Aircraft Type and Registration:	Cessna T310R, N6834L
No & Type of Engines:	2 Teledyne Continental TSI0-520-BB piston engines
Year of Manufacture:	1981
Date & Time (UTC):	30 March 2004 at 0840 hrs
Location:	Near Laneshaw Bridge, Colne, Lancashire
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 and FAA Private Pilot's Certificate issued on basis of UK Licence
Commander's Age:	57 years
Commander's Flying Experience:	627 hours (of which 403 were on type) Last 90 days - 3 hours Last 28 days - 0 hours
Information Source:	AAIB Field Investigation

Synopsis

Fire in the aircraft's nose baggage compartment, which started in the vicinity of the cabin heater, caused the smell of smoke in the cockpit. This prompted the pilot to request a return to Leeds Bradford Airport six and a half minutes after he had taken off for a flight to Connaught (Knock) in Ireland. The aircraft successfully negotiated a level turn to the left at 3,400 feet onto a south-easterly heading but then started a rapid descent and a steep turn or series of turns where radio and radar contact was lost. This may have been the result of controlled flight or uncontrolled manoeuvres. The aircraft was seen to be flying slowly and 'not in trouble' a matter of seconds before it struck the ground. The aircraft crashed in a field at an elevation of 950 feet above mean sea level (amsl) approximately 0.5 nm to the south-south-east of the last radar return and within two minutes of loss of contact. Ground impact marks were consistent with an uncontrolled impact yet the positions of some of the controls suggested that the pilot may have been trying to make a forced landing, albeit with a tailwind, into a sloping field which may have appeared level from the air. Post mortem examination of the pilot concluded that there was no evidence of cabin air contamination which

could have had an incapacitating effect and that he died as the result of multiple injuries sustained at the time of impact. One Safety Recommendation is made to the FAA concerning the inspection of combustion heaters.

History of the flight

The pilot was flying solo in his privately owned aircraft from Leeds Bradford Airport to Connaught (Knock), Ireland. Although there was no significant cloud for his departure the visibility was 4,000 metres. At 0814 hrs he requested clearance to taxi. ATC advised him that they had not received his flight plan, which had been faxed to them earlier, so the pilot resubmitted it from the aircraft using his mobile telephone. Due to a further delay, resulting from a problem with the telecommunication links between Leeds Bradford and Manchester ATC, N6834L was eventually cleared to taxi at 0825 hrs, 11 minutes after the pilot's original request. As the aircraft taxied past one of the maintenance company's hangars, an engineer in an office noticed that the pilot was repeatedly looking down inside the aircraft. The engineer made particular mention of this to his colleague because the aircraft was negotiating a sharp right turn on the taxiway at the time. The pilot was known to use the cabin heater when it was cold and operating its controls, that are positioned low on the instrument panel, may have been occupying his attention at that time.

The aircraft completed a power check before lining up on Runway 32, was cleared to take off at 0831 hrs and carried out a normal takeoff and turning left towards Keighley, a Visual Reporting Point (VRP) 9 nm to the west. Two minutes after departing the pilot was instructed to transfer to the Leeds ATC Approach frequency, which he did. Having been restricted, initially, to an altitude not above 2,000 feet on the QNH, the pilot was cleared to climb further to an altitude of 3,400 feet. He then requested, and was given, a Flight Information Service. Six and a half minutes after departing from the airport the pilot informed Leeds ATC that he would like to return. During his exchange with ATC he advised the controller that this was because there was a smell of smoke in the cockpit. N6834L was cleared to return to the airport via Keighley, not above an altitude of 2,000 feet. In response to the controller's request, the pilot confirmed that he was the only person on board the aircraft. When making this radio transmission, at 0838:20 hrs, the pilot sounded distracted. No further transmissions were received from the pilot.

The Leeds radar controller, who had displayed on his radar screen both primary and secondary information from the aircraft, saw it make a left turn while it maintained an altitude of 3,400 feet. According to secondary radar information, it stayed at this altitude until 0838:52 hrs. Thereafter, there was only primary radar contact (without altitude information) until 0839:26 hrs. Recordings of the radar information, retrieved some time later from the Great Dunn Fell, Clee Hill and Claxby radar heads showed the aircraft's track until it disappeared from the radar screen (see Figure 1).

Having seen the primary radar contact disappear the radar controller, who was also controlling two other aircraft, waited for two further sweeps (16 seconds) of the radar before transmitting a radio check to N6834L at 0839:43 hrs. There was no reply. The controller made three further attempts, without success, to establish radio contact with the pilot and asked another aircraft if they had heard any transmission from N6834L. At 0841:00 hrs the controller again transmitted a radio check but there was no reply from the pilot in N6834L.

The last radar contact placed the aircraft in the vicinity of Wycoller Country Park, 15 nm west of Leeds Bradford Airport. A driver in a car park on the eastern edge of the country park, whose broken down car was being repaired at that time, heard what sounded like the noise of an aircraft or 'an old tractor engine' coming from the direction of a hill half a mile to his east. The noise reminded him of a car engine running on dirty petrol. He looked up and saw very low in the sky a slow moving, white coloured, light aircraft, heading in a north-westerly direction as if it was taking photographs or just "messing about". "It appeared to be flying level and did not seem to be in trouble". After glancing at the aircraft the driver turned away and continued talking to the mechanic repairing his car. He then heard a noise "like farm machinery tumbling down a gulley". Both he and the mechanic looked up and the mechanic remembered seeing the nose of an aircraft digging into the ground with its tail somersaulting over the top. The driver's recollection was of a large amount of dust and debris travelling down the hillside in a westerly direction. Just before the crash the mechanic recalled hearing the noise of an engine which was "spluttering or failing, as if it was running out of fuel". He said that this sound had lasted for two to three seconds.

The driver and mechanic ran approximately 800 metres to the scene of the accident and, as they ran, the mechanic called the emergency services on his mobile telephone. That call was timed at 0841:03 hrs. As they approached the wreckage they were aware of a very strong smell of fuel. However, despite the aircraft being severely disrupted, there was no fire. The pilot, who had been thrown about 10 metres clear of the main body of the aircraft, did not appear to have survived the accident. The emergency services arrived approximately 10 minutes later.

