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COMMERCIAL AIR TRANSPORT

GENERAL AVIATION

CONTENTS (Continued)

SPORT AVIATION / BALLOONS

ADDENDUMS and CORRECTIONS

(ALL TIMES IN THIS BULLETIN ARE UTC)

INCIDENT

Aircraft Type and Registration:	Avro 146-RJ100, G-CFAA
No & Type of Engines:	4 Lycoming LF507-1F turbofan engines
Year of Manufacture:	2000
Date & Time (UTC):	7 January 2005 at 1335 hrs
Location:	London City Airport, London
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 5 Passengers - 53
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to Ground Strike Indicator
Commander's Licence:	Airline Transport Pilots Licence
Commander's Age:	35 years
Commander's Flying Experience:	7,100 hours (of which 880 were on type) Last 90 days - 133 hours Last 28 days - 33 hours
Information Source:	AAIB Field Investigation

Synopsis

During a landing in blustery conditions on Runway 28 at London City Airport, the aircraft's tail struck the ground, causing damage limited to the Ground Strike Indicator.

History of flight

The crew reported for duty after a night stop in Geneva and carried out planning for a scheduled public transport flight to London City. The flight crew obtained the London City Terminal Aerodrome Forecast (TAF) for the period 1000 to 1900 hrs, which predicted wind from 220° at 20 kt gusting to 30 kt with a 30% probability of temporary periods of stronger wind from 220° at 30 kt gusting to 40 kt throughout the period. Visibility was forecast to be more than 9 km throughout the period and the lowest predicted cloudbase was 1,400 ft. In light of the blustery conditions, they elected to load additional fuel for the flight.

The flight progressed normally and as the aircraft crossed the English coast, the flight crew received the London City ATIS Information Romeo, which stated that Runway 28 was in use and the surface wind was from 230º at 7 kt, and later Information Tango, which reported the wind as from 230º at 21 kt gusting 32 kt.

The crew briefed that the co-pilot would fly the approach and that the commander would take control at an appropriate moment and carry out the landing. The commander briefed that he would not add any speed increment for the gusts during the approach, as positive windshear had been experienced just prior to touchdown in similar wind conditions on the previous two days[1]. The landing weight was calculated at 35.3 tonnes and the reference speed for the approach (V_{ref}) was determined to be 116 kt. In benign conditions, the approach speed is normally 5 kt above V_{ref} but increments may be added for strong or gusty winds.

The aircraft was directed by ATC towards the approach, and the Aerodrome Controller at London City cleared the aircraft to land. The controller stated that the wind was from 240º at 25 kt gusting 33 kt, minimum 9 kt, adding that a previous landing aircraft had reported "*JUST STRONG CROSSWINDS"* with no negative windshear, and that the conditions had been smoother below 200 ft. The flight crew acknowledged this information.

The co-pilot, who was flying the aircraft using the autopilot and autothrottle, set the speed bug at 121 kt and the aircraft was established on the glideslope from level flight at 3,000 ft in the landing configuration (Flap 33, the landing gear 'DOWN', and airbrake fully deployed). The controller transmitted updated wind information to the crew as from 230º at 22 kt gusting 33 kt.

The aircraft broke cloud at about 2,000ft above the runway and the commander stated to the co-pilot that he was content to leave the speed bug set at 121 kt but would carry an extra 5 or 10 kt of speed, with the intention of reducing to V_{ref} over the threshold. At about 1,300 ft above the runway the commander took control and, shortly afterwards, disconnected the autopilot and autothrottle.

As the aircraft approached 500 ft above the runway, the controller transmitted further instantaneous wind information as from 240º at 23 kt. As the aircraft passed 500 ft, an automatic callout alerted the flight crew to this height, and the co-pilot responded to the automatic callout stating "STABLE AS IT'S GOING TO BE TODAY".

The commander reported that the approach was *'pretty much in the slot'*. He stated that the company procedures required that the flare manoeuvre should begin at 100 ft above the runway, and that he began the flare at that height. At about 50 ft, he described feeling the aircraft sink slightly, but stated that he decided not to apply additional thrust as the acceleration time of the engines would have made an increase in thrust ineffective in combating the sink. The commander described the landing as being *'firm, as intended, in the right place and at the right speed'*. After landing, the commander taxied the aircraft to the parking stand, the engines were shut down and passengers disembarked.

Once the aircraft had parked, an engineer conducted a routine walk-around inspection and noticed that the Ground Strike Indicator (GSI) under the aircraft's tail had sustained damage. He reported this to the flight crew and the aircraft was grounded until a detailed inspection had been carried out. The flight crew were unaware that the tail had contacted the runway until the engineer advised them of the damage.

Aircraft damage

The GSI is a 2.3 m long aluminium strip secured lengthwise to the centreline of the aircraft's tail underside. It has a U-shaped cross-section with a width of 5.5 cm and a height of 1.5 cm. The strip forms a hollow channel and is designed to crush and absorb some of the impact energy during a tail strike. Any damage to the strip also serves as a clear indication that the tail has been struck

Footnote

[1] A positive windshear adds speed or energy to the aircraft, and may result in too high a touchdown speed, or a touchdown further along the runway length than is desirable.

The aircraft was not equipped with a tail strike indicator in the flight deck.

The damage to G-CFAA was confined solely to the GSI. The forward 1 m section of the GSI had sustained scraping and crushing damage but the damage had not penetrated the aircraft structure.

Flight Recorders

The aircraft was fitted with a solid state Flight Data Recorder (FDR) capable of recording a range of flight parameters. The aircraft was also fitted with a Cockpit Voice Recorder (CVR) which recorded crew speech and area microphone inputs. Both recorders were removed from the aircraft and successfully replayed at the AAIB facilities.

A time-history of the relevant parameters during the incident is shown in Figure 1.

The final descent into London City was from 3,000 ft (radio height), and began 3 minutes 40 seconds before touchdown. At that time, the aircraft was in the landing configuration with flaps extended to 33º, landing gear 'DOWN' and the airbrakes 'OUT'. The speed during the descent was 120 kt (V_{ref} +4 kt) ±10 kt calibrated airspeed (CAS). Autothrottle was engaged throughout the descent until about 1,100 ft, about 75 seconds before touchdown.

The data presented for the incident landing starts just over 16 seconds before the touchdown with the aircraft on the glideslope; 245 ft above the ground; at 125 kt (ie V_{ref} +9 kt); with a descent rate of about 750 ft/min and a fan speed (N1) of about 57% on each of the engines. For clarity, the Power Lever Angle (PLA) and N1 are shown for engine No 4 only; these are, however, representative of those of the other three engines.

The figure shows two points during the descent (Points A and B of Figure 1) at which additional thrust was applied. The first thrust increase was from 57% to 63% N1, at about 150 ft and 9 seconds before touchdown. This increase in thrust followed an increase in aircraft pitch attitude from -5º to 0º and coincided with a decrease in airspeed from V_{ref} +6 kt to V_{ref} -2 kt.

The second thrust increase was from 60% to 69% N1, at about 85 ft and 5 seconds before touchdown. This occurred as the aircraft pitch decreased slightly and the airspeed increased from V_{ref} -2 kt to V_{ref} +6 kt. As the N1 began to increase, the airspeed reduced by 16 kt to V_{ref} -10 kt over 3 seconds, at a peak deceleration of 7 kt per second; the aircraft pitch attitude remained nominally level and the ground speed only increased by 2 kt to 94 kt. The aircraft height when the airspeed reached V_{ref} -10 kt was 35 ft and the airspeed remained at V_{ref} -10 kt until touchdown.

At touchdown the recorded pitch attitude peaked at 6.6º and the descent rate was 600 ft/min (10 ft/sec).

Ground marks

The runway was examined shortly after the accident. A line of paint deposits and scrape marks, some 4 m long, was found approximately 50 cm to the right of the centreline of Runway 28, its easterly end being some 80 m from the beginning of the available runway length. The colour of the paint deposits was consistent with the paint on the remaining part of the aircraft's underside in the area of the GSI.

The Airport and the Operator's Operations Manual

London City Airport is built on a narrow strip of land between two docks, and is surrounded by tall buildings. The statutory requirements regarding runway dimensions and the available building space result in the runway being both narrow and short.

The Operator's Operations Manual describes London City Airport as follows:

> *'The Airport, in the Docklands, East London, is 19 miles east of, and lies beneath the approach path, to Heathrow. The approach glide slope are steep at 5·5° and the strip is short and narrow at 1199m x 30m. The obstacles for the approach, go-around and take off are significant and numerous.'*

and also stated:

> *'Speed control during the approach and landing must be accurate'*

The Operations Manual included specific requirements regarding operations into London City, specifying amongst other things that monitored approaches (during which one pilot flies the approach until the other pilot takes over control to accomplish the landing) were to be used at London City. All landings there were to be carried out by captains, who had to receive a briefing, steep approach training (including a training detail in an aircraft) and an airport familiarisation visit before becoming qualified to operate into London City. Co-pilots were required to receive training in the form of a briefing and steep approach simulator training before becoming qualified to operate into London City.

The Operations Manual contained other advice and instructions regarding steep approaches and flying technique. It placed emphasis on accurate speed control and in particular, the importance of avoiding too high an airspeed on the approach.

The operator had also published a Flight Operations Bulletin and a two-part article on tail strikes with a covering letter. The article was written by a very experienced BAe 146 pilot who had been responsible for some of the production test flying of the aircraft. These both gave further advice concerning correct techniques.

Analysis

The operator's training requirements reflected an acknowledgement of the demanding nature of London City Airport. The Operations Manual contained generic advice about steep approaches and advice specific to London City; the operator had also issued both a Bulletin and an informal article to amplify this advice to its pilots.

The flight proceeded normally until the final stages of the approach, where the conditions at London City were very gusty. The commander bore in mind the positive windshear he had encountered in similar gusty weather over the previous two days and elected not to add an increment to the final approach speed. His decision also reflected consideration of the comment from the previous landing aircraft, passed on by ATC.

As the aircraft approached, at about 85 ft, the commander increased thrust from 60% to 69% N1 and decreased the pitch attitude slightly. Both of these actions should, in still air, have resulted in an increase in airspeed. However, the airspeed decreased by 16 kt over 3 seconds, although the ground speed increased slightly. By 35 ft, the speed was 10 kt below V_{ref}, making a normal touchdown difficult to achieve, with any attempt to flare the aircraft for touchdown causing a further reduction in speed. During the flare, the pitch attitude increased to 6.6° nose up and the tail contacted the runway. This evidence is consistent with an encounter with significant negative windshear immediately prior to touchdown.

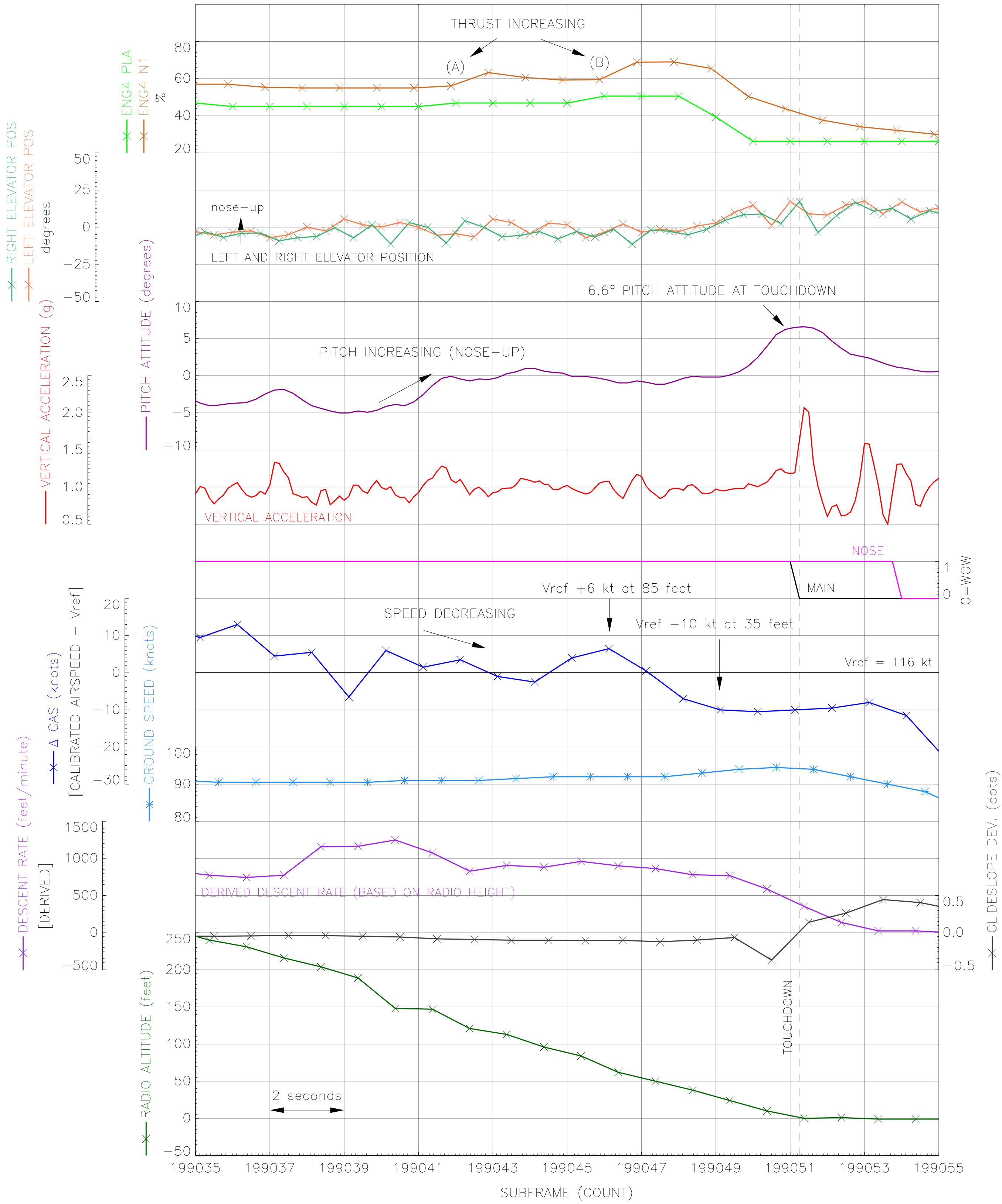


Figure 1

Salient FDR Parameters
(Incident to G-CFAA on 7 January 2005)

INCIDENTS

Aircraft Type and Registration:	Avro 146-RJ100, G-CFAC and others
No & Type of Engines:	4 Lycoming LF507-1F turbofan engines
Year of Manufacture:	Various
Date & Time (UTC):	Various dates and times
Location:	Various
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - Various Passengers - Various
Injuries:	None
Nature of Damage:	None
Commanders' Licences:	Airline Transport Pilot's Licence
Commanders' Ages:	Various
Commanders' Flying Experiences:	Various
Information Source:	Aircraft Accident Report Forms submitted by pilots and subsequent enquires by the AAIB

Synopsis

During the winter of 2004/2005, UK-based airline operators experienced numerous incidents of restricted elevator and aileron controls on their Avro 146-RJ100 fleets. One operator also reported occurrences of restricted elevator controls on its Embraer 145 and Bombardier DHC-8 aircraft. These aircraft types are similar in having non-powered flight controls. Other European operators of Avro 146/RJ-series aircraft also reported flight control restriction events during the same period.

Many of these events were found to be associated with residues of 'thickened' de-icing fluids, that had accumulated in the aerodynamically 'quiet' areas of the elevator and aileron controls. These residues rehydrate on exposure to precipitation and can freeze at altitude, with the potential for restricting control movement. In most of these incidents, the control forces returned to normal after the aircraft had descended into warmer conditions. Despite recent industry efforts at addressing the problems posed by such residues, an effective solution remains to be found.

This bulletin reiterates the safety recommendations issued in a recent AAIB bulletin, which stated that the build-up of such residues must be avoided through a tightly controlled regime of inspection and cleaning, and that new types of thickened fluids must be developed, whose residues do not cause flight control restrictions on aircraft with non-powered flight controls.

Recent flight control restriction events

A previous AAIB bulletin report (EW/C2002/12/02) listed occurrences of flight control restriction events believed to have been caused by the freezing of thickened de-icing fluid residues. In 2005, numerous other similar events were reported in the UK and elsewhere in Europe. The majority of these incidents involved Avro 146/RJ-series aircraft, but other aircraft with non-powered flight controls such as the Embraer 145 and Bombardier DHC-8 were also affected.

The descriptions of these events and the subsequent findings are presented in Table 1 (see page 14). In many of these events, subsequent inspection of the aircraft highlighted the presence of de-icing fluid residues in locations and quantities that could have caused control restrictions. At the time, the affected operator had a scheduled maintenance task to inspect its aircraft for de-icing fluid residues every 31 days.

