recommended that the European Aviation Safety Agency requires that crews of helicopters, fitted with a Terrain Awareness and Warning System, be provided with an immediate indication when the system becomes inoperative, fails, is inhibited or selected OFF.

Safety Recommendation 2011-059

It is recommended that the European Aviation Safety Agency reviews the acceptability of crew-operated ON/OFF controls which can disable mandatory helicopter audio voice warnings.

Safety Recommendation 2011-060

It is recommended that the Civil Aviation Authority reviews the guidance in *Civil Aviation Publication (CAP) 562, Civil Aircraft Airworthiness Information and Procedures*, Part 11, Leaflet 11-35, *Radio Altimeters and AVADs for Helicopters*, regarding the pre-set audio height warning that is triggered by the radio altimeter and may not be altered in flight, to ensure that crews are provided with adequate warning to take corrective action.

Safety Recommendation 2011-061

It is recommended that the European Aviation Safety Agency ensures that helicopter performance is taken into consideration when determining the timeliness of warnings generated by Helicopter Terrain Awareness and Warning Systems.

Safety Recommendation 2011-062

It is recommended that the European Aviation Safety Agency reviews the frequency of nuisance warnings generated by Terrain Awareness and Warning System equipment in offshore helicopter operations and takes appropriate action to improve the integrity of the system.

Safety Recommendation 2011-063

It is recommended that the European Aviation Safety Agency, in conjunction with the Federal Aviation Administration, defines standards governing the content, accuracy and presentation of obstacles in the Terrain Awareness and Warning System obstacle database for helicopters operating in the offshore environment.

Safety Recommendation 2011-064

It is recommended that the European Aviation Safety Agency establishes the feasibility of recording, in crash-protected memory, status indications from each avionic system on an aircraft.

Safety Recommendation 2011-065

It is recommended that the European Aviation Safety Agency considers amending certification requirements for rotorcraft, that are certified in accordance with ditching provisions, to include a means of automatically inflating emergency flotation equipment

Safety Recommendation 2011-066

It is recommended that the European Aviation Safety Agency modifies European Technical Standard Order (ETSO) 2C70a and ETSO 2C505 to include a requirement for multi-seat liferafts, that do not automatically deploy their Sea Anchor, to include a label, visible from within the inflated liferaft, reminding the occupants when to deploy the Sea Anchor.

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Safety Recommendation 2011-067

It is recommended that the Federal Aviation Administration modifies Technical Standard Order (TSO) C70a to include a requirement for multi-seat liferafts, that do not automatically deploy their Sea Anchor, to include a label, visible from within the inflated raft, reminding the occupants when to deploy the Sea Anchor.

Safety Recommendation 2011-068

It is recommended that the European Aviation Safety Agency requires Eurocopter to review the design of the fairings below the boarding steps on AS332 and EC225 series helicopters to reduce the possibility of fairings shattering during survivable water impact and presenting sharp projections capable of damaging liferafts.

Safety Recommendation 2011-069

It is recommended that the European Aviation Safety Agency, in conjunction with the Federal Aviation Administration, review the design requirements and advisory material for helicopters to require 'delethalisation' of the fuselage to prevent damage to deploying and floating liferafts following a survivable water impact.

Safety Recommendation 2011-070

It is recommended that the European Aviation Safety Agency ensures that a requirement is developed for all emergency equipment, stowed in deployable survival bags, to be capable of being easily accessed and utilised by the gloved hands of a liferaft occupant whilst in challenging survival situations when a liferaft may be subject to considerable motion in cold, wet and dark conditions.

Safety Recommendation 2011-071

It is recommended that the European Aviation Safety Agency reviews the location and design of the components and installation features of Automatically Deployable Emergency Locator Transmitters and Crash Position Indicator units, when required to be fitted to offshore helicopters, to ensure the reliability of operation of such units during and after water impacts.

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FORMAL AIRCRAFT ACCIDENT REPORTS ISSUED BY THE AIR ACCIDENTS INVESTIGATION BRANCH

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.

2011

1/2011 Eurocopter EC225 LP Super Puma,
G-REDU
near the Eastern Trough Area Project Central Production Facility Platform in the North Sea
on 18 February 2009.

Published September 2011.

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BULLETIN CORRECTION

AAIB File: EW/C2011/01/01

Aircraft Type and Registration:	Cameron O-120 hot air balloon, G-BVXF
Date & Time (UTC):	1 January 2011 at 0947 hrs
Location:	Midsomer Norton, Somerset
Information Source:	Field investigation

AAIB Bulletin No 10/2011, page 113 refers

In the report published in Bulletin 10/2011, the supplementary oxygen system was mistakenly identified as being supplied with a cylinder pressure of '200 psi'. This was a typographical error – the system was supplied with a cylinder pressure of **200 bar**.

This was corrected in the online version of the report on 31 October 2011 and a correction will appear in the December 2011 Bulletin.

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