Pathology

The post-mortem report concluded that the pilot died as a result of multiple injuries sustained at the time the aircraft struck the ground. There were no predisposing medical conditions which might have caused or contributed to the accident and the toxicology examination revealed no drugs, alcohol or evidence of cabin air contamination which could have had an incapacitating effect.

Meteorological information

The synoptic situation at 0600 hrs on 30 March 2004 showed high pressure centred over Norway and Poland feeding a generally light south-easterly flow over Lancashire.

The weather in the area of the accident included mist and haze up to 500 feet agl, especially in valleys, with further layers of thin haze up to around 6,000 feet amsl. There were possible patches of broken stratus cloud, as the valley fog thinned and lifted, between 100 and 500 feet agl and further isolated patches of thin strato-cumulus cloud above 5,000 feet with cirrus cloud above 20,000 feet amsl. The surface visibility was between 4,000 metres and 6 kilometres, generally improving to 7 to 12 kilometres by 0900 hrs, and the surface wind was 080º/5-10 kt. At 3,000 ft amsl the wind had veered to 140º/15-20 kt.

The Aerodrome Meteorological Report (METAR) at Leeds Bradford Airport at 0820 hrs gave a surface wind of 050º/4 kt, a visibility of 4,000 metres in mist, no significant cloud and a surface temperature of +5ºC. A further meteorological observation at Leeds Bradford at the time of the accident reported a surface wind of 060º/6 kt, a visibility of 4,000 metres in mist and, again, no significant cloud.

This reflects the visibility recalled by one of the witnesses at the car park adjacent to the crash site. Shortly before the accident he could not see the top of a hill that was 3,800 metres away to his south, whereas he had been able to see it about 45 minutes earlier. The top of the hill is 800 feet higher than the elevation of the car park.

Pilot qualifications and experience

The pilot started flying in 1993 at the age of 47. Two years later, having completed 100 hours of flying, he gained his UK Private Pilot's Licence (Aeroplanes) with a rating for single engine aeroplanes (Landplanes). Two months after that he added an Instrument Meteorological Conditions (IMC) rating to his licence.

Between March and May 1996 he undertook a course of instruction in N6834L, which he had recently purchased, and was issued of a rating for multi-engine aeroplanes (Landplanes). His logbook indicated that, in July 1996 after another course, he passed the flight test for an IMC (multi) rating. This however, was not recorded in his licence; a possible oversight by the examiner. His logbook also contained annual signed entries for Certificates of Experience, valid until 24 July 2000.

The pilot started making the first of many flights between Leeds and Knock, in 1996. In 1999, following a number of incidents in Ireland over a two year period, the pilot was directed by the Irish

Authorities not to fly in their airspace until the latest of those incidents had been investigated. The Irish Aviation Authority (IAA) also communicated with the Civil Aviation Authority (CAA) expressing their concern that the pilot might place himself and others in jeopardy if his standards of airmanship and lack of appreciation of the limitations of his licence continued at the levels they had encountered. There is no record of any action taken by the CAA in response to those concerns beyond a copy of a draft letter acknowledging the IAA's communication and mention of a possible interview that was to be arranged with the pilot. The IAA subsequently lifted their ban on the pilot in May 2002.

Between December 2001 and March 2002 the pilot undertook a course of instruction in Florida, USA culminating, on 27 March 2002, in the issue of a FAA Private Pilot's Certificate with ratings for 'single and multiengine land instrument airplanes'. The licence was '*issued on the basis of and valid only when accompanied by'* the pilot's UK licence and that '*all limitations and restrictions on the UK pilot licence apply'*. The pilot's UK rating had lapsed, therefore his FAA certificate ratings were not valid from the moment it was issued.

The pilot resumed his regular but infrequent flights between Leeds Bradford and Knock in May 2002 and returned to Florida in October 2002 for further instruction on the PA-28 and PA-23. While there he completed an instrument competency check on the PA-28. He had further periods of instruction in Florida in May 2003 (PA-28 and PA-23) and February 2004 (PA-34 and Cessna 172), during both of which he completed instrument competency checks. In the latter period of training he completed 2.7 hours of flying. In between his visits to Florida he continued to fly between the UK and Ireland. The accident flight was his first since returning to the UK from his last period of instruction in Florida. His most recent flights within the British Isles had been to Knock on 26 October 2003, returning to Leeds Bradford on 8 November 2003.

The pilot always used the same instructor when he was flying in the USA. This instructor confirmed the hard work that the pilot put into his flying reflecting, he said, the ability of someone who had come to flying late in life. In particular, the instructor commented that the pilot was able to deal with a situation when given the time to think it through in advance but could not deal so well with a problem presenting itself unannounced.

Radar information

Radar returns from three radar heads were available for the accident flight, each with differing amounts of coverage. The returns from the Clee Hill radar appeared to be the most accurate for the latter part of the flight with a final point 0.5 km from the accident site. No height information was available for this point as it was only a 'primary' radar return.

The recorded radar data was used to ascertain much of the aircraft's track over the ground and its altitude (Figure 2). During the course of the investigation an aircraft was flown over the position of the accident site at an altitude of 1,500 feet on the QNH; approximately 550 feet agl. At that altitude it was clearly visible on both primary and secondary radar but this begged the question as to why the accident aircraft had not been visible on secondary radar for the last 34 seconds that it 'painted' a primary radar return.

Another Cessna T310R, G-GOTX, which was involved in an accident in Humberside earlier in the same month disappeared from the radar screen when it was at an altitude of 3,200 feet amsl. In that case it was considered possible that the altitude recorded on radar was influenced by static pressure errors caused by the manoeuvres that that aircraft appeared to carry out. N6834L was not, apparently, conducting complex manoeuvres so it is probable that another factor was responsible for the lack of received altitude information. It is possible that the N6834L entered a high rate of descent, its radar transponder failed or that electrical power was removed from the transponder.

The radar recordings showed that the aircraft completed a level turn at an altitude of 3,400 feet amsl and it is possible that it then started a very rapid descent. Two minutes and 11 seconds elapsed between the last secondary radar altitude information and a witness to the accident dialling the emergency services on his mobile telephone. Allowing at least 15 seconds for the witness to react to the situation before making that call means that the aircraft descended at an average of 1,280 feet per min (fpm) before striking the ground. This is not an overly rapid rate. However, the aircraft may have descended from 3,400 feet to 1,500 feet, or lower, in the 34 seconds that it remained as a contact on primary radar. That would result in a rate of descent, during that period, of 3,350 fpm or greater.