The AAIB consulted other accident investigation bodies in Europe for information on flight control restriction events. The information obtained is presented in Table 2 (see page 19). Although some events are still being investigated, de-icing fluid residues appear to be implicated in some cases. Following these events, the operator of the Swiss-registered (HB-) aircraft changed its maintenance practices to inspect for de-icing fluid residues every 14 days (reduced from 28 days) and inspection and cleaning is now required within two/three days following an application of thickened de-icing fluid.

Effects of thickened de-icing fluid residues

In recent years there has been a tendency towards the greater use of ‘thickened’ de/anti-icing fluids, because of the improved holdover times that they provide. Industry experience has shown that the repeated use of ‘thickened’ de-icing fluids (specifically ISO Type II, III and IV fluids) for de-icing or preventative anti-icing can result in a gradual accumulation of fluid residue in the aerodynamically ‘quiet’ areas in the control surface gaps. As these fluids are applied with a high pressure spray, the fluid can also enter cavities in the control surfaces (eg, control rod apertures).

With time, the glycol antifreeze component of the fluid evaporates, leaving a dry, grey or blackish residue, comprised largely of the thickening agent, which is very hygroscopic and has little or no antifreeze properties. The repeated application of thickened fluid causes the residues to accumulate in increasing quantities, unless removed by regular cleaning. On exposure to moisture, for example, during rain showers, the residues will absorb water and swell to many times their original volume, to form a thick gel which can bridge the gaps between flight control surfaces and adhere to control mechanisms.

When the aircraft climbs above the freezing level the residues may freeze, with the potential for causing partial restriction, or in the worst case, complete jamming of the affected controls. If the autopilot is engaged at the time, symptoms may include: pitch oscillation, failure to level off at the selected flight level, or failure to capture the selected heading. The control forces usually return to normal after the aircraft has descended and the residues have thawed.

Normally this problem only affects aircraft with non-powered flight controls, because the power control units on aircraft with hydraulically-powered flight controls can overcome any such restriction caused by frozen residues.

Previous AAIB bulletin: 146-200 G-JEAX incident

The problems posed by the increasing use of 'thickened' de-icing fluids on aircraft with non-powered flight controls were highlighted in a recent AAIB bulletin report (EW/C2002/12/02) published on 5 February 2004, which reported on an incident of restricted elevator controls on BAe 146-200 G-JEAX, on 12 December 2002. This report highlighted the dangers posed by de-icing fluid residues and consequently the following Safety Recommendations were made to the United Kingdom CAA:

Safety Recommendation 2003-119

'It is recommended that the Civil Aviation Authority require operators of aircraft with non-powered flying controls that are vulnerable to the effects of freezing of re-hydrated de-icing fluid residues, to establish engineering procedures for the inspection and removal of such residues from critical flying control surfaces'.

Safety Recommendation 2003-82

'The Civil Aviation Authority should consult with anti-icing fluid manufacturers with a view to encouraging them to develop fluids, with suitable 'holdover' times, that incorporate gelling agents that are not rehydratable.'

De-icing procedures

Within the United Kingdom, and variously around Europe, the de-icing and anti-icing[1] of aircraft is usually performed by contracted service providers, with few airline operators possessing their own equipment. There is currently no requirement for the training or licencing of de/anti-icing personnel and so there is no direct control over the manner in which fluids are applied[2]. A key requirement from operators is for de-icing fluids with long holdover times to provide protection from ice for the longest possible time and thus minimise departure delays. This drove the development and introduction of so called 'thickened' Type II, III and IV fluids (to specification SAE AMS 1428A), which are much more viscous than the Type I fluids. The former provide increased protection by forming a much thicker layer of fluid over the aircraft surfaces. The thickened fluids are also commonly used for preventative anti-icing.

In-service experience with the thickest (Type IV) fluids showed that they produced significant amounts of residues which caused control restrictions on aircraft with non-powered flight controls. This led to recommendations from the aircraft manufacturers that Type IV fluids should not be used on such aircraft, and ultimately, the issuing of an Operations Directive from the Joint Aviation Authorities (JAA) containing similar advice.

In the UK the use of Type II fluids, one in particular branded as 'Type II+', has become predominant. These fluids, in theory, contain less thickening agent and should be less viscous than Type IV fluids, but in practice they can have similar viscosities. Industry experience has shown that Type II de-icing fluid residues can produce similar problems of flight control restrictions.

These problems may be alleviated by de-icing with Type I fluids which, being considerably less viscous,

Footnote

[1] Anti-icing of aircraft normally occurs some time prior to a departure, typically, the night before when snow, ice or frost is anticipated, and usually involves the use of a 'thickened' fluid. De-icing will typically be carried shortly before departure when accumulations of ice, snow, etc, need to be removed from the airframe, and may be performed using both thickened and unthickened fluids, depending on the holdover time required.

[2] If not applied appropriately, anti/de-icing fluids may easily enter flight control mechanisms within control surfaces, through actuator rod apertures, for example, where it is difficult to subsequently inspect for, and remove, residues.

tend to run off surfaces more readily and do not leave significant residues. It is understood that operators in North America prefer to use a two-stage de-icing procedure, with an initial application of Type I fluid, followed by the application of a thickened fluid to anti-ice, if required. Whilst some European airlines consulted by the AAIB stated that they would prefer to de-ice in this way, the availability of Type I fluid in Europe is extremely limited, given the far greater demand for the thickened fluids, and de-icing service providers are reportedly reluctant to stock this fluid.

Notwithstanding this, in Europe, some operators have guaranteed their own stock of Type I de-icing fluid for use at some airports, but they are still very much in the minority.

Regulatory information pertaining to aircraft de/anti-icing

Aviation fuels, oils, greases and similar substances are regulated and generally conform to specifications agreed with the relevant Airworthiness Authority. Such substances are usually approved for use following test and evaluation by the manufacturer to ensure, firstly, that they perform as intended and, secondly, that they pose no short or long term risk to flight safety. In addition, their 'shelf life', usage and/or manner of storage and are usually specified. At present, no such regulation applies to the manufacture, quality or application of de/anti-icing fluids.

The Joint Airworthiness Requirements Section JAR-OPS 1.345 'Ice and other contaminants - ground procedures' states:

> *'a) An operator shall establish procedures to be followed when ground de-icing and anti-icing and related inspections of the aeroplane(s) are necessary.'*

To the AAIB's knowledge, there are no further requirements beyond this relating to either the procedures for de-/anti-icing or the properties required of the fluids. However, advisory material is provided in the supporting document ACJ OPS 1.345: Paragraph 3d) states:

> *'Fluids used for de-icing and anti-icing should be acceptable to the operator and the aeroplane manufacturer. These fluids normally conform to specifications such as SAE AMS 1424, 1428 or equivalent. Use of non-conforming fluids is not recommended due to their properties not being known.'*

Section 8 *'Special Maintenance Considerations'*, states:

> *a) General*
>
> *The operator should take proper account of the possible side-effects of fluid use. Such effects may include, but are not limited to, dried and/or re-hydrated residues, corrosion and the removal of lubricants.*
>
> *b) Special Considerations due to residues of dried fluids*
>
> *The operator should establish procedures to prevent or detect and remove residues of dried fluid. If necessary the operator should establish appropriate inspection intervals based on the recommendations of the airframe manufacturers and/or own experience.*
>
> *ii) Operators are strongly recommended to request information about the fluid dry-out and re-hydration characteristics from the fluid manufacturers and select products with optimised characteristics.'*

On 15 September 2005, the JAA issued a Safety Information Communication the subject of which is '*Information on precautions and measures to be taken to counteract the presence, and also the formation of ice and other contaminants prior to flight*'. In this document, the phenomenon and hazards of the drying out and re-hydration of certain anti-icing fluids are highlighted. Reference guidance material is also provided.

The Association of European Airlines (AEA) document entitled '*Recommendations for De-Icing/Anti-Icing of Aircraft on the Ground*' is generally accepted by European airlines to be the definitive guidance document on ground de/anti-icing practices, but it is not compulsory to follow these recommendations.

Airframe manufacturer's advice to operators

The information provided by the regulatory authority implies that the aircraft manufacturer will recommend inspection intervals for the detection and removal of de/anti-icing fluid residues. The aircraft manufacturers have issued a considerable amount of advice to warn operators of the problems posed by thickened de/anti-icing fluid residues and the importance of inspecting for residues and removing them by regular cleaning of the affected areas, however, with some exceptions, these documents generally do not go as far as to recommend inspection intervals, leaving this to the operator to determine, based on their own service experience.

Given the problems on Avro 146/RJ aircraft in the winter 2004/2005 period caused by de-icing fluid residues, the aircraft manufacturer, BAE Systems, issued Technical Operational Response (TOR) Serial Number 2845, containing a draft revision to Chapter 12-30-31 of the Aircraft Maintenance Manual. This contains comprehensive instructions on how and where to inspect for residues and how they should be removed. The instruction also recommends the frequency of inspection, as follows:

> *'It is recommended that where thickened (Type II, Type III or Type IV) anti-icing fluids are used, the aircraft should be inspected for residues daily. Operators should develop an inspection and cleaning schedule taking into account their own operational environment and procedures, as well as the factors affecting build-up as stated above. If any residues are found they must be removed from the aircraft before the next flight.'*

BAE Systems has also issued a reference card to operators which provides advice on the application of de/anti-icing fluid. This contains a caution that fluid should not be applied to the aircraft in a forward direction, in order to prevent it entering the structure through various aerodynamic fairings. The manufacturer has also re-issued Service Information Letter (SIL) 27/80 to include the latest 'winterisation' advice.

Information gathered by the AAIB suggests that operators who inspect for de/anti-icing fluid residues more frequently, scheduled either on a short time interval, or after a specified number of applications of thickened de-icing fluids, tend not to suffer from flight control restriction problems. Operators' experience suggests that an inspection interval of 30 days may not be frequent enough. Whilst frequent inspection and cleaning of the flight controls places a large burden on an operator's resources, and requires the availability of suitable facilities and equipment (eg, hangars and access hoists), such inspections are unavoidable if thickened de/anti-icing fluids are used on aircraft with non-powered flight controls.

During the winter of 2005/2006, one operator reported three incidents of elevator trim circuit restrictions on an Avro RJ aircraft. A significant amount of anti-icing fluid residue was found to have accumulated under fairings on both elevators. These fairings covered the two trim circuit control rods where the trim tab drive passed in to the trim tab itself. As a result of this finding, on 20 January 2006, the manufacturer issued an All Operators Message (AOM), 06/001V, to highlight this finding and recommend rectification action. A copy of this AOM is appended to this report (see page 20).

BAE Systems Anti-icing Residue Focus Group

On 10-11 May 2005 the manufacturer of the Avro 146/RJ series aircraft, BAE Systems PLC, held a forum for operators of the aircraft type to discuss the subject of fluid residues. This meeting was also attended by representatives from the UK CAA and the AAIB. This provided an open forum for operators to share their experiences of the problem and the measures taken to combat the effects of the residues of thickened fluids.

At the forum, the aircraft manufacturer committed to issuing further information to operators on maintenance practices for the inspection and removal of the residues. The forum highlighted some initiatives which, if implemented, would help address the problem of fluid residues. These included:

- Minimising the use of preventative anti-icing with thickened fluids.
- Where possible, use of Type I fluids for de-icing.
- Exploring the possibility of greater availability of Type I fluids at operator's hub stations.
- Seeking assistance from the fluid manufacturers on cleaning solutions/solvents and the use of residue identification dye.

Discussion

The numerous recent incidents in the UK and elsewhere in Europe, of flight control restrictions attributable to the freezing of residues of thickened de/anti-icing fluids, show that this problem has still not been addressed effectively. This is a matter of concern, given that the potential dangers posed by such residues were publicised both in a recent AAIB bulletin and in advisory material issued by the aircraft manufacturers and the JAA. Experience has shown that the currently available thickened de-icing fluids, with their rehydratable residues, are not practically suited for use on aircraft with non-powered flight controls. They pose a potential hazard to flight safety through their ability to cause flight control restrictions, unless strict procedures are invoked to inspect for, and remove, the residues on a frequent basis.

Industry experience suggests that the problems can be largely eliminated by frequent controlled inspections and removal of the accumulated residues. Despite operators having adopted such a process, a small number have continued to experience problems. Evidence suggests that operators who perform the inspection and cleaning task at a short time interval, or who schedule the task based on the number of applications of thickened fluid, are generally more successful in managing the problem than an operator who inspects for residues at an interval of 30 days, for example. Most aircraft manufacturers do not specify to operators a suitable frequency for the task, leaving it to the operators to decide, based on their own, possibly limited, experience. Given that the task to inspect and remove the de/anti-icing fluid residues is very labour intensive and places a heavy burden on an operator's resources, it can at best be considered a short term solution which addresses the symptoms, rather than the cause of the problem.

The JAR OPS requirements state:

> *'Fluids used for de-icing and anti-icing should be acceptable to the operator and the aeroplane manufacturer.'*

For aircraft with non-powered flight controls, the thickened de/anti-icing fluids currently available are neither acceptable to the operator nor to the aircraft manufacturer. However, as long as market forces continue to drive for de/anti-icing fluids with longer holdover times, thickened fluids will continue to be supplied in preference to Type I fluids. It is therefore considered that a regulation is necessary to ensure that only suitable fluids are used on aircraft with non-powered flight controls.

A potential solution would be for operators of aircraft with non-powered flight controls to avoid using the thickened fluids where possible and to de-ice using Type I fluids. Even though some operators would prefer to do this, the de-icing service providers seem reluctant to hold stocks of Type I fluid, given the limited demand from the relatively small number of operators of such aircraft. As there is a general desire within the industry to use thickened fluids which provide anti-icing protection for long holdover times, if a 'thickened' fluid could be developed whose residues are not rehydratable, the potential for such a fluid to cause flight control restrictions on aircraft with non-powered flight controls would be much reduced.

Conclusions

The hazards posed by the re-hydrated residues of thickened de/anti-icing fluids in causing flight control restrictions on aircraft with non-powered flying controls have been well publicised by both the aircraft manufacturer's and the JAA's advice to operators, and also in a recent AAIB bulletin. Despite this, recent events in the UK and elsewhere in Europe in the winter of 2004/2005 have shown that the problem is still prevalent, suggesting that more effective action is required.

The options available to operators of non-powered flight control type aircraft for de-icing are few, given the limited availability of Type I fluids and the use of currently available thickened fluids which impose a large penalty in increased maintenance costs. Therefore, the AAIB believes that regulation is necessary to effect the changes necessary to resolve this situation.

Safety Recommendations

Previous safety recommendations made by the AAIB were addressed to the UK Civil Aviation Authority. However, it is apparent that this problem also affects operators throughout Europe. Within European aviation, the JAA has oversight of operational matters, whilst EASA has responsibility for certification standards and the airworthiness of aircraft and their components. In order to effectively address the safety issue of the accumulation of rehydrated residues of 'thickened' de-icing fluids, which can freeze in flight and cause flight control restrictions, the following safety recommendations are made:

Safety Recommendation 2005-135

It is recommended, that the Joint Aviation Authorities, in consultation with the European Aviation Safety Agency, issue safety documentation to strongly encourage operators of aircraft with non-powered flight controls to use Type I de/anti-icing fluids, in preference to 'thickened' fluids, for de-icing.

Safety Recommendation 2005-136

It is recommended that where the use of 'thickened' de/anti-icing fluids is unavoidable, the Joint Aviation Authorities, in consultation with the European Aviation Safety Agency, ensure that operators of aircraft with non-powered flight controls who use such fluids, invoke controlled maintenance procedures for the frequent inspection for accumulations of fluid residues and their removal.

Safety Recommendation 2005-137

It is recommended that the European Aviation Safety Agency introduce certification requirements relating to de/anti-icing fluids for use on aircraft with both powered and non-powered flight controls.

Safety Recommendation 2005-148

It is recommended that prior to the European Aviation Safety Agency assuming responsibility for operational matters within Europe, they consider the future need for the training and licencing of companies who provide a de/anti-icing service, so that anti-icing fluids are applied in an appropriate manner on all aircraft types, but specifically to ensure that the entry of such fluids into flight control mechanisms and control surfaces is minimised.