GPS data

The aircraft was fitted with a panel-mounted Trimble TNL 2000T GPS unit that sustained damage in the accident. This unit has a limited memory only capable of recording a position fix of the 'last known point', date and time when electrical power is removed from the unit (Figure 1).

The 'last displayed position' refers to that which would be shown on the GPS display, updated once every second from position fixes made five times per second. The 'last known position is the latest (and last) of these implying that the displayed position could be up to 0.8 seconds older than the last position fix.

The date and time that power was removed from the unit was recorded as 30 March 2004 at 0839:05.672 hrs UTC; very close to the time and position at which transmissions were no longer received from the aircraft's radar transponder. The recorded GPS altitude at the last fix (3,187 feet amsl) was close, within the unit's tolerance of ±900 feet, to the aircraft's reported altitude of 3,400 feet. At this stage the sequential positions recorded from the Clee Hill radar indicated a track of approximately 120ºM, towards the airport.

Emergency procedures

The Pilot's Operating Handbook specifies an emergency procedure for *Inflight Cabin Electrical Fire or Smoke.* It lists the immediate action memory items as:

1. *Electrical Load – REDUCE to minimum required.*
2. *Attempt to isolate the source of fire or smoke.*
3. *Wemacs – OPEN.*
4. *Cabin Air Controls - OPEN all vents including windshield defrost.*
   CLOSE if intensity of smoke increases.

This is followed by the non-memory action to:

5. *Land and evacuate airplane as soon as practical.*

In supplementary information the manual states that:

> *if the smoke increases in intensity when the air controls are opened, they should be closed as this indicates a possible fire in the heater or nose compartment.*

It also advises that:

> *when the smoke is intense, the pilot may choose to expel the smoke through the foul weather window (in the pilot's side window), but cautions that the foul weather window should be closed immediately if the fire becomes more intense when the window is opened.*

It is not clear whether the pilot had managed to identify the source of the smoke.

Aircraft history

N6834L had been built by Cessna in Wichita in 1981 as a T310R, serial number 310R-2137 and had operated in the USA, and then in Belgium, until 1996, with 2,868 hours logged. After its change of ownership and move to the United Kingdom in 1996, the aircraft continued to be operated on the US register, maintained by a maintenance company at Leeds Bradford Airport under FAA Regulations.

Up to the date of this accident, N6834L had logged 3,287 flight hours, 420 in the eight years since the change of ownership, flown almost exclusively by the new owner. The rate of utilisation was high in the earlier years and much lower in the last two years. The aircraft had last been flown on 8 November 2003; over 4 months before the accident flight.

As delivered by the manufacturer in 1981, the aircraft had an avionics fit suitable for operation in IFR, including a two-axis autopilot system. During the period to 1996 a number of additional items were added, under the FAA STC (Supplemental Type Certificate) system. These included a weather radar system, graphical engine monitors, a Trimble TNL-2000 GPS navigation system and a Precise Flight speedbrake system.

Accident site

The aircraft struck the ground in a field of rough grass on sloping moorland (Figure 3). The initial point of impact was on the right wing tip tank and a long ground scar showed the initial impacts of the right engine, the nose, fuselage, the left engine and the left wing. There was separation at this point of both propellers, both engines and both tip tanks, as well as fragmentation of the nose section. The remaining portions of the fuselage, wings and empennage came to rest around a stone wall after travelling 100 metres and the engines were found 135 metres from the initial impact.

Measurements from the ground marks showed that the aircraft was travelling in a direction of 300ºM when it struck the ground, approximately 30º nose down and with a banked 45º to the right. Examination showed that the landing gear and wing flaps were retracted at the time of impact. Aerial photographs taken a few days after the accident showed extensive damage to the grass around the initial impact, demonstrating that there had been large amount of fuel onboard at the time of the accident. The pattern of the damage to the vegetation indicated that, as would be expected, the bulk of this fuel was in the main tanks, at the wing tips. The nature of the impact, at speed into soft ground and the fragmentation of the tip tanks, meant that there was no post-crash fire.

Examination for fire and smoke

The wreckage was examined closely for evidence of smoke or burning preceding the impact. As there had been no post-crash fire, it was clear that any marks of heating or combustion found in the wreckage would have occurred before the aircraft hit the ground.

There was no evidence of any electrical arcing, sooting or other heating or combustion found around the instrument panel or any part of the cabin. There were, however, items recovered from varied locations around the wreckage site which exhibited fire and heat damage. All of these items would have been located in the nose section of the fuselage. They included items of clothing and baggage, the manual tow-bar, pieces of the nose structure itself and components from the aircraft heating and ventilation system, including the combustion heater which showed a distinct pattern of fire damage. There was no fire damage found on any item from any other area of the aircraft.

Detailed wreckage examination

Flight controls

The primary flying control cables (ailerons, elevator and rudder) were traced through the wreckage and there were no indications of pre-existing damage. The wreckage was too damaged for reliable measurements from the aircraft trim mechanisms; in this aircraft the autopilot system also works through these trim actuators. Both panels of the additional speedbrake system, mounted in the aft bay of the engine nacelles, were found to have been in the retracted position at impact. Parts of the 'foul weather' window were identified but its position at impact could not be determined.

Engine and propeller controls

The throttle quadrant was found intact, although separated from its normal mounting in the cockpit. There were signs of impact to the control levers and thus the positions of the throttle (power) and mixture levers, having freedom to move, could not be treated as reliable. However, both propeller speed levers were found fully aft in the 'feather' position, beyond the gate mechanisms which prevent inadvertent 'feather' selection. In this aircraft, movement of a propeller speed lever to 'feather' requires that the lever be moved inboard. There was no damage on the gates. It is likely therefore, that these lever positions represented a deliberate selection by the pilot at a very late stage in the flight.

Propellers

The propellers were taken to an overhaul facility for examination. The general damage to the blades indicated that there had been some degree of rotation of both propellers at impact but there were no distinct indications that there was substantial power being transmitted. Mechanical damage to the left propeller hub indicated that, at impact, this propeller was at, or very close to, the 'feather' position. In contrast, the mechanical damage to the right propeller indicated that it had been within the normal operating range of a rotating propeller but close to the 'fine pitch' end of the range.

Engines

Both engines were too damaged for functional testing. However, a strip examination showed that both were mechanically intact, with no sign of pre-impact distress. The colour and condition of the ignition plugs was consistent with normal operation and the magnetos were tested satisfactorily.

The cockpit fuel selectors were found in their respective 'LEFT ENGINE OFF' and 'RIGHT ENGINE OFF' quadrants, consistent with the selector valves themselves and the sense of the control movement (a cable 'pull' will move selector and valve to different positions). However, the disruption to the airframe means that this evidence of fuel selection is not fully reliable.

Instruments and avionics

The avionics systems in the aircraft were too badly damaged in the ground impact for functional testing. However, it was noted that, where the ON/OFF switches could be tested on individual navigation and communication units, the selection was always found in the ON position. The HSI (Horizontal Situation Indicator) and RMI (Radio Magnetic Indicator) gyro instruments were both found with headings of 120ºM, corresponding to the likely heading of the aircraft when power was removed from the GPS and, probably, the radar transponder.

Both the HSI and RMI instruments are electrically 'slaved' to remote gyros and would thus stop operating with the loss of electrical power. However, the aircraft's two artificial horizon instruments were both vacuum-driven, as was the directional gyro mounted in front of the right-hand pilot seat. The altimeters and airspeed indicators were conventional pressure instruments. These would have continued to function without electrical power.

The Cessna T310R electrical system diagram shows that electrical power could be removed either by the Avionics master switch (mounted on the circuit breaker panel to the left of the pilot) or by use of the three 'ganged' Master switches (left alternator, battery and right alternator) mounted low on the instrument panel. These three Master switches would routinely be exercised by the pilot at the start and end of each flight and selection to OFF would remove electrical power from certain instruments and the navigation and communications systems. In addition, electrical power would be removed from other aircraft systems, including the cabin heater, flaps, landing gear and speedbrakes. The engine and propeller controls would not be affected.

Effects of fire

Because of the disruption to N6834L in the impact, another Cessna T310R, manufactured in 1978, was examined by the AAIB. This examination confirmed that the pattern of heat damage to the contents of the nose compartment in N6834L was consistent with a fire centred under the combustion heater. It also confirmed that the aircraft's electrical systems would not have been affected by the fire as the electrical looms in the nose were routed under the floor on the left-hand side of the nose compartment, separated from the combustion heater by the nose leg bay. The only aircraft system that would have been affected by a localised fire around the combustion heater, in this example T310R, would have been the right pitot pressure line, routed through the combustion heater compartment. In N6834L, however, this pitot line did not exist as the aircraft had a single (left) pitot probe.

Heater system

N6834L was equipped with a combustion-type cabin heater (model 8259JR-2, manufactured by South Wind) mounted in the nose compartment. This arrangement is common in aircraft with twin piston engines.

In this design, the heater is supplied by ambient airflow, through flexible ducting and a dedicated ventilation fan, and delivers heated air into the cabin through further flexible ducting into controllable heat outlets. The heated cabin air, which is not recirculated, exhausts overboard.

The layout and functioning of the cabin heating and ventilation system can be seen at Figures 4, 5 and 6. Figure 4 shows the position of the combustion heater in the nose of the aircraft and the routeing of the heating and ventilation air flows into the cabin. Figure 5 shows the principal components of the system (combustion heater, ventilation fan, centrifugal fan and fuel pump), as configured for a bench test. Figure 6 illustrates the internal functioning of the combustion heater.

The heater depends on the aircraft's fuel system for its fuel supply. The fuel to each engine is normally drawn directly from the main tank (tip tank) on that side, via a fuel selector valve. The fuel line to the cabin heater is drawn from a point on the fuel line between the right tank and the right selector valve, so the position of either fuel selector will not affect the heater, for which the dedicated fuel line has a separate electrically-operated solenoid.

Fuel and combustion air are supplied from a pump and centrifugal fan respectively, driven by a single motor, and the fuel and air are introduced into the core of the heater, where they are ignited by a single ignition plug. The combustion core is surrounded by a jacket that acts as a heat exchanger for the warm air being supplied to the cabin. The combustion air is exhausted downwards from the heater directly to the outside, through a short exhaust pipe.

The pilot's control of the combustion heater is by means of a variable thermostatic valve and a three-position switch. In the HEAT position, the fuel supply solenoid is energised to open, the motor for the fuel pump and the combustion heater is powered, the igniter operates and the ventilation fan is powered. With the switch at FAN, only the ventilation fan is powered. At OFF, all the circuits are de-energised. The design of the heater also ensures that the fuel and combustion air continue to be provided only if the heater is operating correctly and selected to HEAT.

A Cessna Service Bulletin, MEB95-9, applies to these heaters. This Bulletin was issued in June 1995 and covered the inspection of the aluminium fuel lines to the heater, looking for evidence of fuel leaks and corrosion. Corrosion beyond 'minor pitting' would require the fuel line's replacement with a stainless steel line. Inspection was required within the earlier of 100 hours of operation or 12 months calendar time. There was no requirement for repeated inspections.

In addition, specific inspections for this model of heater are specified in an FAA Airworthiness Directive from 1981, AD81-09-09. This AD required an initial inspection and overhaul within 50 hours of heater operation and then a repeat every 250 hours of heater operation, with a further provision for overhaul every 1,000 hours of heater operation.

Heater system examination

The combustion heater, examined in detail by the AAIB with a representative from the heater manufacturer present, showed extensive external heating damage (Figure 7).

The outer casing (or 'jacket') showed that the fire within the nose compartment was predominantly under the heater, towards the aft end. This is the area of the assembly closest to the fuel line from the aircraft to the fuel pump assembly, the fuel line attaching the fuel pump to the heater and the fuel drain line from heater itself. The connection in the leading edge of the right wing showed that the fuel supply line had not been replaced by the stainless steel line as provided for in the Cessna Service Bulletin MEB95-9.

Disassembly of the heater showed a normal pattern of internal combustion, with no leaks of the burner assembly other than an anomalous hole (approx ⅜" across) on the aft end plate. This hole had been made with considerable force and there was no mechanism that would have created it other than the aircraft's impact with the ground. It was also noted that there had been no recent maintenance in this area of the aircraft.