	DATE	AC Reg	INCIDENT DETAILS	FINDINGS
Avro 146/RJ				
1	18-Mar-05	G-CFAC	With AP engaged @ FL22 abnormal variation in ROC/ROD. On disconnecting AP only minimal movement of elevator and ailerons possible. Normal control regained at FL070. Conditions: VMC, Rain. AAIB File ref: EW/G2005/03/09	Re-hydrated de-icing fluid residues found under aileron panels 511BB, 611BB, 533CB, 633CB, 533BB and 633BB & elevator panels 347BB, 348BB, 333BB & 334BB. Areas washed & cleaned w/ warm water, then lubricated.
2	18-Mar-05	G-CFAC	A/P failed to follow FD turn cmd at FL130 w/ flight control restrictions in pitch & roll after A/P disengaged. PAN & air-turnback. Pitch restriction remained until start of final approach. A/c descended to lower altitude & restriction reduced as OAT increased. AAIB File ref: EW/G2005/03/11	Further contamination found under elevator panels 333AB, 334AB 348AB, 347AB, 336MB & 335MB & heavy contamination under panels 336CT & 335CT. When rehydrated significant residue build up around servo/ trim tab bearings & rod ends. Areas cleaned and re-hydrated several times before all traces of contamination cleared. Signs of re-hydrated fluid under aileron panels 511FB, 611FB, 331BB, 631BB, 533AB, 633AB, 581AAB, 681AAB, 581ABB & 681ABB. Significant contamination found esp. in the shrouds around the servo/trim tab rods after re-hydration. Areas cleaned & re-hydrated several times before all traces of contamination had cleared. Items lubricated & op chk of flying controls performed.
3	19-Mar-05	G-CFAA	At FL280 in clear air, a/c failed to follow AP commands. When AP disconnected, pitch & roll controls restricted & trim wheels jammed. PAN declared & descended to FL200. Pitch problem moderated during descent. Full roll authority not regained until FL080. Light/mod. rain during previous turnround at SZG. Departure climb flown thru mod. icing until around FL140. AAIB File ref: EW/G2005/03/18	De-icing fluid residue contamination reported on ailerons and elevators but no specific locations recorded. A/c returned to service - further report of flight control restriction on 30/3/05 at FRA.
4	22-Mar-05	G-CFAB	Just prior to reaching cleared level FL250 with AP engaged, pitch difficulties experienced with V/S fluctuations of of up to +/- 600 fpm, which persisted after level off. When AP disconnected, pitch/roll forces were heavy. Normal control regained by 5000 ft. Conditions: Day VMC. Wx on departure moderate rain with surface temp +12 degrees. AAIB File ref: EW/G2005/03/14	De-icing fluid residue found in ailerons & elevators. Residue removed IAW company procedure and the aircraft returned to service. Further reports made under ASR 283/05/146 & 290/05/146 where further residues were noted to have been found in the same locations as previously.
5	22-Mar-05	G-CFAD	At FL250 in day VMC, just before TOD, a/c failed to track LNAV properly. When AP disconnected, ailerons found frozen. Directional control available with rudder. PAN called & descent made, on passing FL120 controls freed & PAN cancelled. No record in Tech Log of de-icing for 12 days. Moderate rain for 30+ mins on ground prior to departure. AAIB File ref: EW/G2005/03/13.	Contamination from de-ice fluid residue found on operating rods under panels 531/631AB, 533/633BB, 533/633AB (LH/RH ailerons) & under panels 347BB, 347AB, 336AB (LH/RH elevators). Residue cleaned out.
6	23-Mar-05	G-CFAH	In level flight @FL220 w/ AP engaged, a/c failed to follow FD heading change. On disconnecting AP aileron controls found to be restricted. Full control regained later regained on passing FL100 @OAT +2 C. AAIB File ref: EW/G2005/03/20.	On engineering inspection contamination found around panels 581/681AB (input to left & right aileron torsion bar). Contamination cleaned off

TABLE 1: Control Restriction Events on UK-Registered Aircraft - Avro 146/RJ

	DATE	AC Reg	INCIDENT DETAILS	FINDINGS
7	25-Mar-05	G-OINV	Level @ FL270 in day VMC, aileron trim warning occurred. AP disconnected. Roll control available but no spoiler movement in R/H turns. Full roll spoiler not available until just before landing. A/c last de-iced on 13-3-05, no rain overnight. A/c flown through a layer of cloud 500 ft thick after take off. Possible defect w/ spoiler system. AAIB File ref: EW/G2005/03/21.	Full inspection of roll spoiler system carried. Captain confirmed system had come good when OAT had risen. No sign of water ingress to the components Nor any hydraulics problems. Both system contents correct. Autopilot functioned-NFF. Spoilers deployed & indication good. Full range of aileron movement achieved. A/c considered serviceable. Crew asked to monitor on return to Inverness.
8	26-Mar-05	G-OINV	Aileron trim warning during right turn, controls stiff during right turns. OK in left turns. A/c flown manually to ILS approach LGW R/W 08R. Controls returned to normal at temps above 0 deg C. See item above. AAIB File ref: EW/G2005/03/22.	Inspection of roll spoiler and aileron linkages carried out. Operation found to be very smooth. System checked with & w/out auto pilot. A/c considered serviceable for return flight to Inverness pls report any further problems. Suggest lubrication of various bearing & rod ends.
9	27-Mar-05	G-CFAB	In cruise a/c not tracking LNAV properly. When A/P disconnected, ailerons found to be frozen with virtually no control available from them. Airframe & engine a/ice selected on and a/c descended after PAN call. Normal control restored by FL120, PAN canx. On approach to FRA on prev sector a/c flew thru rain for several minutes. AAIB File ref: EW/G2005/03/23.	On inspecting aircraft no contamination found on the aileron controls. Minor contamination found on the elevators at panels 347AB/BB. Area washed and a/c returned to service.
10	29-Mar-05	G-CFAB	A/c failed did not follow AP turn cmd properly. A/c felt to jerk and failed to apply enough bank. On disconnecting AP ailerons found very stiff to operate. Diversion to GLA where visibility better. Controls became normal on descending thru' 5000 ft where OAT +2 deg C. Drizzle on turnound and rain during climb this sector. VMC in cruise. AAIB File ref: EW/G2005/03/17.	Reported failure to follow steering command from FD. Inspection revealed de-ice residue contamination at the LH/RH aileron inputs under panels 581AB/AAB & ABB & 681AB/AAB & ABB. Residues cleaned off and aircraft returned to service.
11	30-Mar-05	G-OINV	During cruise aileron trim caption came on. When AP disconnected ailerons v. stiff & no movement of R/H roll spoiler. AP reengaged when light went out. When giving hdg changes trim light came on again & AP unable to follow FD. OAT -30 deg C in thin cirrus (=icing) on descent. Ailerons still stiff @ FL150. At FL070 (0 deg C isotherm) controls unfroze to give full & free movement. See item above. AAIB File ref: EW/G2005/03/28.	Initial inspections found no de-ice residue on the aileron controls & emphasis moved to the roll spoiler mechanism. The cam box on the RH wing was replaced. A/c operated a number of sectors with similar reports of OAT levels without further report. On 5/4/05 the aircraft was reported with minor restriction again in RH turns with an aileron trim warning. A/c had stood overnight in heavy rain. On arrival back at INV the input connectors (behind panels 581-681AAB/ABB) on the LE of the LH & RH ailerons were checked and found to have a minor level of de-ice fluid residue contamination. The residue was removed. RH roll spoiler also replaced as a precaution.
12	30-Mar-05	G-BZAY	In descent passing FL 270 w/ AP in, a/c made uncommanded LH turn. AP disconnected & ailerons found frozen. (Roll spoilers appeared OK on gauges). A/c difficult to control in roll. Further descent initiated promptly. Controls began to return to normal at FL130 but did not fully recover until passing 3000 ft where OAT 0 deg C. A/c not de-iced in previous 2 weeks. AAIB File ref: EW/G2005/03/25.	Minor contamination of the aileron servo actuator found. Extensive cleaning carried out and a/c released to service. Refer to 289/05/146 for further report on next flight where the aircraft diverted to MAN during positioning flight EDI to BHX

TABLE 1 (cont.): Control Restriction Events on UK-Registered Aircraft - Avro 146/RJ

	DATE	AC Reg	INCIDENT DETAILS	FINDINGS
13	30-Mar-05	G-BZAY	In cruise heading control poor on AP. When AP disconnected, aileron controls very stiff to the right & almost non-existent to the left. PAN & diversion due poor weather at planned destination. Controls freed up at around 6000 ft during descent. 0 deg C level at 6000 ft. AAIB File ref: EW/G2005/03/30.	Second report on the same day. After this report further contamination was noted on under the final drive panels on the LH & RH ailerons (581/681AAB & ABB) & on the left and right elevators under panels 348AB/BB & 347AB/BB. Contamination removed & areas thoroughly cleaned. Aircraft returned to service.
14	30-Mar-05	G-MABR	During cruise, AIL warning occurred. QRH actioned & warning extinguished. A/c stiff in roll with AP disconnected. Roll normal at lower altitudes in warmer temperatures. AAIB File ref: EW/G2005/03/29.	Found aircraft contaminated with residue of de-icing fluid. ETR TS5845R4 carried out. Contamination removed.
15	30-Mar-05	G-CFAC	In cruise at FL300 after 44 mins flying, a/c failed to respond to FD commands in roll. When AP disconnected, although responding in pitch, a/c was difficult to roll left or right. Roll control improved in the descent. Occasional showers whilst parked outside overnight at Stuttgart. Minor de-icing fluid rehydrated residues found on RH aileron. AAIB File ref: EW/G2005/03/24.	On engineering inspection at BHX minor contamination reportedly found on the RH aileron's final drive. Residue removed and the aircraft returned to service.
16	30-Mar-05	G-BZAZ	In climb at about 16,000 ft with AP in V/S mode a/c oscillated in pitch at =/- 400 fpm. Same response with AP in Speed Mode. When AP disconnected controls heavier than normal, esp pitch. Controls freed up fully by 6,000 ft in the descent. A/c parked overnight in heavy rain. On taxi out elevator water drain procedure performed. AAIB File ref: EW/G2005/03/26.	During subsequent inspections contamination was noted at the LH & RH aileron final drive locations at panels 533/633AB & on the LH and RH elevators at panels 335/336AB, 347/348AB & 347/348BB. All areas cleaned & the aicraft was retuned to service.
17	30-Mar-05	G-CFAA	During initial climb AP disconnected with 'ELEC TRIM' & 'FTC' captions lit. QRH actioned to no avail. In hand flown descent, higher than normal forces required to roll a/c to left. Roll control became normal after selection of Flap 18. AAIB File ref: EW/G2005/03/27.	On engineering inspection heavy contamination reported on ailerons & elevators but no specific locations were recorded. A/c cleaned at these locations and returned to service.
18	30-Mar-05	G-CFAC	In cruise a/c failed to follow FD roll demand. AP disconnected to manually correct. Aileron controls found very stiff. PAN call issued & a/c continued to destination. Aileron control became easier passing FL070 but was not fully free until vectors to the ILS were given.	No contamination found on the ailerons & only minor contamination found on elevators. Contamination was cleaned and the aircraft RTS.
19	30-Mar-05	G-BXAR	Overspeed occurrence as a/c descended from cruise. A/c passed thru tailwind into headwind. AP slow to compensate. When AP disconnected controls had limited travel & were very heavy. AAIB File ref: EW/G2005/03/32.	No contamination found during the subsequent inspection. Possible that this event not related to de-ice residue. Flight Ops: Crew debiefed - inital overspeed possible due to atmospheric conditions / failure of GNSX to compute windspeed /direction. Overspeed should have been controlled using automatics, suspected that crew are not familiar with manual flight control forces experienced at higher speeds.

TABLE 1 (cont.): Control Restriction Events on UK-Registered Aircraft - Avro 146/RJ

	DATE	AC Reg	INCIDENT DETAILS	FINDINGS
20	30-Mar-05	G-CFAH	Passing FL200 in AP level change climb, vertical speed variation of +/-1500. When AP disconnected control foces in pitch & roll heavier than normal. Control forces normal again by latter stages of approach. AAIB File ref: EW/G2005/03/33.	On engineering inspection heavy contamination found under panel 581ABB (LH aileron) and light contamination under panel 681ABB (RH aileron). Both LH and RH elevator controls were contaminated but no locations specified. Contamination cleaned & aircraft returned to service.
21	06-Apr-05	G-MANS	A/C climbed to FL260 with no indication of any problem, but experienced problems maintaining cleared FL AP disconnected at 26200 and LH control column was found locked solid. (calvary charge heard on deselection of auto pilot)! Unable to overpower the LH control column, "pitch jam" called and elevator disconnect pulled. LH column still locked. First officer had control. Card 32A actioned & 32B actioned. Autopilot disengaged on later attempts. Card 34B actioned before an uneventful landing.	Heavy contamination by de-ice residue of elevators found during inspection. Elevator interior cleaned.
22	07-Apr-05	G-BZAX	In descent AP reluctant to follow heading. When AP disengaged control restriction felt in ailerons. Much more noticeable with right roll. Restriction continued until approach, by landing no apparent restriction. Rain prior to departure at Zurich & a/c in moist cloud until FL300. AAIB File ref: EW/G2005/04/10.	Aircraft was found contaminated with de-ice residue when inspected. Internals of flight controls cleaned as required by ETR TS6779.
23	08-Apr-05	G-BZAV	A/c observed to be oscillating in pitch whilst maintaining FL300. AP disconnected, elevator found to be frozen. Descent initiated - restriction also noted in roll. A/c flown manually, full control recovery at 2000 ft. AAIB File ref: EW/G2005/04/11.	De-ice fluid residue contamination found in elevator & aileron controls. Interior of the controls were washed and aircraft returned to service on 9/4/05.
24	19-Apr-05	G-CFAC	During descent a/c did not follow heading commands on AP. When AP disconnected, roll control found to be almost totally jammed to left and extremely stiff to right. A/c descended immediately & roll control became easier in warmer air. Full roll control regained at approx 4000 ft at OAT +10 deg C. Freezing level at FL070. Rain at Frankfurt on departure with temp +11 deg C. Elevator drained for 30 sec prior to departure. Engine & airframe anti-ice on for whole flight. AAIB File ref: EW/G2005/04/13.	When panels 581/681AAB and 581/681ABB on L/E of L/H & R/H ailerons removed, "considerable" contamination found at the LH aileron (under panels 581AAB/ABB) & area cleaned to remove contaminant. The RH aileron satisfactory.
25	22-Jun-05	G-CFAA	Approaching cleared level w/ AP engaged, abnormal pitch & roll response occurred. When AP disconnected at FL140, abnormal 'jolts' evident in pax cabin. Subsequently during manual flight, pitch & roll controls reportedly v. stiff. AAIB File ref: EW/G2005/06/31.	De-icing fluid rehydration checks carried out on AP, elevators, ailerons & elevator tab rod. No anomalies found & a/c returned to service.

TABLE 1 (cont.): Control Restriction Events on UK-Registered Aircraft - Avro 146/RJ

	DATE	AC Reg	INCIDENT DETAILS	FINDINGS
Embraer 145				
1	30-Mar-05	G-ERJF	On initiating descent with autopilot engaged. A/C began to oscillate in pitch. Autopilot disconnected & retrimmed. Elevator found seized. A/C decended through 0 deg C isothern using trimmer & thrust. Elevator effective on passing 0 deg isothern. Normal approach and landing.	Heavy de/anti ice fluid contamination found in & around elevator & tabs. De/anti ice fluid residue rehydrated & multiple flush/ cleans c/out to removed contamination range of movement checks c/out satis
2	06-Apr-05	G-EMBL	On levelling @ FL260 on descent from FL360 AP had difficulty in maintaining level. AP disconnected & found to be very stiff. A/C elevators - pan call initiated - flown manually in descent through freezing level where control returned to normal. Normal approach & landing.	
Bombardier DHC-8				
1	15-Mar-05	G-NVSA	A/c was flown with an ADD for pitch oscillations in cruise w/ AP2. In cruise, AP1 also found similarly affected. A/c oscillated around + - 200' from captured ALT with vertical speeds of approx +/- 1200 FPM. On disconnecting AP the force required to maintain the a/c level was very high. A/c also v. difficult to trim. As OAT increased above 0 deg C pitch forces returned to normal. AAIB File ref: EW/G2005/03/10.	Elevator inspection C/O I.A.W. ETR TS5900R4. Heavy contamination apparent @ elevator surfaces, control rods, servo tabs, trim tabs & quiet areas. Amount of re-hydrated de-icing fluid considered sufficient to cause control movement restrictions.
2	05-Jul-05	G-BRYX	Passing FL150 in day VMC, 'NOSE DN PITCH MISTRIM' annuniciation occurred. AP was disconnected & 'nose down' pitch trim could not be moved, although 'nose up' trim available. When QRH actioned, standby nose down trim also failed. Flight completed manually. Pitch trim normal after arrival at destination. This flight & previous 3 were flown in wet & icy conditions. AAIB File ref:EW/G2005/07/13.	Engineering inspections unable to replicate fault. During subsequent inspection & lubrication of elevator trim jacks, some moisture contamination of RH screw-jack was found.
3	27-Sep-05	G-NVSA	Following top of descent, AP 'pulsated' as AP attempted to trim down. When AP disconnected, 'pitch-up' felt. Trim restricted until FL080. AAIB File ref: EW/G2005/09/13.	