Therefore, all the mechanical damage to the heater was found to be consistent with the ground impact and all the heat damage was found to be consistent with an external fire, centred in the area immediately below the heater, while the aircraft was still in the air.

This external fire had, in particular, badly affected the electrical wires which provide the control system harness for the heater. Expert examination of the ruptured and melted ends of these wires indicated that there may have been some electrical arcing but there was no indication that this initiated the fire.

The examination showed three items of evidence indicating that the heater was not continuing to operate at the time of the impact with the ground:

1) the combustion blower had no scoring marks to denote rotation at impact,
2) the damage to the wiring, which occurred before impact, would have prevented further supply of fuel and combustion air as both the fuel pump and supply solenoid require positive electrical supply and,
3) the overheat switch on the heater body had 'popped', also preventing further supply of fuel and combustion air to the heater.

Combustion heater regulations

The current certification requirements for combustion heaters in this category of light aircraft are detailed in Part 23 of the Federal Aviation Regulations (FARs - in the USA) and CS-23 (Certification Standards - in the European Union). These codes are, on this topic, essentially identical and require that the compartment surrounding a combustion heater be treated as a 'fire region' if *"… the heater fuel system has fittings that, if they leaked, would allow fuel vapours to enter this region."* (FAR 23.859) These requirements include the means of fire detection and suppression, with further requirements for fireproofing and are the same requirements as those for larger Transport Aeroplanes (FAR Part 25 and CS-25).

However, FAR 23.859 had been amended in October 1980 (Amendment 23-27). Previous to that time the certification requirements for combustion heaters in light aircraft were lower and did not include, for instance, any requirement for the means of fire detection and suppression. As this aircraft type was certificated well before 1980, the later requirements of Amendment 23-27 did not apply.

Combustion heaters - previous occurrences

A number of accident and incident databases were researched to look for cases, particularly in the United States, where combustion heaters were considered to have been causal factors in aircraft accidents. Despite the mixed reputation carried by these heaters in light aircraft, there were very few accidents in which the Federal investigators had considered the heater as playing any part. The manufacturers of the heaters consider this to be due to the multiple 'fail-safe' design features of the heaters and, in the case of N6834L, there was evidence that the airborne fire was limited both in extent and duration.

Maintenance details

The aircraft's maintenance at Leeds Bradford Airport was carried out by a local company, operating under the appropriate FAA approvals. Because of the aircraft's lower rate of utilisation in the last two years, the major maintenance inputs had been for Annual Inspections, the latest being performed in July 2003. These Annual Inspections, as applied by this maintenance organisation, included items in the nose compartment of the aircraft but did not detail the form of inspection of the heater or require a check of its operation.

According to the aircraft's maintenance records, there had been an inspection of the combustion heater on 22 February 1996 after the aircraft's arrival. This included the application of the FAA Airworthiness Directive AD81-09-09. As the heater was inspected at 2,868 hours of flight time in 1996, at the current rate of utilisation, a specific inspection would not have been required for a further 250 hours of heater operation.

The hours of heater operation are normally recorded on a 'heater meter' in the nose compartment, linked directly to the electrical circuits of the combustion heater. In this accident the nose compartment had been considerably disrupted and the heater meter could not be identified within the wreckage and furthermore, the maintenance organisation had not made periodic note of the operating hours from the meter. The AD81-09-09 notes that *"In complying with this AD, if the owner or operator cannot document combustion heater operative time, the aircraft time must be used"*. According to this interpretation, the next AD inspection would have been required at 3,118 hours of aircraft time, which was reached in June 1999.

The aircraft maintenance records also did not show any record of the manufacturer's Service Bulletin on the heater fuel lines, MEB95-9, having been performed and the fuel line identified at the wing connection was of the original aluminium alloy type. The compliance period (100 hours of operation or 12 months, from June 1995) covered the move of the aircraft to the United Kingdom in early 1996 and its change of ownership. From the maintenance records, it appears that the omission of this Service Bulletin was unintentional.

As a result of these discrepancies, the AAIB conducted a series of interviews with the maintenance engineers who had performed the recent Annual Inspections (August 2003 and July 2002). Although, many months after the work, the engineers did not have a detailed recollection of the particular work they had performed on N6834L, they understood the inspection requirements in the area of the combustion heater and stated that an operational check of the heater would have been conducted at the same time as the required, and documented, engine runs.

The maintenance requirements for light aircraft registered under the CAA are broadly similar to those under the FAA. However, for all models of combustion heaters, there is a further requirement for UK-registered aircraft (CAP 747 Generic Requirement No 11, dated 28 February 2005, previously CAA Airworthiness Notice, No 41, Issue 9, 29 Oct 2001 - "*Maintenance of Cockpit and Cabin Combustion Heaters and their associated exhaust systems*"). This Airworthiness Notice ensures that, irrespective of operating hours, a combustion heater will be specifically dismantled and inspected at least every two years.

Analysis

Operations

The pilot continued to fly in the USA and UK in the honest belief that his FAA certificate, coupled with annual training and flying checks in the USA, qualified him so to do. He was however, not qualified to fly in the UK or USA unless he was under instruction. The instructor who trained him in the USA recognised his flying aptitude and indicated that his ability was consistent with someone initiating and pursuing an interest in aviation later in life. He also commented that the pilot was able to handle situations which he had previously thought through but was less able to deal with unexpected and unusual situations.

The aircraft engines, that cold morning, had probably been running for at least 17 minutes before the aircraft took off and it is possible that the pilot had started the heater while the aircraft was still on the ground; it is possible that he was operating the heater controls when he was seen to be looking inside the cockpit while taxiing.

The fire in the forward baggage compartment, six minutes after takeoff, would have been very alarming and the pilot's radio call to return to Leeds Bradford Airport was logical in the circumstances. Although he reported a smell of smoke in the cockpit to ATC there was no evidence from the post-mortem that he had inhaled any smoke or been incapacitated by it. He was, by all accounts, fit and healthy.

The visibility during the flight would not have afforded a good natural horizon and the pilot would not have been able to see Leeds Bradford Airport when he turned back and started his descent. Therefore, not only was there a need to action the procedure for a serious emergency, but he had to navigate and fly the aircraft primarily with reference to his flight instruments. Given the pilot's ability and previous incidents, this situation would have generated a very high workload. Additionally he had had little flying practice in the previous eight months and the flying he had carried out had been in the USA accompanied by an instructor on different aircraft types.

The indications from the Trimble GPS and its last recorded position suggest that the power to that piece of equipment was removed 21 seconds before the last primary radar contact was recorded. Following power removal to the GPS equipment, there were no further recorded secondary radar contacts and the pilot did not, apparently, make any further radio transmissions. The emergency procedure for '*Inflight Cabin Electrical Fire or Smoke'* includes reducing the electrical load to the minimum in an attempt to isolate the source of fire or smoke. The inference therefore, is that the pilot switched off the power to these pieces of equipment while still at an altitude of 3,400 feet and flying in a south-easterly direction.

It cannot be determined whether the pilot did this by isolating the avionics electrical bus or by selecting the three Master switches to OFF. However, familiarity with the location and function of the Master switches, lack of familiarity with the avionics bus switches and uncertainty as to the source of the smoke make it more likely that he selected the Master switches to OFF.

The aircraft probably developed, for a period of time, a high rate of descent after leaving an altitude of 3,400 feet; in the order of 3,350 fpm or more. However, neither the impact marks nor the witness report that the aircraft was glimpsed flying level just before the accident suggest such a high rate of descent at those moments.

Following the last primary radar contact the aircraft turned from a track of about 120ºM on to a track of approximately 300ºM, as indicated by the impact marks. That turn does not appear to have started before the last radar contact at 0839:26 hrs. With that in mind, the aircraft turned through 180º, 540º, 900º, or other multiples of 360º, in no more than one and a half minutes. The aircraft made good about 0.5 nm on a track of 150ºM between the last primary radar contact and the impact point. This puts the point of impact about 0.25 nm to the right of the aircraft's last known track. By simple formula, an aircraft flying at, say, 120 kt would need a 60º angle of bank to achieve a 180º turn and remain within 0.25 nm of the original track. If the aircraft had been flying at a slower speed the angle of bank required would have been correspondingly less. In the absence of more recorded data, a number of manoeuvres are conceivable, all of which would involve steep angles of bank.

The pilot had expressed his wish to return to Leeds Bradford. The rapid descent and turn towards the north-west was not communicated to the radar controller who transmitted four radio checks to N6834L between 0839:43 hrs and 0840:18 hrs. It is highly likely therefore, that the aircraft was still airborne when some, if not all, of these radio calls were made and there is no evidence from the post-mortem that the pilot was incapacitated. So, if the manoeuvre was intentional, it reflects a desire by the pilot to land the aircraft immediately. This possibility can be given further credence by the evidence that power was removed from some, if not all, of the avionics instruments.

In summary, the aircraft lost height rapidly and turned tightly, either because the pilot decided to land immediately or because he had lost control. The impact marks show that the aircraft struck the ground in an uncontrolled fashion and, with the one witness who saw the aircraft airborne stating that it did "not seem to be in trouble" shortly before the impact, it is possible that control may have been lost only moments before impact. From the air, the field where the aircraft impacted was sloping away from the aircraft's direction of approach and may have appeared flat. It is therefore possible that the pilot was trying to land on what he thought was a benign surface, although he made no PAN, MAYDAY or other radio call to that effect. The fact that the fuel supplies to the engines were found in the OFF position and that both propeller speed levers had been selected to the gated feather position adds weight to that hypothesis. With a surface wind of about 080º/5-10 kt the aircraft would have had a downwind component before it struck the ground.

Systems

The negative results of the post-mortem and toxicology examinations and the lack of recorded flight information, particularly towards the end of the flight, make it impossible to determine positively the process which led from the detection, by the pilot, of smoke in the cockpit to the impact with the ground. However, the technical examination showed a very high probability that the smoke detected by the pilot came from a fire centred around the area of the cabin heater.

There was no indication that the fire would have affected other aircraft systems and the apparent loss of electrical power, at the same time, to the GPS, radar transponder, the HSI and RMI navigational instruments could not be attributed to the fire. This is both because of the physical separation between these systems and the fire and the redundancy (battery, left alternator and right alternator) of the electrical supply. Although N6834L did not have systems, other than the heater system, routed through the heater compartment, examination of other similar types has shown that this area may, in some cases, be used for other systems.

One effect of the fire in the nose compartment would have been to remove the supply of further fuel to the heater, because of the 'fail-safe' design of the combustion heater control system. It was not possible to determine whether the cessation to the fuel supplied into the fire was because of this 'fail-safe' effect of the fire or because of the removal of electrical power. But, regardless of how the fuel supply was removed, the compartment around this heater was inadequately equipped to allow control of an airborne fire by the pilot. Although compliant with the design requirements of FAR Part 23 at the time of its type certification, the compartment was neither equipped with the means of fire warning nor of fire suppression.

Because of the fragmentation of the nose section, it was not possible to determine either the exact manner in which the fuel escaped from the combustion heater system or the manner in which it was ignited. However, the geometry in this area suggests that the fuel was probably present as a result of a small fuel leak, most probably at a pipe union, and that the ignition was from either the heater exhaust or, possibly, an electrical or heater fault.

In general, however, these problems normally manifest themselves over a period of time and the system of periodic inspection is designed to catch such problems before they become a threat. In this case, the low utilisation of this aircraft meant that, under the FAA maintenance regime applied to this 'N-registered' aircraft, specific inspections of the combustion heater were very rare.

A different approach to continued airworthiness, where compartment design does not meet current certification standards, has been taken by the CAA in the UK. The CAA Airworthiness Notice No 41 (Maintenance of Cockpit and Cabin Combustion Heaters and their associated exhaust systems) applies a further requirement, ensuring that, irrespective of operating hours, a combustion heater will be specifically dismantled and inspected at least every two years. There is clear merit in ensuring this sort of 'calendar backstop' for periodic inspections and, in this instance, there is also a case for requiring repeat inspections using the content of the manufacturer's Service Bulletin MEB95-9. The following Safety Recommendation is therefore made:

Safety Recommendation 2005-066

It is recommended that the FAA introduce inspection and maintenance requirements for combustion heaters in Part 23 aircraft to ensure that adequate detailed inspections are carried out at specified calendar intervals.