TABLE 1 (cont.): Control Restriction Events on UK-Registered Aircraft - Embraer 145 & Bombardier DHC-8

	DATE	AC Reg	INCIDENT DETAILS	FINDINGS
Avro 146/RJ				
1	12-Mar-03	D-AEWA (146-300)	Between FL80 & FL100 with AP engaged, unusual behaviour of AP observed, starting w/ slight pitch oscillations, increasing to around 3,500-4,500 ft/min (or 18 deg pitch up). A/c behaved the same after disconnecting AP. Flight conditions: IMC & icing. Engine & airframe anti & de-ice on and working normally. A/c control regained only slightly with manual elevator trim. Reaching VMC and non-icing conditions out of FL130, no improvement of a/c handling. The only way to control the a/c was by using manual elevator trim. Emergency declared & flapless ILS approach to STR flown w/ 60 NM final.	Based on German AAIB (BFU) preliminary findings: When a/c inspected in hangar ca 1-1.5 hrs after landing, ice found bewtween fin and rudder & small amount of ice found in gap between elevator and horizontal stabiliser. Evidence of de-icing fluid residues found on fin & rudder. BFU Investigation ongoing.
2	22-Mar-05	HB-IXQ	On short final after switching off autopilot, F/O reported 'sticky' elevator controls as if the AP had not disconnected after AP cut. After 5 seconds control feel was back to normal. Mod icing reported bu ZRH ATC below FL150 but no visible ice on a/c.	Visual inspection of elevator revealed a jelly like substance & dirt between horizontal stabiliser, elevator and control tabs. A lot of gaps covered with jelly-like substance. Washed down elevator & cleaned all surfaces.
3	23-Mar-05	HB-IXK	In climb out from FL220 a/c unstable in pitch. When VS mode set to 1500 ft/min, AP not able to hold 1500 ft/min climb. ROC varied between 1800 ft/min & 200 ft/min. A/c controllable with high force input on elevator. At approx. 8,000 ft normal ops again.	Entire elevator moving surfaces clean & free from jelly-like material. All drain holes free. Opened all hinge inspection covers on LH & RH elevators. Found small traces of jelly-like material. Cleaned by hand. Both elevator servos replaced (suspect one clutch was engaged).
4	24-Mar-05	HB-IXH	During climb above FL200 we observed big pitch changes in 'LVL CHG MODE' with FGC2. Changed to VS but AP was not able to maintain steady VS. AP disconnected & elevator found almost impossible to move, control was only possible with trim. Airframe & tail anti-ice were selected on 10 mins earlier. IMC conditions with icing. Control over elevator regained below FL100 & out of icing conditions. Successful landing with Flaps 24 (for more aerodynamic control).	Visual inspection of LH & RH elevator moving surfaces - found small amount of jelly-like material along the hinges of moving surfaces & in front of leading edge of moving surface. Opened all inspection panels on hinges of moving surfaces. Found small amount of jelly-like residue on LH & RH most inboard hinge. Cleaned affected area. LH & RH elevators washed.
5	25-Mar-05	HB-IXQ	FL215 IAS MODE 280 kt, OAT -20 deg C, light to mod. Pitch changes with VS varying between +2,800 & -300 ft/min. Wind change from 8-19 kt, suspected waves. To stabilise, pitch change mode changed from IAS to VS. Pitch changes increased. Suspected frozen elevator. AP disconnected & found elevator blocked. Unable to maintain present FL. Vertical control achieved by means of El pitch control. Informed ATC for descent & return to ZRH. Full control achieved below 5,000 ft, OAT + 2 deg C.	Not known.
6	25-Mar-05	HB-IXH	During climb in VMC, passing FL 210, speed 250 kt, experienced moderate pitch changes in 'LVL CHG MODE' with FGC1 & AP on. AP was disconnected & pitch changes reduced. At that time pitch oscillation started & reduced when speed decreased towards 210 kt.	Not known.
7	30-Mar-05	D-AVRG (Avro 146 RJ85)	During climb, low freq. pitch oscillation (AP in 'V/S mode', vertical speed fluctuating significantly). During level flight same behavior in 'altitude hold' mode. Crew disconnected AP & noticed in manual flight that unusually heavy control inputs necessary for pitch & roll control. Crew decided to divert to Cologne but situation deteriorated. Priority landing in Frankfurt requested & emergency declared. During descent, situation improved slightly, followed by 'normal' approach & landing.	Reported to German AAIB (BFU) - File ref: BF 17/05. Currently under investigation.

TABLE 2: Control Restriction Events - Other European-Registered Aircraft

All Operator Message: Ref 06/001V

All Operator Messages Contain Safety Related Information

Recommended Distribution

Aircraft Type : Bae 146 / Avro RJ

X	**Engineering**	X	**Flight Operations**
X	**All Maintenance Staff**	X	**All Flight Crew**
X	**All Ground Staff**		**All Cabin/Operations Staff**

SUBJECT: Flight Controls – Icing Restrictions ATA: 27

Reason

Recent reports of elevator trim circuit restrictions.

Description

An operator has reported three incidents of elevator trim circuit restrictions, the controls were inspected and cleaned on the aircraft following the incidents. The elevators were then removed from the aircraft for further investigation. This revealed a significant amount of anti-icing fluid residue under fairings on both elevators. On re-hydration this residue impinged on the control rods. The fairings, part number HC552H0341, cover the two trim circuit control rods where the trim tab drive passes into the trim tab itself.
De-icing/Anti-icing the aircraft from the rear increases the probability of fluid entering this area.

Recommendations

Operators are advised to remove the fairings when inspecting the aircraft for fluid residue accumulations. If residues are found ensure they are removed before further flight. The fairing is retained by tri-wing screws, part number NAS4403-4 and -5.These fasteners have proved difficult to remove on occasion, particularly when the slots become filled with paint. It is permissible to replace them with NAS7403-4 and -5 screws if required. BAE Systems will supply necessary approvals if required.
Operators are recommended to ensure their service providers are following the guidelines of BAe146/AvroRJ De-icing/Anti-icing Application Guide as issued by BAE Systems, in particular with the respect to direction of de-icing.

BAE SYSTEMS Regional Aircraft, Prestwick International Airport, Ayrshire, Scotland, KA9 2RW, United Kingdom.
Tel. +44 (0)1292 675000

Additional Information

There have been a few reports of restrictions of flying controls recently. This fits the weather pattern which was seen last year, and which has been described previously. A period of cold weather, giving repeated applications of anti-icing fluid, followed by warmer weather gives the fluid time to dry out and form residues. This has been followed by warmer wetter weather, which re-hydrates the residues, and leads to ice formation in critical areas. Operators are reminded of this phenomenon.

Early indications are that this weather pattern is about to repeat itself. Operators are reminded that their inspection/cleaning regime should take this into account

CUSTOMER TECHNICAL SUPPORT

AOM 06/001V
Page 2 of 2

INCIDENT

Aircraft Type and Registration:	Avro 146-RJ100, G-CFAF
No & Type of Engines:	4 Lycoming LF507-1F Turbofan Engines
Year of Manufacture:	2001
Date & Time (UTC):	1 October 2004 at 1355 hrs
Location:	Near Birmingham Airport, West Midlands
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 5 Passengers - 80
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	45 years
Commander's Flying Experience:	6,500 hours (of which 2,500 were on type) Last 90 days - 60 hours Last 28 days - 20 hours
Information Source:	AAIB Field Investigation

Synopsis

The crew had planned an instrument departure from Birmingham Airport using the aircraft's Flight Management System (FMS), although they believed the Honiley VOR to be out of service. Shortly after takeoff, the crew observed indications showing that the Honiley VOR was serviceable and whilst confirming its identity, inadvertently retracted the flaps instead of the landing gear. When the aircraft was at about 750 ft agl, the stick shaker activated. The commander immediately reduced the pitch attitude and allowed the aircraft to accelerate to a safe speed and the co-pilot raised the landing gear. The remainder of the flight was uneventful.

History of flight

The pilots reported for duty at 0515 hrs at their home base, Birmingham Airport, for a three sector day, at the end of which they were to position back to Birmingham as passengers. The commander was a training captain with the company although no training was planned for the flights that day.

The first return flight went without incident. At Birmingham the pilots returned to the crewroom for a scheduled break before their third and final sector of the day, which was to be flown in a different aircraft. This break was rostered as 2 hours 35 mins but, owing to a delay on the sector back into Birmingham, this was reduced to 2 hours. At about 1300 hrs the pilots boarded the aircraft to carry out the final sector to Stuttgart.

The before flight checks were completed and the crew briefed for a reduced thrust take off, with Flap 18 set, from Runway 15. The ATIS information used by the pilots for the before flight checks and briefing, valid at 1250 hrs, reported that the Honiley VOR was out of service. Just prior to pushback, at about 1440 hrs, clearance was received from ATC for a COWLY 1E departure. This departure required reference to the Honiley VOR, a fact noted by both pilots. However they considered that despite the VOR being out of service they would still be able to continue with the departure using the aircraft's flight management system (FMS), which they believed was certified for use during instrument departures. The aircraft was pushed back from the stand 10 minutes behind schedule although there was no ATC slot time to make for the departure and neither pilot reported feeling under any pressure.

The commander was the handling pilot for this final sector and after a normal engine start the aircraft was taxied and lined up on Runway 15. Once cleared for takeoff the commander advanced the thrust levers and engaged the autothrust. The take-off roll was completed as normal and once the aircraft was airborne both pilots commented to each other that the Honiley VOR appeared to be serviceable, as the beam bar on both their navigation displays had become active. The co-pilot called "positive climb" and the commander instructed him to raise the landing gear. The co-pilot believes that at about this point he pressed the VOR ident button on the communications selector to identify the Honiley beacon and confirm that it was indeed serviceable. As he was doing so he caught sight of the three green landing gear position indicator lights still illuminated which caused him to question the commander as to whether he wanted the gear up. The commander replied he thought he had already ordered it to be raised. Almost immediately the co-pilot advised the commander that he had in fact retracted the flaps by mistake and he reached forward and raised the gear lever.

The commander immediately decreased the pitch in order to accelerate the aircraft at which point the stick shaker briefly activated. The commander could not recall whether or not he increased the thrust to the Take Off and Go Around Maximum (TOGA Max) setting. The commander estimated the aircraft descended by about 100 ft during the acceleration to zero flap speed (V_{FTO}), at which point the commander resumed the climb. The aircraft had remained in visual meteorological conditions at all times and the crew could see the ground throughout; they considered that at no time was there a risk of impact. On resuming the climb the commander called for the autopilot to be engaged and continued on the cleared departure.

The rest of the flight went without incident and the aircraft landed safely at Stuttgart at 1515 hrs. The two pilots then positioned back to Birmingham as passengers on the same aircraft and on returning to the crewroom at about 1925 hrs the commander filed a company air safety report and immediately notified the base manager of the incident.

Stall warning and identification system

The aircraft was fitted with a stall warning and identification system which activates the stick shaker and stick pusher, respectively, in response to the instantaneous sensed angle of attack (AOA). The AOA required to trigger a response varies according to the flap setting and the aircraft's speed.

Throughout the sector of the climb during which the stick shaker was activated in this incident, the airspeed remained below 185 kt. With the flaps set at 18, as they were for this takeoff, the stick shaker would have operated at 17° AOA and the stick pusher at 25° AOA. With the flaps retracted, however, the stick shaker would have operated at 16° AOA and the stick pusher at an AOA of 22.5° at speeds below 158 kt, reducing linearly to 19.5° at 185 kt.

There was no indication of AOA available to the pilots of this aircraft, therefore a safe margin from the aerodynamic stall was ensured by reference to airspeed. With the aircraft at the weight calculated for this takeoff, the stick shaker would have operated, in 1g flight, at 163 kt and the pusher at 153 kt.

RNAV[1]

The operator had two types of FMS fitted to its RJ100 fleet, the GNS-X and GNLU 910. The aircraft involved in this incident was fitted with the GNLU 910 and at the time the company Flight Operations Manual contained the following information:

> *2.2.1 Flight Management Systems*
>
> *The RJ100 Fleet is fitted with 2 different FMS; the GNS-X and the GNLU 910. Both systems contain Departure and Arrival information within their databases. The GNLU system is certified to P-RNAV standard and may be used for RNAV departures and arrivals without further restriction. The GNS-X system is only certified to B-RNAV standard and may not be used as the sole reference for RNAV departures and arrivals below MSA. If the crew is not able to verify the navigational performance of the GNS-X system using raw navigational information then alternative arrangements should be made. VNAV data is available from both systems but it can only be used as advisory information to help plan climbs and descents.*

Flight data

Data was successfully downloaded from the aircraft's solid state flight data recorder and its enhanced ground proximity warning system (EGPWS) computer. The cockpit voice recorder had been overwritten.

The flight data for the event is given in Figure 1.

The key points taken from the data are as follows:

- Flap retraction started 5 to 6 seconds after takeoff (defined as weight off wheels from all three gear squat switches) with a Computed Air Speed (CAS) of 157 kt.
- Flap retraction took between 18 and 22 seconds to complete.
- Approximately 23.5 seconds after takeoff the gear status changed from locked down to not locked down.
- Approximately 24 seconds after takeoff, between 0.125 and 1.125 seconds after the landing gear was unlocked from the down position, the stick shake warning was initiated. At this point, the CAS was between 154.5 kt and 155 kt, the altitude was approximately 800 ft AAL, the height was 750 ft AGL, the Angle Of Attack (AOA) was between 15.8 and 16.4 degrees, the flaps were still moving but were at less than 1 degree, the pitch attitude was 16.6 degrees nose up and the wings were within 0.5 degrees of level.
- The stick shaker operated for between 1 and 2 seconds when the design alert criteria were exceeded.

Footnote

[1] Area Navigation (B-RNAV meaning Basic and P-RNAV meaning Precision (Area Navigation))

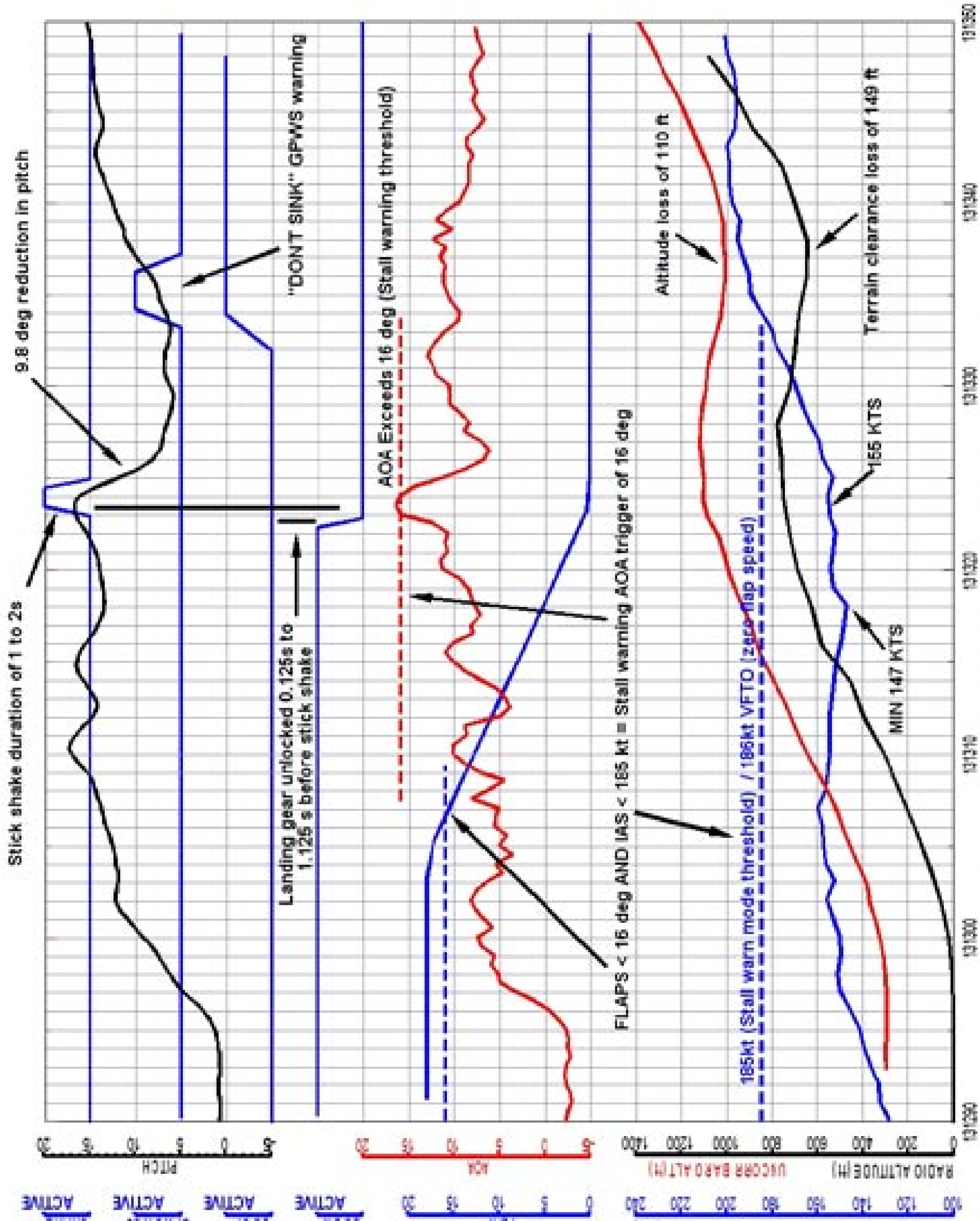


Figure 1

Key flight parameters
(Incident to G-CFAF on 1 October 2004 at Birmingham)

- After the stick shake, the pitch was reduced by 9.8 degrees over a period of approximately 6 seconds.
- Approximately 10 seconds after the onset of the stick shake warning, the aircraft reached the V_{FTO} of 186 kt and the Ground Proximity Warning System (GPWS) issued a mode 3 "Don't Sink" alert.
- The altitude loss during the event was 110 ft, with a reduction in terrain clearance to 624 ft.
- The thrust levers were not moved during the event.
- There were very slight fluctuations in N1% on all four engines during flap retraction.