Conclusion

It is concluded that a fire in the nose baggage compartment, which started in the vicinity of the cabin heater, caused the smell of smoke in the cockpit. This prompted the pilot to request a return to Leeds Bradford Airport six and a half minutes after he had taken off for Connaught (Knock) in Ireland. The aircraft successfully negotiated a level turn to the left onto a south-easterly heading but then started a rapid descent and a steep turn or series of turns. This may have been the result of controlled flight or uncontrolled manoeuvres. The aircraft was seen to be flying slowly and 'not in trouble' a matter of seconds before it struck the ground. However, the impact marks are consistent with an uncontrolled impact. The positions of some of the controls suggest that the pilot may have been trying to make a forced landing, albeit with a tailwind, into a sloping field which may have appeared level from the air.

The post mortem concluded that there was no evidence of cabin air contamination which could have had an incapacitating effect on the pilot and that he died as the result of multiple injuries sustained at the time of impact.

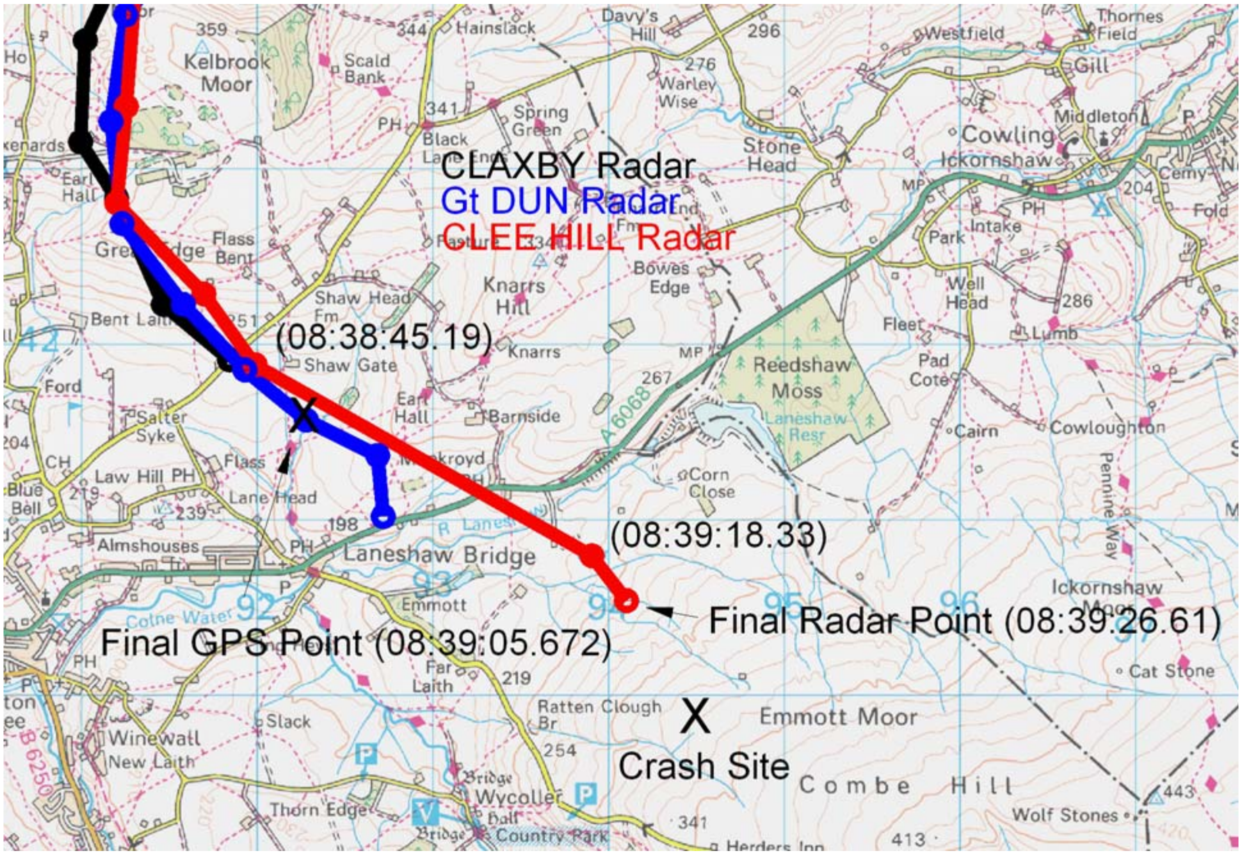
CLAXBY Radar
Gt DUN Radar
CLEE HILL Radar
(08:38:45.19)
(08:39:18.33)
Final Radar Point (08:39:26.61)
Final GPS Point (08:39:05.672)
X
Crash Site