Analysis

Investigation of this incident has focussed on trying to determine why the co-pilot mistakenly selected the flap lever when attempting to raise the gear. In doing so several significant areas were identified which may have been contributory.

a Fatigue

The co-pilot commented that he had had a particularly busy roster during the month leading up to the incident, flying 87 hours 50 minutes in the previous 28 days. The legal absolute maximum number of flying hours quoted in CAP 371 over the same period is 100 hours. In the same period he had been rostered nine days off, two of which were single days off. In all but one case these days off were preceded by duty periods finishing between 2035 hrs and 2110 hrs (local) and all were followed by duty periods starting between 0600 hrs and 0925 hrs (local). He stated that the week leading up to the incident had been particularly busy with six duty periods, half of which involved early starts.

Whilst his roster conformed to the required legal limitations the co-pilot believed that it had left him generally fatigued. This, in his opinion, was the major cause of the incident and he stated that he had failed to recognise in himself "a level of fatigue that would facilitate such an error".

Both pilots had also intended to eat at the company canteen during their break in the crewroom, however they had not gone straight to the canteen and by the time they did so it had closed. Despite there being opportunities to eat elsewhere within the airport both pilots chose to wait for their crew meal on the third sector. Thus both pilots had not eaten since their crew meals on the first sector of the day. The co-pilot believed that this had amplified the effects of his fatigue.

b Distraction

The ATIS valid at 1250 hrs, which was used by the pilots, stated that the Honiley VOR was out of service. Neither pilot stated that they checked the ATIS for updates prior to their pushback at 1340 hrs, nor did they question ATC about the status of the Honiley VOR when given their clearance. Birmingham Airport ATC have stated that their procedures preclude the issuing of a clearance without the necessary navigational aids being serviceable.

The crew believed that the Honiley VOR was out of service but that they could depart solely by reference to FMS. Both pilots were still sufficiently aware of the Honiley VOR to cause them to comment when the VOR appeared active shortly after rotation, the point at which the beacon is normally received when operating from that particular runway. The co-pilot also stated that he was keen to identify the beacon aurally to ensure that it was indeed serviceable. This involved him selecting the VOR button on his communications selector box, situated on the right-hand side of the central console, just above the flap lever. It was whilst doing so that he noticed the three green landing gear lights still illuminated and became aware of his error.

The flap lever is situated next to the communications box and is similar in operation to the landing gear lever, ie pull either lever out and then either raise or lower it to raise or lower the flaps/gear. The toggles however are deliberately different in shape. It is possible that in focussing on his need to identify the VOR, when the co-pilot went to raise the landing gear lever he was already sub-consciously directing his hand towards the communications box, which resulted in his hand going to the flap lever instead. Once his hand was on the flap lever, using the same action as he was conditioned to use on the landing gear lever, in this case pulling out and raising the lever, he would have raised the flaps.

Information from the co-pilot and the FDR indicate that the VOR was identified during the initial climb between 100 and 700 ft agl. Whilst no specific reference could be found in the Operations Manual current at the time, this would seem to be an inappropriate point in the departure sequence to be carrying out such a task. Indeed, the Operations Manual stated that even in the event of an engine failure after takeoff, no actions should be taken below 500 ft above airfield level.

c Aircrew Actions

Having realised his mistake the co-pilot immediately informed the commander and raised the landing gear. At this point the flaps were almost fully retracted and the stick shaker operated for between 1-2 seconds. The commander immediately responded by reducing aircraft pitch attitude from 16.6° to 5.8° nose up in order to accelerate the aircraft towards its zero flap speed (V_{FTO}) of 186 kt.

When the stick shaker activated, the aircraft's speed was 155 kt CAS. The performance information in the aircraft Flight Manual states that at the aircraft's reported weight, with wings level and a mid centre of gravity, the stick push would operate at 153 kt IAS (equivalent in this case to CAS). The stick pusher operation, however, would have been triggered by the sensed AOA rather than the airspeed and, due to the effects of power and reduced 'g', the stall speed would have been lowered slightly. Notwithstanding this, it can be seen that the aircraft came within a few knots of a full stall, it's height at the time being only 769 ft agl.

The aircraft took approximately 10 seconds to accelerate to V_{FTO} during which time it lost 110 ft, descending to a terrain clearance of 624 ft. Study of the FDR shows that the thrust levers remained at their reduced thrust take off setting (N1 Flex) throughout the acceleration and that engine power remained constant. The memory items contained within the stall warning drill require power to be increased. Had power been increased from N1 Flex to N1 Ref it would have provided additional thrust approximately equivalent to 300 ft/min rate of climb. This enhanced performance capability could have been used to either reduce the height loss during recovery or to increase the acceleration rate to V_{FTO}.

The pilots were also asked if they had considered lowering the flaps again to their original position when they realised that they had been mistakenly raised. They believed that to do so might have caused the flaps to lock in position and so they had elected to leave them in the UP position. This belief stemmed from previous training received that should the flap lever position be reversed whilst the flaps were still travelling then a FLAP INOP would be annunciated and the flaps would stop moving.

Investigation has revealed that this would only happen should the flap lever remain out of the gate for two or more seconds. In this situation if the flaps have reached either the FLAP 0 or FLAP 33 position when the INOP light illuminates then a ground reset would be required to restore the system. Thus in this incident the crew could have safely reversed the flap selection should they have wished to do so. Whilst the operator stated this information was provided in training no reference could be found relating to it in the Operations Manual. After discussions with the aircraft manufacturer the operator has now included relevant information in the Operations Manual.

RNAV

The pilots believed that as the aircraft was equipped with the GNLU system they would be able to fly the COWLY 1E without the use of the Honiley VOR, referring only to the FMS as their sole means of navigation during the departure.

The operations manual did not make it sufficiently clear that the certification to P-RNAV standard related only to the equipment. At the time of the incident the company had not been given authorisation to operate any of its aircraft to a P-RNAV standard. To do so would require the company putting specific operational requirements into place to ensure that the safety of the operation matched that of the P-RNAV system, principally involving the production and audit of the database used. As such, all aircraft within the operator's fleet were being operated to a B-RNAV standard, under which the pilots must monitor the navigational accuracy of the aircraft's flight path during the departure procedure by reference to primary navigation aids, as stated in JAA Temporary Guidance Leaflet (TGL) No 10:

> *"during the pre-flight planning phase, the availability of the navigation infrastructure, required for the intended operation, including any non-RNAV contingencies, must be confirmed for the period of intended operation."*

If the Honiley VOR had been out of service the pilots would not have been able to monitor the flight path generated by the FMS and, therefore, they should not have accepted the clearance.

A further requirement for an aircraft to carry out a departure by sole reference to RNAV is stated in EASA Series Guidance Material AMC 20-5:

> *"When flying SIDs/STARs the procedure established by the State of the aerodrome has to be authorised/published by that state for the use of GPS. The state of operator/registry (as applicable) has to approve the operator for such operations."*

At the time of this incident only two airports in the UK had a procedure complying with this requirement. This did not include Birmingham Airport.

Comment

Since this incident the operator has published updated information to its crews in an attempt to clarify the restrictions applying to the use of RNAV equipment. This investigation has attempted to understand fully the current restrictions imposed by the CAA and other European States' aviation authorities. This related not only to restrictions imposed on equipment in use but also to restrictions imposed on the operation of such equipment to see how these may have related to this incident. The matter is complex and there were be numerous, and sometimes conflicting, sources of reference information emerging from both regulators and operators.

The operator is this case is particularly concerned about this situation as countries to which it currently operates are now publishing procedures for use by B-RNAV equipped aircraft when flying above MSA. These rely on navigation by conventional aids when below MSA but then allowing the use of RNAV waypoints when above MSA. This must be seen in context with the current CAA view that B-RNAV is primarily designed for enroute navigation and that no such procedures therefore exist in the UK.

Another serious incident, also under investigation by the AAIB but involving a different operator, has demonstrated that where crews have available to them equipment that they feel capable of operating but are not authorised to do so, there remains a strong temptation for them to make use of such equipment when they feel it is warranted. The matter is made considerably worse where the guidance material is sufficiently vague that crews can apply their own interpretation to it. To cover all the eventualities that crews are likely to encounter on a route network covering numerous countries with different aircraft types and RNAV equipment standards, clear guidance is essential.

Conclusion

The co-pilot mistakenly selected the flap lever when attempting to raise the landing gear after takeoff. The reasons for this are likely to have been the result of a combination of fatigue, distraction and inappropriate task prioritisation.

The dangers of such actions have long been recognised and attempts have been made to alleviate the problem by design. To aid proper recognition of the lever being selected, the flap lever toggle has been designed to represent a flap and the gear lever toggle, a wheel. The levers are also positioned so that the flap lever is easily accessible by both pilots whilst a conscious effort has to be made to reach for the gear lever. Pilots are also trained to take due care when making any selection, especially at critical phases in flight. This message has been further reinforced by the operator in this incident by subsequently issuing instructions to crews on the matter in the Operations Manual.

Occurrences of inappropriate selection on the flight deck, however, remain a recurring problem. Research has revealed numerous similar cases, the most serious being when a fuel switch was mistakenly selected instead of landing flap resulting in an aircraft landing with the wrong flap setting with one of its two engines shut down.

Safety Recommendations

The operator in this incident has been extremely open and co-operative and, as a result, further incidents of inappropriate flap and landing gear lever selections have come to light. It is, however, the belief of the AAIB that this does not point to a particular problem with this operator or aircraft type, but rather an under-reporting of such events by others. This is likely to result from the fact that most mis-selections are quickly recognised and rectified before they lead to a more serious reportable incident. Certainly it is known that one recent serious incident involving the mis-selection of flight controls by another operator went un-reported to the AAIB.

Safety Recommendation 2006-002

It is recommended that the Civil Aviation Authority encourage operators to monitor possible mis-selections of gear and flap levers through established flight data monitoring programs in an attempt to identify the scale and severity of the problem.

Whilst not the prime focus of this investigation the AAIB has become aware of issues surrounding the use of FMS in combination with RNAV. This and other incidents raise concern that there is a lack of clear understanding at all levels within the airline industry about current advances and the permitted use of FMS navigation, especially in the departure and approach phases of flight. Clarity is required, especially on the flight deck, to provide a proper understanding and therefore use of these systems. Only in this way can maximum advantage be made of the technology whilst still operating within current navigational requirements.

Safety Recommendation 2006-003

It is recommended that the Civil Aviation Authority should provide up-to-date guidance to operators regarding the use of FMS for navigation purposes, keeping it under frequent review, and require operators to update their operations manuals in accordance with the latest guidance within a specified period.

INCIDENT

Aircraft Type and Registration:	BAe 146, EI-CPJ
No & Type of Engines:	4 Lycoming LF507-1F turbofan engines
Year of Manufacture:	1994
Date & Time (UTC):	7 October 2005 at 1823 hrs
Location:	Runway 10, London City Airport, London
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 4 Passengers - 41
Injuries:	Crew - None Passengers - None
Nature of Damage:	None known
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	60 years
Commander's Flying Experience:	11,000 hours (of which 5,000 were on type) Last 90 days - 150 hours Last 28 days - 38 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

During the landing roll, after the nose wheel made contact with the runway, the nose wheel steering system was found to be ineffective and the nose landing gear began a violent shimmy, which continued until the aircraft came to rest. Initial examination revealed that the anti-torque links central pivot bolt was missing, although it was not determined whether this had been a consequence of, or had precipitated, the shimmy. Later examination revealed that the nose wheel steering/ friction damper breakout torque was some 34-40% of the specified value and the oleo inflation pressure some 28% above its specified value.

History of the flight

After a gentle touch down on Runway 10, the nose wheel started to vibrate as it made contact with the runway. When braking was applied to the main wheels, the vibration became severe; brake pressure was then reduced, but the vibration persisted and the nose wheel steering was found to be inoperative. Because of the severity of the vibration, the aircraft was brought to rest as quickly as possible, using moderate differential braking to maintain directional control, and the first officer transmitted a PAN call to ATC.

After having come to rest, the airport Rescue and Fire Fighting Service (RFFS) attended the aircraft and the commander was asked by ATC to communicate directly with them on 121.6 MHz. The crew then saw a fireman apparently attempting to communicate with the aircraft by means of a hand-held radio, but nothing of his message was heard on board the aircraft. He was asked to repeat his message, and, on that occasion, communications improved sufficiently that most of his message was received. An engineer then attended the aircraft and, after carrying out a visual inspection of the nose landing gear (NLG) climbed into the cockpit via the electronics bay and informed the crew that a bolt was missing from the torque link assembly. The aircraft was subsequently towed to its stand, and the passengers disembarked normally. The missing bolt was not recovered, despite an extensive search both at London City Airport and its departure airfield.

Aircraft examination

Detailed inspection of the NLG by the operator's line engineering staff, and later by specialists from the landing gear manufacturer, confirmed that the bolt which forms and the central pivot in the torque link assembly was missing. It was also established that after this bolt had detached, the upper half of the torque link had pivoted down such that its free end had come into contact with a shoulder on the lower (sliding) part of the landing gear. In doing so, it had become, in effect, a solid strut which had prevented the oleo from compressing during the roll out. As a consequence, the full weight of the nose, some 2.5 tonnes, had been supported by the trapped upper link.

Except for localised damage on the nose leg itself, caused directly or indirectly by the torque link disconnection, no damage was found either on the NLG assembly or in the nose wheel bay. The NLG was subsequently removed from the aircraft and taken to the manufacturer's facility where it was subjected to detailed examination. No abnormalities could be found externally except for localised damage to the torque link components and adjoining parts of the landing gear housing, which had evidently occurred after, and as a direct consequence of, the bolt separation.

Subsequent checks carried out in a test rig revealed that breakout torque of the nose wheel steering/castering friction damper was approximately 35-40% of the specified value. It was considered by the manufacturer that the effect of this would be to predispose the gear to a divergent shimmy oscillation, of the type which had occurred during the landing. Also, evidence was found of internal oil leakage past the seals of the oleo strut, and its inflation pressure was found to be approximately 28% above the specified value; apparently in compensation for the loss of oil from the working section of the strut. However, this was not considered to have been a causal factor in the violent shimmy or the loss of the torque link bolt.

To date, no explanation has been found for the separation and loss of the torque link bolt assembly, nor has it been possible to determine whether the loss of the bolt was the cause, or merely a symptom, of the shimmy which occurred during the landing. The NLG manufacturer is undertaking further detailed inspection of the unit concerned as it undergoes repair and overhaul, and an addendum will be issued to this report in the event that further information of relevance comes to light.

INCIDENT

Aircraft Type and Registration:	BAe 146-200, G-JEAW
No & Type of Engines:	4 Lycoming ALF-502R-5 turbofan engines
Year of Manufacture:	1986
Date & Time (UTC):	7 December 2005 at 1805 hrs
Location:	Southampton Airport, Hampshire
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 5 Passengers - 85
Injuries:	Crew - 3 (Minor) Passengers - 5 (Minor)
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	39 years
Commander's Flying Experience:	6,208 hours (of which 3,069 were on type) Last 90 days - 146 hours Last 28 days - 43 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

During pushback and the taxi for departure on the fifth sector of the day, with the auxiliary power unit (APU) bleed air source selected, the cabin crew and a number of passengers detected fumes in the cabin. Two cabin crew members experienced physiological effects. Inspection of the aircraft revealed the presence of de-icing fluid in the APU air intake. The probable cause of the incident was contamination of the cabin air supply from the ingestion of de-icing fluid into the APU compressor. The aircraft had been de-iced prior to the first sector of the day.