Figure 1

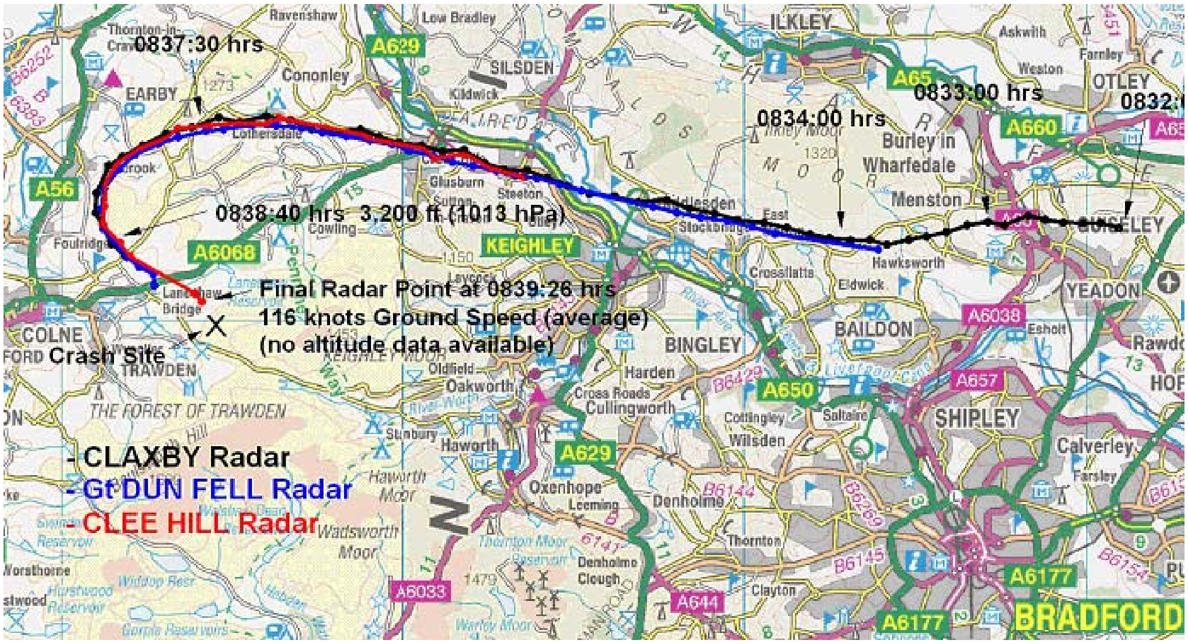

Figure 2 - Radar traces of flight by N6834L

Figure 3 - Accident site - N6834L

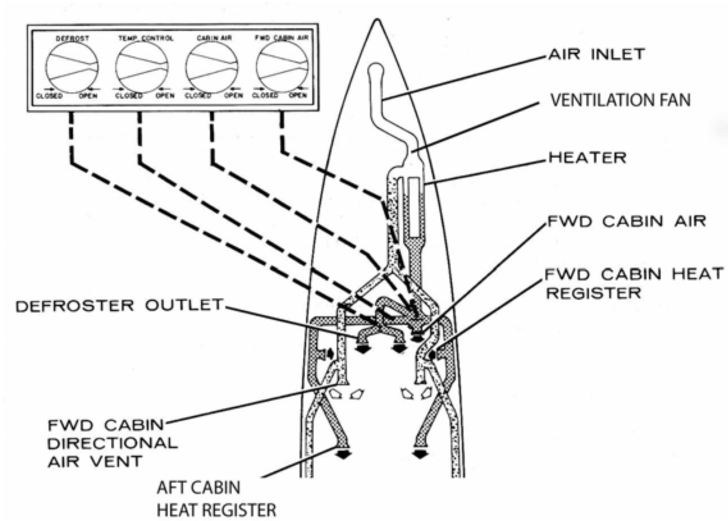

Figure 4 - Heater and ventilation system - T310R

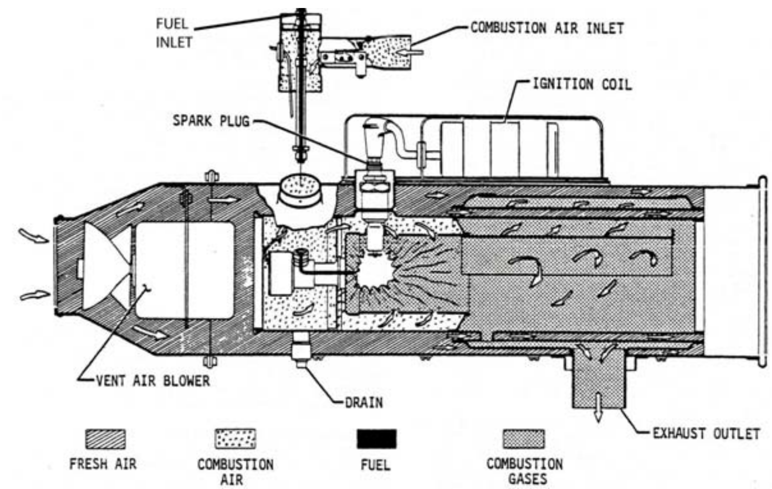

Figure 6 - Combustion heater function

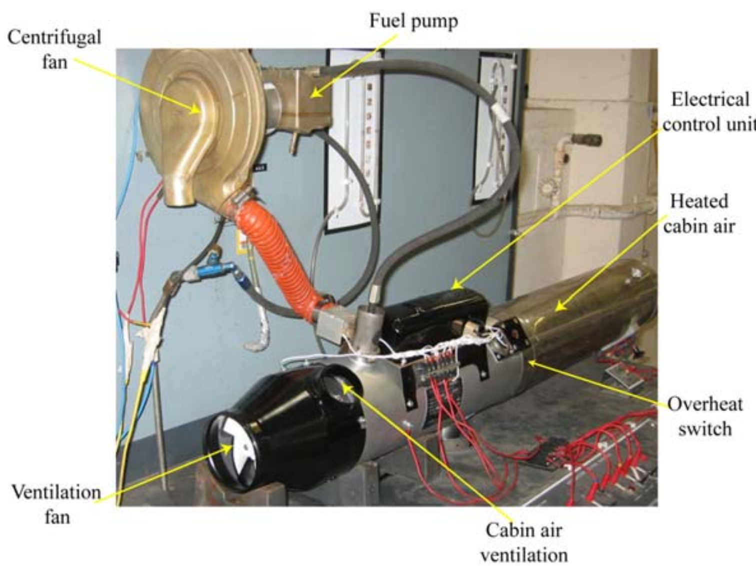

Figure 5 - Typical T310R combustion heater - bench test

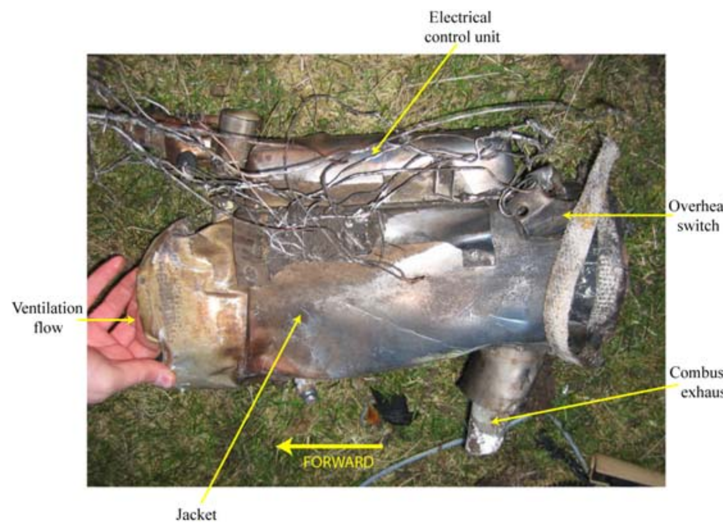

Figure 7 - Combustion heater, N6834L - left side