History of the flight

Prior to the pushback and short taxi from Stand 6 to holding point B1, the APU had been started and its bleed air source selected to supply the environmental control (air conditioning) system. During pushback and the taxi, the three cabin crew and a number of passengers reported acrid smelling fumes throughout the cabin. One cabin crew member became nauseous and started vomiting, another felt light-headed and complained of a racing heartbeat. The third member was aware of the smell, but the only symptom experienced was a momentary light-headedness. At this stage the aircraft had been at the holding point for about five minutes and, when the commander was informed, he decided to abandon the flight. After obtaining ATC clearance, the aircraft was taxied back to stand, during which time the APU bleed air was selected off and engine bleed air selected on, in an attempt to purge the fumes in the cabin. However, this proved ineffective. Fumes were not detected on the flight deck at any time. Once on stand, the engines were shut down and the passengers disembarked.

Five passengers provided details to crew of their experiences, one of whom complained of a burning sensation in the eyes. Fifteen other passengers also reported smelling fumes in the cabin but suffered no ill effects. The most affected cabin crew member had difficulty concentrating, was unable to perform her duties and continued vomiting, sporadically, for up to one hour after the event. The commander accompanied the three cabin crew members to a local hospital where they underwent medical tests.

This was aircraft's fifth sector of the day and the crews' third sector, on this aircraft, which had been de-iced prior to its first departure.

Investigation

Following this incident, the APU and engines were thoroughly examined for oil leaks that might have allowed oil to enter the bleed air system, but none were found. The hydraulic system was inspected and tested, and found to be satisfactory, and engine ground runs were performed, with bleed air selected, in an attempt to reproduce the fumes. None were noted.

On further examination, a large quantity of de-icing fluid was found within the environmental control systems bay, which is adjacent to the APU. The area was cleaned and the aircraft returned to service. There have been no further reports of fumes in the cabin to date.

The APU inlet on Avro 146/RJ aircraft is located on the upper left side of the rear fuselage. The inlet has no door and is permanently exposed to the outside, rendering it susceptible to contamination from de-icing fluid running down the fuselage into the inlet.

Following the incident, the operator issued a Notice to Aircrew (NOTAC) which stated that the APU air supply should not be used on the sector immediately following de/anti-icing, and that the APU compressor air inlet drain must be kept free of de/anti-icing fluids. This is in accordance with advice provided by the aircraft manufacturer in its '*Plane Freezing*' winter operations document.

On 17 November 2005, the operator issued another NOTAC, No 42/05, titled '*BAE Systems Medical Advice Following a Cabin Fumes Event'*, which is based on NOTAC OP43, as issued by the manufacturer. This document gives advice on actions to be followed during a Smoke and Fumes event, specifically, advice to hospitals as to which tests and procedures should be followed. The results of the medical checks on the cabin crew members following this event, which were carried out in accordance with NOTAC 42/05, did not produce any abnormal findings.

INCIDENT

Aircraft Type and Registration:	BAe HS125 Series 700, EI-WJN
No & Type of Engines:	2 Garrett/Honeywell TFE-731-3R1H turbofan engines
Year of Manufacture:	1979
Date & Time (UTC):	20 September 2005 at 1006 hrs
Location:	Prestwick Airport, Ayrshire
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 2 Passengers - 4
Injuries:	Crew - None Passengers - None
Nature of Damage:	Nos 1 and 2 tyres destroyed. Further damage to No 1 wheel and door linkage
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	54 years
Commander's Flying Experience:	17,400 hours (of which 3,307 were on type) Last 90 days - 72 hours Last 28 days - 19 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further information from ATC and Airport Fire Service

Synopsis

As the aircraft touched down on Runway 31 at Prestwick both tyres of the left main landing gear burst. The pilot maintained directional control, turned the aircraft off the runway and brought it to a stop on a taxiway. Examination of the wheels showed that the damage to the tyre of the inboard wheel was consistent with it not having spun up at touchdown and that the outer rim of the outer wheel had acted as a rolling surface following the bursting of that tyre. Examination of the brake units revealed some discrepancies, but none that would have resulted in locking of the brakes or explained the failure of the tyres at or near touch-down.

History of the flight

The aircraft was landing on Runway 31 at Prestwick after a flight from Shannon Airport. As the aircraft touched down the crew noted that it pulled sharply to the left and that the application of right rudder pedal and right brake were needed to keep the aircraft straight. The flight crew reported to ATC that they believed that they had burst tyres and were able to keep the aircraft on the runway. The aircraft was turned off the runway under its own power, at the last high-speed turnoff, and came to a halt on Taxiway Kilo. The Airport Fire Service responded promptly with three vehicles and it was quickly established that there was no fire and that damage was limited to the left landing gear.

ATC immediately closed Runway 31 after the incident because of the likelihood of there being debris on the surface. At the time the wind was reported as being from 230º at 12 kt and a senior manager of the operating company, who was travelling as a passenger, reported the touch-down had felt normal.

Examination

Inspection of the landing gear showed a different pattern of damage between wheels Nos 1 and 2, on the left side. Wheels Nos 3 and 4, on the right side of the aircraft, were undamaged.

All that remained of the tyre on wheel No 1 were the two beads and some shredded portions of the tyre sidewalls which had remained attached to the beads. The even pattern of damage to the wheel rim showed that, following the tyre burst, this wheel had been rotating for at least part of the time that the aircraft rolled along and clear of the runway and this damage was not inconsistent with a tyre burst at, or very shortly after, touch-down. By contrast, there was no visible damage to wheel No 2 and its tyre was intact over some 180º of its circumference. The remaining circumference of the tyre showed two very large and distinct areas of 'chamfer' and local heating, where the tyre had slid along the runway surface without rotation. (See Figure 1.)

The only other damage to the aircraft was secondary, the failure of the linkage retaining the landing gear door. This appeared to have occurred because the No 1 tyre burst.

Figure 1

View looking aft and inboard on the Nos 1 & 2 tyres after landing

The brake units were returned to the manufacturer, for test and examination. This showed a number of minor technical discrepancies, none of which would have resulted in locking of the brakes or explained the failure of the tyres at or near touch-down.

In normal operation, this aircraft had tended to have a higher rate of wear of the brakes on the left side as compared to those on the right. On the day before this flight, the left brakes had been changed and the braking system tested and found satisfactory during a taxiing test.

Discussion

The landing was conducted in good weather conditions, with only a moderate crosswind; touchdown appeared to have been at a normal descent rate and aircraft attitude. One explanation of the difference in the damage to the two tyres could be that one had a lower inflation pressure, although discussion with the operator indicated that this was unlikely. More probably, the slight angle of bank to the left after the touchdown and tyre burst had resulted in the outboard rim of the No 1 wheel becoming the weight-bearing rolling surface for the left landing gear which had resulted in the No 1 tyre experiencing a different post-burst loading.

The damage to the No 2 tyre was consistent with that to be expected if the wheel had failed to spin up at touchdown. This could occur if some brake pressure were present at the wheel when the wheel touched down which, in turn, would annul the anti-skid function of the braking system, leaving the brake ‘locked on’. Since, during the investigation, no significant deficiencies were found in the braking system of the aircraft, it was considered likely that some braking was being applied, inadvertently, on the left side at touchdown.

INCIDENT

Aircraft Type and Registration:	Boeing 737-33V, G-EZYN
No & Type of Engines:	2 CFM56-3C1 turbofan engines
Year of Manufacture:	1999
Date & Time (UTC):	22 March 2005 at 1050 hrs
Location:	Near Lyons, France
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 5 Passengers - 110
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	46 years
Commander's Flying Experience:	5,555 hours (of which 5,355 were on type) Last 90 days - 211 hours Last 28 days - 88 hours
Information Source:	AAIB Field Investigation

Synopsis

During a flight from Nice to Luton, the flight crew experienced progressive abnormal annunciator indications. For some of these there were no procedures in the Quick Reference Handbook. Having determined that these indications were a symptom of a greater electrical problem, including degradation of their flight instruments and loss of protection systems, a PAN call was declared and a diversion to Lyons initiated where an uneventful landing was made. The subsequent investigation revealed that a failure of a contact post had occurred in the R1 relay associated with the Battery Busbar, and that power had been lost from this Busbar in flight. There were no drills published for such a failure on this model of the Boeing 737. With this failure there is a risk that, due to the loss of power to the equipment cooling fans, all attitude information could eventually be lost if power is not switched to an alternate supply. The many different configurations of the electrical system in the Boeing 737-300/400/500 fleet have made it difficult for the manufacturer to produce a generic procedure for this failure, although they have provided information to enable operators to write a procedure for their own aircraft. One safety recommendation is made.

History of the flight

The aircraft departed Nice en-route for Luton and had been cleared to climb to FL360. As it passed FL340 the flight crew noticed SPD LIM annunciators on both Electronic Attitude Director Indicators (EADIs). In the absence of any Quick Reference Handbook (QRH) procedure for this indication, the crew continued the climb, looked for other abnormal signs and checked the circuit breakers. Three amber lights, for SPEED TRIM FAIL, MACH TRIM FAIL and AUTO-SLAT FAIL, were visible on the left System Annunciator Light Panel on the glare shield; however, the MASTER CAUTION light was not illuminated. The crew checked the hydraulic indications, which were normal, but observed that both engine N1 and fuel flow gauges were blank and that the WXR FAIL annunciator was displayed on the Electronic Horizontal Situation Indicators (EHSIs). They completed the QRH procedures for the three amber lights and noted that the aircraft was limited to a speed of 0.74 Mach, as a consequence of the MACH TRIM FAIL indication. The crew requested a descent to FL300, informing ATC that they had a technical problem. The commander stated that the Minimum Manoeuvre Speed (MMS) indication had disappeared from the EADIs and flight at FL360 gave a narrow buffet margin, whilst descent to a lower level would give the aircraft a greater margin at a speed of 0.74 Mach.

At this stage, the crew realised that the failures must be linked to a more general electrical system problem. During the descent, the Standby Attitude Indicator (AI) began to topple, followed shortly by the loss of background colour from both the commander's and co-pilot's EADIs. The crew recognised this as an indication of the loss of the cooling system to these units. Because the crew were concerned that this would, in time, be followed by complete EADI display failure, they selected the Equipment Cooling Supply and Exhaust switches from Normal to Alternate, despite the fact that the amber Equipment Cooling OFF lights were not illuminated. After a few seconds background colour was restored to the EADIs.

The aircraft's electrical system was checked using the AC and DC Metering Panel and the flight crew noted that there was no output from the Battery Busbar (Bus) and Static Inverter, while the other readings were normal. There being no abnormal procedure for these failures, the crew elected to divert immediately to Lyons (Satolas); the nearest major airfield. The commander stated that their decision was made due to the lack of engine fire detection and indication systems, as a result of no output from the Battery Bus, the toppling of the Standby AI and the fact that the aircraft systems were not operating normally.

The commander took control as pilot flying (PF) and a PAN call was declared. Because he was unsure of the continuing status of the aircraft's electrical systems, and feared losing the main EADIs in the Instrument Meteorological Conditions (IMC) that prevailed at the time, the commander expedited the descent until the crew were established in Visual Meteorological Conditions (VMC). During the diversion the Senior Cabin Crew Member (SCCM) knocked on the Flight Deck door and, on being let in, informed the flight crew that all Passenger Address (PA) and interphone communications in the cabin were inoperative. The commander briefed the SCCM on the problem, and their intentions, and instructed him to prepare for a precautionary landing. Thereafter the flight deck door remained unlocked. The cabin crew individually briefed the passengers and the commander attempted to make an announcement from the flight deck over the PA system, without success.

At some stage during the diversion the flight crew noticed that the flight deck clocks had failed and the co-pilot recalled seeing a blue COWL VALVE OPEN light for the right engine, although the commander did not remember discussing this with him at the time.

The autopilot and autothrottle were operating normally so the crew left them engaged throughout to reduce their workload. They established VMC at an altitude of 4,000 ft amsl and ATC gave them radar vectors for an Instrument Landing System (ILS) approach to Runway 18L at Lyons. When the aircraft was established on the localiser the crew found that they could not arm the autobrakes and discussed the need for manual braking. They also checked that there was sufficient runway for landing in such circumstances.

On selecting the landing gear down, the crew only received a red nose wheel 'disagreement' light. They requested an over-flight of the runway at an altitude of 2,000 ft amsl and asked ATC to visually check that the landing gear had extended. ATC confirmed that they could see that it had extended and the crew then requested radar vectors for another ILS approach to the same runway. This gave time for the co-pilot to check the 'Main and Nose Gear Viewers', in the cabin and on the flight deck respectively, to confirm that the landing gear was locked down, which it was.

The aircraft established on the localiser for the second time and, when it captured the ILS glideslope, all the aircraft's electrical systems returned to normal and the failure indications cleared. The commander then disengaged the autopilot and flew the aircraft manually. After an uneventful landing, the commander made a reassuring PA to the passengers. The Airport Fire Service, who had attended the landing, were stood down and the aircraft was taxied on to a stand and shut down without further incident.

Battery Bus description

A schematic diagram of the aircraft electrical system is shown at Figure 1, where the battery relays are in the area enclosed by the dashed line. Additional detail of the 28 volt DC system is shown at Figure 2, where it can be seen that the Battery Bus is supplied from the Transformer-Rectifier Unit (TRU) No 3. In the event of a main AC failure, the DC and AC elements of the Standby power system are supplied by the Battery Bus and static inverter respectively.

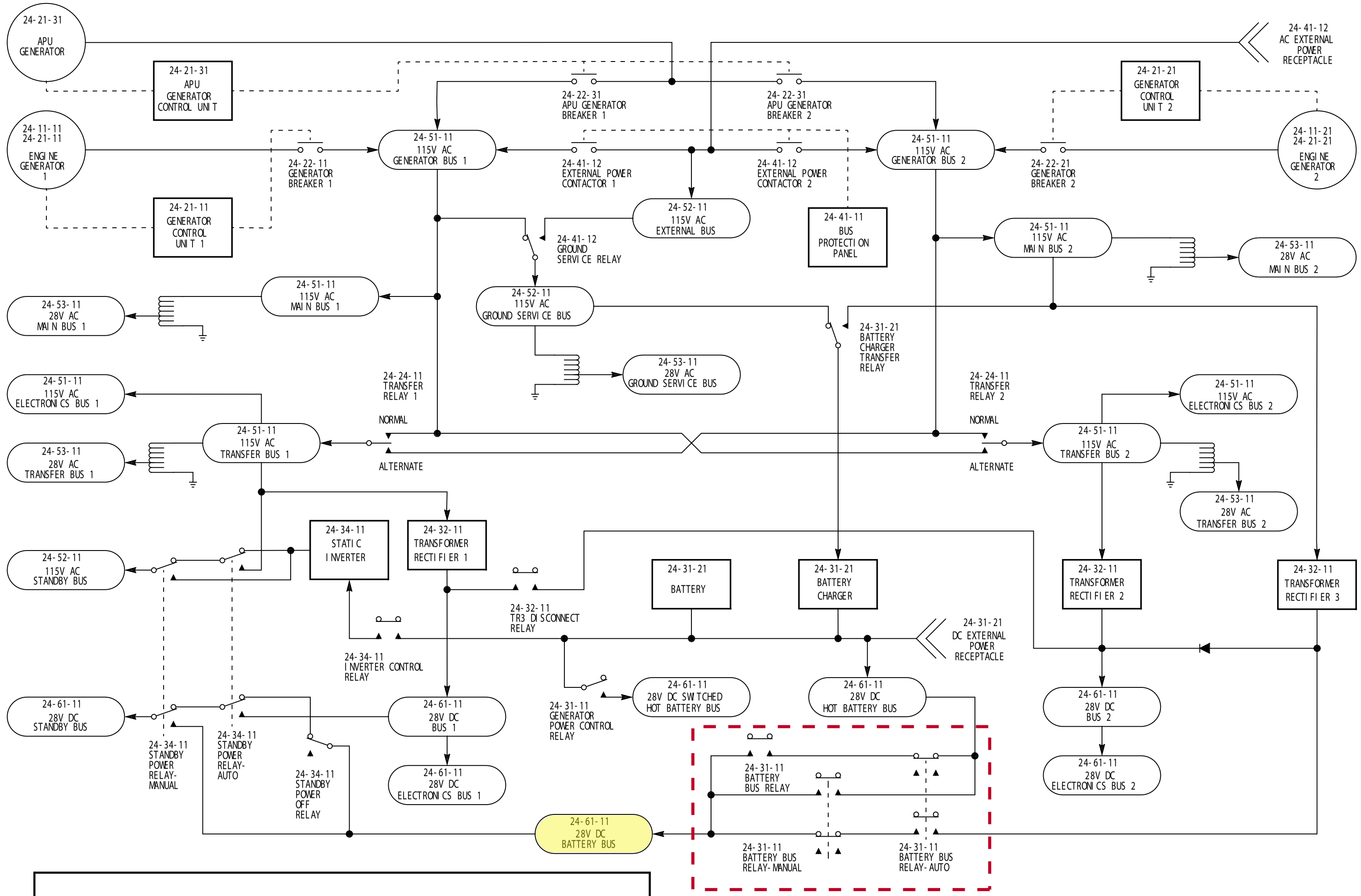
Investigation of the aircraft

Following the incident, the operator contacted the aircraft manufacturer for assistance, who, after analysis of the crew reports, suggested that a fault may have occurred in the 'R1' or 'R326' relays.

These relays are in the circuit that supplies power to the Battery Bus. The R1 relay was replaced and the appropriate checks indicated that the electrical systems were operating normally; accordingly, the aircraft was returned to service. The removed component was sent to a UK maintenance organisation for investigation. On receipt, the relay was, unusually, found to rattle. When tested, the switching operations were audible, but the A1 and A2 contacts (refer to Figure 2) remained open circuit. An internal inspection revealed that a contact post had broken off, possibly as a result of a fatigue process associated with the stresses of the contacts opening and closing. The relay had been on the aircraft since its delivery in 1989, since when it had achieved 16,680 flight hours.

Effect of relay failure on aircraft systems

The loss of the Battery Bus would result in the immediate loss of all connected systems, although the impression given by the crew was one of progressive failures. This may simply have been an issue of perception, as there would have necessarily been a time lag between the loss of power and, for example, the toppling of the internal gyroscope in the Standby Attitude Indicator. Similarly, the loss of colour on the



NOTE: Switch/relay contact positions shown for aircraft on the ground, electrical power OFF

Schematic reproduced by kind permission of Boeing

Figure 1

Boeing 737-300/400/500 Electrical Schematic

Page 24-00-01, Boeing Systems Schematic Manual

EADIs would have occurred as a result of the loss of the power supply to the equipment cooling fans. In such an event, according to the aircraft Maintenance Manual (AMM), low airflow sensors within the cooling ducts send a signal to the symbol generators, which inhibits the EADI raster display, thus reducing the heat generated. The effect of this is to remove the colour, although the EADIs and EHSIs will continue to operate in monochromatic mode. In addition, the weather radar display is removed from the EHSIs, resulting in a WXR DSPLY annunciation. In the event of an overheat condition, temperature sensors on the EADI's and the EHSI's also cause a discrete signal to be sent to the symbol generators, with the same result. According to the AMM, in the event that the temperature continues to rise for any reason, the displays will shut down although, in fact, they are designed to operate for a minimum of 90 minutes without cooling. The above symptoms were exactly as the crew reported and, moreover, when the equipment cooling fan power supply was selected to 'ALTERNATE', the displays returned to normal. This occurred "within a few seconds", as the airflow sensors registered the restored flow and removed the raster inhibit signal to the symbol generators.

The loss of the Battery Bus results in the loss of, among others, the Master Caution and the engine fire detection and indication systems, although the fire extinguishing function remains available via the Hot Battery Bus[1]. The inverter control relay would also unlatch, causing the loss of the inverter AC output. On this particular aircraft, the Standby Attitude Indicator is DC powered from the Battery Bus, with an integral inverter providing its AC requirements. As a result of customer options, some 737 aircraft are equipped with a different type of instrument, one that is powered directly from the AC Standby Bus and would thus remain unaffected by the loss of the Battery Bus.

The restoration of the electrical systems, following glideslope capture, may have been a coincidence, as well as being indicative of the intermittent nature of the fault during the final separation of the relay contact post. The DC Buses 1 and 2 are normally connected in parallel, until the Flight Control Computer (FCC) sends a Bus isolation command. This opens the TR3 disconnect relay in Figure 1, in preparation for an autoland, thereby creating two separate DC power supplies as is required for this procedure. Glideslope capture is one of several parameters that must be met before the FCC sends the isolation command. Although this may have altered the load on the DC buses, the R1 relay is on the Battery Bus and should not be affected by the FCC command.

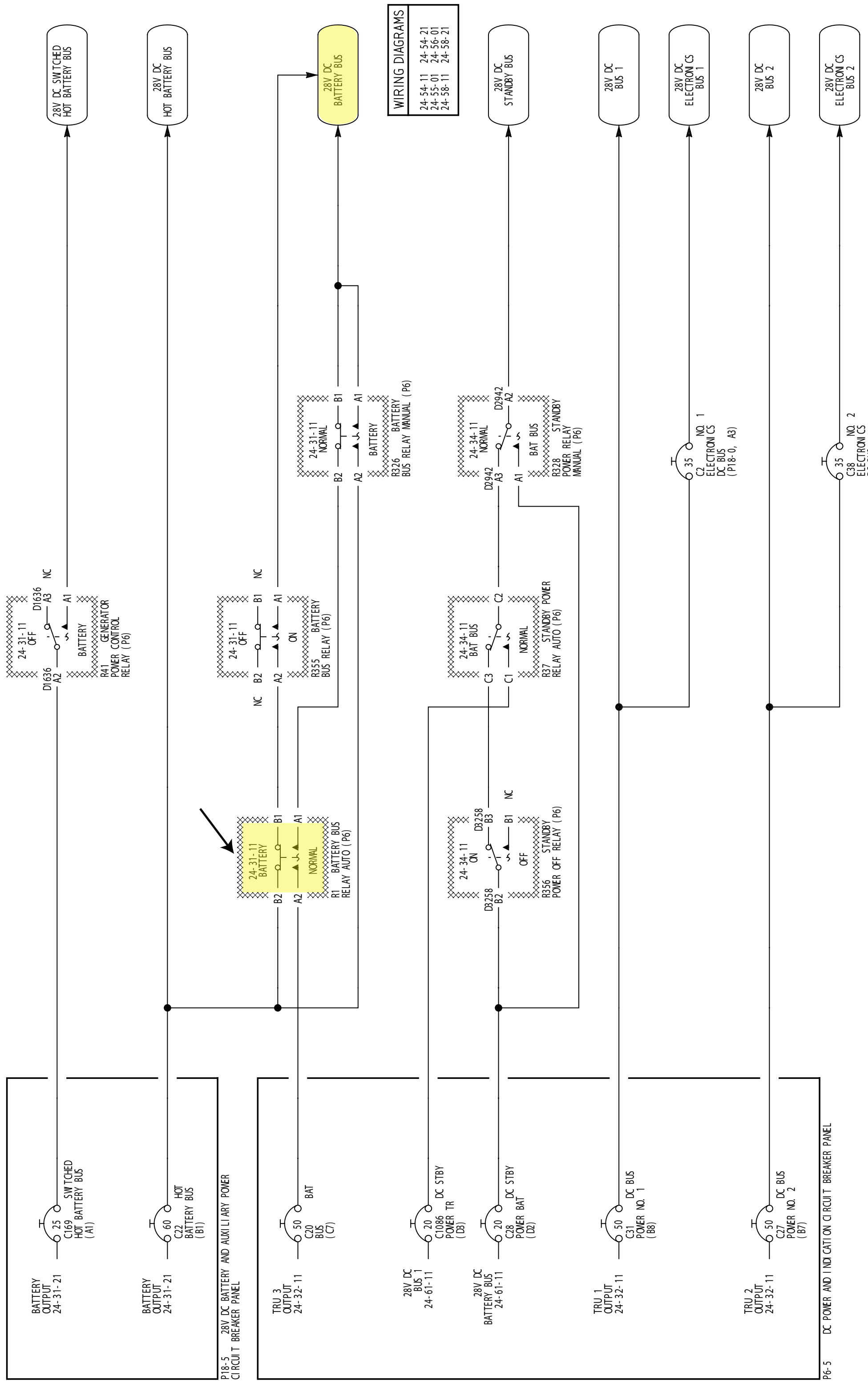
In this incident, the battery and its charging system, remained unaffected and power to the Battery Bus could have been restored by moving the Standby Power switch on the overhead panel from the 'AUTO' to the 'BAT' position.

Flight Operations Technical Bulletin Number 737-300/400/500 98-1

On 20 July 1997, the Danish Air Accident Investigation Board investigated a similar event to a Boeing 737-500, EI-CDT, where the Battery Bus failed and the crew were presented with apparently 'unconnected' cockpit warnings/indications and some instrument and systems failures. The cause of the problem on that occasion was established as a failure of the R1 relay. Two Safety recommendations were made to the Danish Authorities, as follows:

Footnote

[1] The hot Battery Bus is hard wired, through a circuit breaker, directly to the battery.



NOTE: Switch/relay contact positions shown for aircraft on the ground, electrical power OFF

Schematic reproduced by kind permission of Boeing

Figure 2

Boeing 737-300/400/500 Electrical Schematic 28V DC Power Distribution

Page 24-61-11, Boeing System Schematic Manual *'a 'The Civil Aviation Administration takes the necessary actions to seek a reevaluation of the performance of the Battery Bus Relay (R1) in its installation in the Boeing 737 series aircraft to ensure proper function. (REC-04-97)*

b The Civil Aviation Administration takes the necessary action to ensure that the crew of Boeing 737 aircraft has the proper information readily available to quickly restore the electrical power supply in the event of the failure of the Battery Bus Relay (R1). (REC-05-97)'

The report noted that the Battery Bus on that aircraft supplied current to 56 essential systems.

In response to recommendation 'a', the manufacturer issued Service Letter 737-SL-24-120 concerning *Battery/Standby/DC Power System Relays – Preferred Spare'.* In this letter, the manufacturer identifies relays with specific part numbers that they recommend be used in the R1 location.

In response to recommendation 'b', the manufacturer issued Flight Operations Technical Bulletin 737-300/400/500 98-1 concerning *'Battery Bus Failure.'*

This Bulletin was issued on 4 August 1998 and applied to all Boeing 737-300/400/500 aircraft. The relevant text is reproduced below:

***'SUBJECT :** Battery Bus Failure*

Background

Over the last few years several operators have reported in-flight loss of battery bus due to electrical system relay failures. Relay contacts have electrically opened and/or arced, resulting in loss of, or erratic voltage on, the battery bus.

Several improvements have been made to these relays to improve their reliability and eliminate poor electrical contact performance. Despite improvements these relays still occasionally fail. The Boeing data base contains 8 failures since 1990, three of those since 1994.

Failure Indications

737-600/700/800

The STANDBY POWER OFF light illumination indicates one or more of the following busses are unpowered: AC Standby bus, DC Standby bus, or Battery bus. The QRH procedure calls for taking the Standby Power Switch to --- Bat.

737-300/400/500

The STANDBY POWER OFF light will only illuminate for loss of the AC Standby bus. No light or message will tell the flight crew that the Battery Bus has failed. The only indication to the crew that this failure has occurred is the loss of various instrument indications or observing a zero indication on the BAT BUS DC Meters. These instrument indications will vary depending on specific airplane options installed and phase of flight. For example: the Standby Attitude Indicator may fail; the Landing Gear down green lights will be inoperative, but the crew will not see this until the landing gear is lowered.

All 737-300/400/500's will lose at least 1 primary engine display.

The following matrix shows which bus powers the primary engine displays for both EIS (electronic indication system) and Non EIS airplanes.

Parameter	*Non EIS*	*EIS*
N1	***BAT***	***BAT***
N2	*Main or STBY*	*STBY*
EGT	***BAT** or STBY*	*STBY*
FF	*MAIN*	***BAT***

Operating Information

In the past, Boeing has not written Non-Normal procedures unless there is a Master Caution or specific light which indicates the problem. Loss of only the battery bus is not considered a hazardous situation. Normal AC power will provide sufficient instrument indications to the aircrew for continued safe flight and landing.

If an operator wants to provide its aircrews with a procedure to cover a relay failure resulting in loss of the Battery bus, the following information is provided as a starting point.

Loss of both engine N1 indicators is the only indication of a Battery bus failure common to all 737-300/400/500 airplanes. Most airplanes will lose an additional primary engine indication (see matrix above). Additional indications will vary depending on the specific electrical configuration of the airplane. Once a Battery bus failure is suspected, it should be confirmed with the overhead DC indicators. Once confirmed, taking the Standby Bus Switch to BAT should restore the Battery bus. With one or both Generator Busses powered and the Standby Power Switch selected to BAT, the Battery Charger will supply power to the Battery indefinitely.

Boeing has no technical objection to an airline incorporating a loss of Battery Bus procedure in their Operations Manual. However, since there are so many different electrical configurations throughout the 737 fleet, Boeing is unable to publish a generic procedure in the Boeing Operations Manual which will work for all 737-300/400/500 airplanes.'

Other information

According to the aircraft manufacturer, the subject relay type is used in five locations throughout the electrical system, although they are each given separate designations. Although there are around 5,000 aircraft in the world-wide fleet that use this relay, only 2,829 B737 aircraft use this relay to power the DC Battery Bus and, of these, 1,425 aircraft (B737-3/4/500 with EFIS displays and DC Standby Attitude Indicators) are likely to be affected in a similar manner to G-EZYN should the R1 relay fail. To date, a number of relay failures have occurred leading, in some cases, to the in-flight loss of the Battery Bus. The aircraft manufacturer has stated that loss of the Battery Bus not only results in loss of the equipment cooling fans but also loss of the equipment cooling warning light function. Since this incident, the manufacturer has committed to releasing an Alert Service Bulletin in the 2nd quarter of 2006 to change the wiring of the EFIS cooling warning circuit to a different DC Bus.

In the United Kingdom, the Civil Aviation Authority (CAA) has reported the incident to the Boeing 737 Project Certification Manager at the European Aviation Safety Agency (EASA), with a request that the incident be reviewed by the Federal Aviation Administration (FAA). The FAA should advise on whether further action, in the form of a Flight Manual amendment or system modification, should be considered.

Discussion

The failure of the R1 relay resulted, as with the previous event to EI-CDT, in the Battery Bus becoming de-powered, with consequential loss of a number of systems. The flight crew carried out the QRH drills for indicated failures of the speed trim, Mach trim and auto-slat systems but, following the loss of some indicated engine parameters, realised that a more general electrical failure had occurred. The loss of colour on the EADI's was remedied by switching the equipment cooling fan switches to 'ALTERNATE', and the crew were aware of the possibility that the screens could shut down completely due to high temperatures had they not done so. Following the loss of the Standby Attitude indicator, this would have resulted in the loss of all attitude indication. In the light of this, the assertion in the Flight Operations Technical Bulletin that: '*Loss of only the battery bus is not considered a hazardous situation*' is perhaps questionable. This statement was perhaps appropriate to the design of the system as intended, but the subject incident has led the manufacturer to understand that an unforeseen situation can arise. By releasing an Alert Service Bulletin early in 2006, which will change the wiring of the EFIS cooling warning circuit to a different DC Bus on affected aircraft, this warning will not be lost in the event of the DC Battery Bus being unavailable and hence the crew should be prompted to switch to alternate EFIS cooling and maintain their primary attitude reference. The DC powered Standby Attitude Indicator would remain unavailable under these circumstances.

Checklist procedures for electrical system malfunctions cannot reasonably be expected to cater for failures of individual components down to relay level, so the crew were left to conduct their own diagnosis. This they did successfully, to the extent that they identified zero volts on the Battery Bus and the static inverter. However, there were no drills for this condition so they took no additional action, although normal operation, at least on this aircraft, could have been restored by moving the Standby Power switch to the 'BAT' position. This is recognised in the Technical Bulletin, which gives operators the option of incorporating a procedure in their Operations Manual. The manufacturer, however, has not published a generic procedure due to the fact that "there are so many different electrical configurations throughout the worldwide Boeing 737 fleet".

The proposed modification to the electrical system by the manufacturer, should provide a means to preserve the main attitude displays following the loss of the Battery Bus, although it is not known at this point if it will address the loss of other significant systems, such as engine fire detection and indication.

Safety Recommendations

The loss of the Battery Bus on Boeing 737-300/400/500 aircraft results in the loss of a number of significant systems which, on some aircraft, can include the Standby Attitude Indicator. The integrity of the main attitude displays on EFIS equipped aircraft can also be compromised due to the loss of cooling. The flight crew in this incident dealt with the situation effectively, using the procedures available and their knowledge of the aircraft. There is no doubt that a specific procedure for the problem, had one been available to them, would have made diagnosis, crew actions and subsequent decisions significantly more straightforward, while also restoring the aircraft's affected electrical systems. Indeed, the crew may have considered that a diversion to Lyons may not have been necessary. A different crew, however, may not have reacted to the situation in a similar manner, with an attendant risk that loss of all attitude information could have occurred.

After this event, the operator amended its Operations Manual to incorporate such a procedure, subject to their aircraft being of a suitable electrical configuration. It is not clear, however, what the consequences would be of conducting a 'loss of Battery Bus procedure' on an aircraft with an 'inappropriate' configuration.

As a result of this incident, the following Safety Recommendation has been made:

Safety Recommendation 2005-65

It is recommended that the Federal Aviation Administration require that the Boeing Airplane Company examine the various electrical configurations of in-service Boeing 737 aircraft with the intention of providing operators with an Operations Manual Procedure that deals with loss of power from the Battery Busbar.

INCIDENT

Aircraft Type and Registration:	Boeing 737-73V, G-EZKA
No & Type of Engines:	2 CFM56-7B20 turbofan engines
Year of Manufacture:	2003
Date & Time (UTC):	28 December 2005 at 1840 hrs
Location:	6 miles west of Newcastle, Northumbria
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 5 Passengers - 128
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	47 years
Commander's Flying Experience:	11,121 hours (of which 4,380 were on type) Last 90 days - 206 hours Last 28 days - 78 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent enquires by the AAIB

Synopsis

Prior to the flight the aircraft was de-iced due to snow accumulation. During a 'No Engine Bleed Air Takeoff', in which APU bleed air was in use, fumes and smoke entered the cockpit and cabin causing some passengers to suffer from eye and throat irritation. After isolating the APU bleed air and selecting engine bleed air the fumes dissipated. The aircraft returned to Newcastle and the passengers were offered medical attention. The fumes were as a result of de-icing fluid entering the APU air inlet during the initial climb out.

History of flight

The aircraft was being prepared for a scheduled flight from Newcastle to Budapest. During the walkaround checks the flight crew noticed large amounts of snow had accumulated on all the upper surfaces of the airframe, wings and tailplane. Once all the passengers had boarded, the aircraft was de-iced to remove the accumulated snow and ice.

Performance limitations on the aircraft necessitated a takeoff to be made with all available engine power. This required the use of full engine thrust and the bleed air from both engines to be switched off. Bleed air from the APU was then used for air conditioning and pressurisation during the takeoff and initial climb.

The taxi and takeoff were without incident. However, on passing 300 ft, in the climb, the commander sensed a faint smell in the air, after which the first officer noticed thick black smoke appearing from behind the commander's left shoulder. The smoke quickly filled the cockpit, so the flight crew donned their oxygen masks. At the same time the cabin crew contacted the flight crew to inform them that the cabin air was also contaminated.

The suspicion was that the bleed air from the APU had become contaminated and had entered the air conditioning system. The first officer isolated the APU bleed air and changed over to engine bleed air; the fumes and smoke quickly dissipated.

A PAN was declared and a request made to ATC for an immediate return to Newcastle. During this time several passengers began to complain of eye and throat irritation. After landing, the passengers were deplaned and offered medical assistance in the terminal building.

Aircraft examination

A detailed examination of the aircraft by the maintenance organisation did not reveal any defect with the aircraft, bleed air or air conditioning system.

Previous events

A review of the CAA's Mandatory Occurrence Report database revealed at least three previous occurrences of contaminated bleed air during the takeoff on Boeing 737 aircraft. In all three cases the cause was reported as excess de-icing fluid finding its way into the APU air inlet (Figure 1) during takeoff and climb.

Manufacturer's information

The aircraft manufacturer provides information on adverse weather operations and exterior de-icing in a supplementary procedure to the flight crew operations manual. This states that during de-icing:

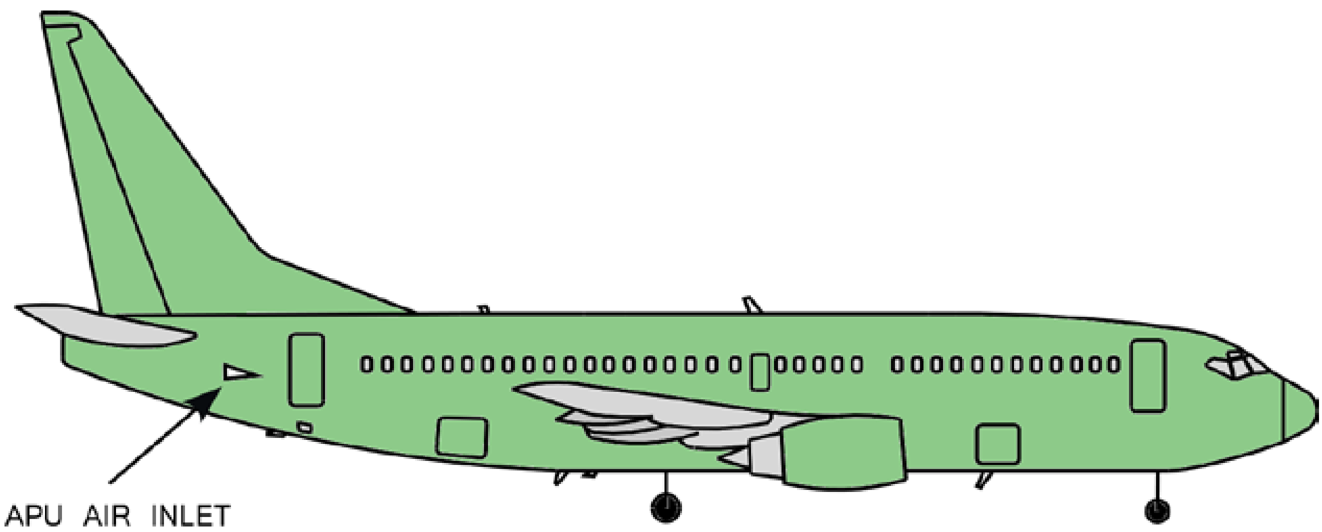


Figure 1
Location of APU air inlet on Boeing 737-700

> *'APU and engine BLEED air switches ....OFF F/O*
>
> *The bleed air switches must be turned off to reduce the possibility of fumes entering the air conditioning system.*
>
> *CAUTION: With the APU operating, ingestion of de-icing fluid causes objectionable fumes and odors to enter the airplane. This may also cause erratic operation or damage to the APU.'*

The manufacturer also provides a supplementary procedure for 'No Engine Bleed Takeoff and Landing' but makes no mention of the possibility of de-icing fluid contamination of the APU air during climb out following a de-icing operation.

The aircraft maintenance manual, which provides the instructions on exterior de-icing, warns that fluid should not be directed at any of the engine or APU inlets and exhausts.

Discussion

The most likely cause of the fumes and smoke that entered the cockpit and cabin was excess de-icing fluid finding its way into the APU air inlet (Figure 1) during the climb out. The de-icing fluid would then enter the hot sections of the APU, causing it to produce smoke and fumes which would then pass through to the air conditioning and into the aircraft. Performance limitations for this takeoff required that all available engine power be used, necessitating that the engine bleed air be switched off and the APU bleed air used for air conditioning and pressurisation instead.

The operator has undertaken to remind those who de-ice the aircraft about the need to take care when de-icing in the vicinity of the APU inlet on Boeing 737 aircraft.

INCIDENT

Aircraft Type and Registration:	Boeing 747-443, G-VROM
No & Type of Engines:	4 General Electric CF6-80C2B1F turbofan engines
Year of Manufacture:	2001
Date & Time (UTC):	26 July 2005 at 2107 hrs
Location:	Approx 100 nm north-east of Nassau, Bahamas
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 18 Passengers - 278
Injuries:	Crew - 14 (Minor) Passengers - 10 (Minor)
Nature of Damage:	Minor cabin damage
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	49 years
Commander's Flying Experience:	10,427 hours (of which 4,105 were on type) Last 90 days - 185 hours Last 28 days - 71 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft encountered an area of unexpected severe air turbulence at FL310 during which some of the cabin crew and passengers received minor injuries.

History of the flight

The aircraft had departed Nassau, Bahamas in daylight on a scheduled flight to London Gatwick Airport. Push-back was at 2030 hrs and takeoff at 2047 hrs. The aircraft's planned route is shown at Figure 1, as plotted by the flight crew on the Significant Weather Chart. Tropical Storm Franklin was located approximately 600 nm northeast of the Bahamas. Associated with Franklin and to the south of it was a band of weather lying approximately north-east to south-west. This weather was forecast to contain isolated embedded cumulonimbus (CB) clouds. The intended track passed south of Tropical Storm Franklin and initially north of the associated weather before passing through the eastern part of the band.

After departure the co-pilot, who was the pilot flying, climbed the aircraft in VMC towards the initial cruising level of FL310. The aircraft's weather radar was used during the climb; weather returns are displayed on the pilots' Navigation Displays (ND) which also display the intended track. Although some CB activity was shown on the weather radar, it was well away from the aircraft's intended track. No weather or turbulence was encountered and no weather avoidance was required. Because the flight conditions were smooth, the seat belt signs were switched OFF and passengers were permitted to move around the cabin.

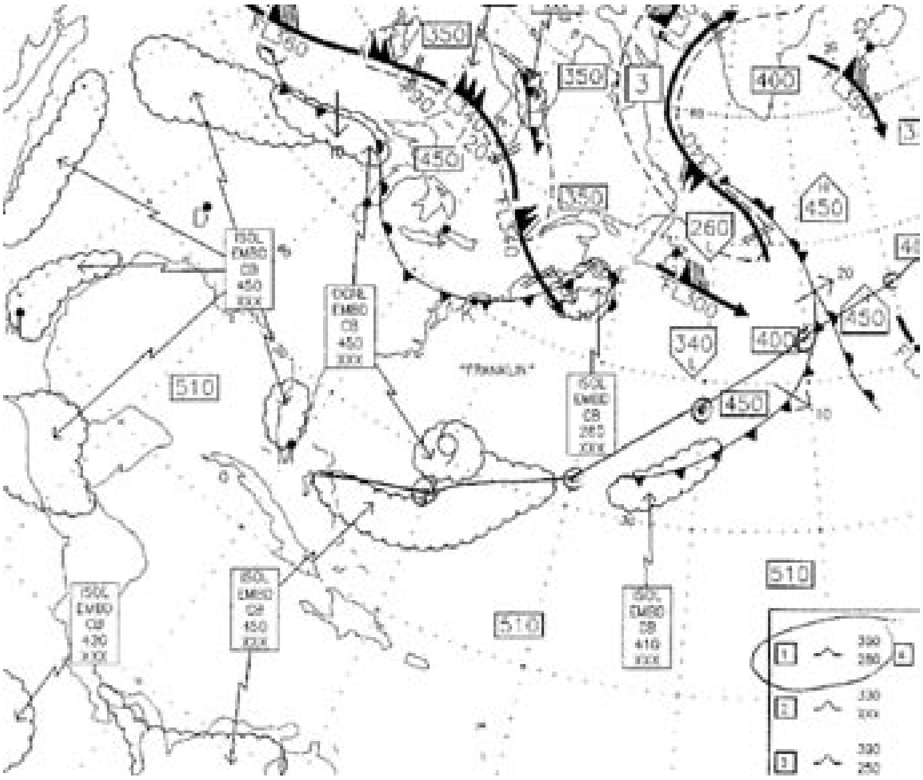


Figure 1

The aircraft's planned route marked on the Significant Weather Chart

The flight crew had discussed the possible effects of the weather, particularly Tropical Storm Franklin, and they had marked on the Mid-Atlantic Plotting Chart, two SIGMET[1] areas received from New York. A copy of the chart is shown at Figure 2 with the SIGMET areas annotated by the crew as E3 and K23. These were areas of moderate turbulence associated with Tropical Storm Franklin. Area E3 was advised before departure whereas the flight crew were not informed of area K23 until after the turbulence encounter.

The aircraft was established in the cruise at FL310 and the weather radar was in use. Again, CB activity was seen on the radar at long range but none that affected the aircraft's intended track. The commander recalled entering an area of cirrus cloud followed by some light turbulence which he described as 'a gentle rumble'. He switched ON the seat belt signs as a precautionary measure and shortly afterwards, the aircraft encountered severe turbulence. The autopilot remained engaged and about 15 seconds later the turbulence ceased.

Some passengers and cabin crew had received minor injuries. Doctors were travelling on the aircraft and assisted with treating the injured. The commander, in consultation with the Flight Service Manager, agreed that none of the injuries required the aircraft to divert. The three flight crew carried out a check of the aircraft systems and available data. Following discussions with company Operations and Maintenance Control, who had received ACARS data relating to the turbulence encounter, the aircraft was found to be fully serviceable. The flight was continued to Gatwick without further incident.

Footnote

[1] Weather advisory service to warn of potentially hazardous (significant) extreme meteorological conditions dangerous to most aircraft, eg extreme turbulence, severe icing, squall lines and dense fog.

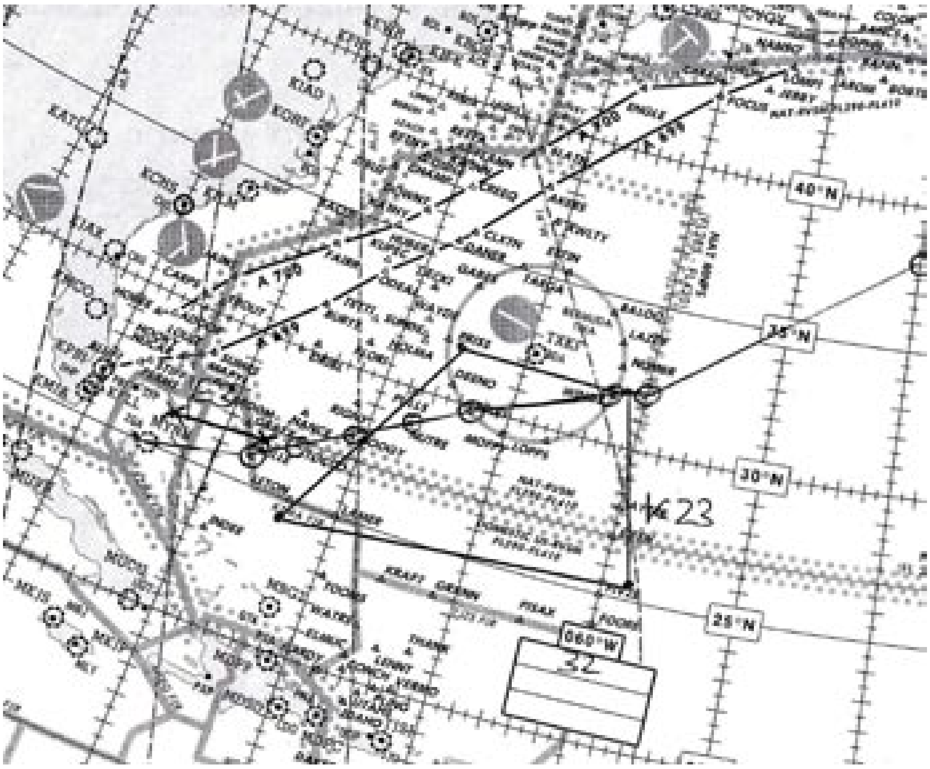


Figure 2

Chart with SIGMET CAT areas annotated by the crew as E3 and K23

Turbulence encounter

Data for the turbulence encounter was recovered by the operator from the aircraft's Flight Data Recorder and a report was made available to the AAIB investigation.

After levelling at FL310 the aircraft was established in the cruise at M 0.855 with the right autopilot engaged in VNAV (Vertical Navigation). The SAT (Static Air Temperature) was a constant -30°C and the wind was from 031° at 11 to 15 kt. The aircraft began to enter light turbulence at 2105:08 hrs which increased in frequency and amplitude. During the first 16 seconds, the minimum and maximum vertical acceleration values were between +0.94 and +1.11 g. In the same period, the SAT reduced to -31.8°C and the wind direction began to veer to 056°, with the wind speed varying between 9 and 29 kt.

At 2106:50 hrs the SAT had reduced to -33.8°C and the amplitude of the vertical acceleration was still increasing to between +0.82 and +1.44 g. At that point the autopilot mode changed to ALT HOLD (Altitude Hold) and the speed window opened initially at Mach 0.862 (the instantaneous speed at the time of mode change) before being selected to Mach 0.844. The aircraft entered the peak 'g' encounter at 2107:02 hrs. The maximum recorded vertical values were between -0.58g and +2.13g which occurred over 3 seconds. Just after the peak vertical acceleration was recorded, the SAT had reduced to 34.5°C. The maximum speed during the encounter was Mach 0.876, with the minimum recorded as Mach 0.839. At the heart of the encounter, the wind direction varied between 024° and 064° and the wind speed varied between 21 and 13 kt.

The maximum and minimum altitude deviations during the encounter were +115 ft and -75 ft from the selected datum. Following the encounter the aircraft returned to normal flight conditions for the remainder of the flight.

Flight planning

The selection of the route a flight should take is produced initially by the operator's Flight Planning Department. A computer programme identifies the most expeditious route based on the upper winds and routeing restrictions such as NOTAMs. The flight planning officer then reviews the route and considers any significant weather obtained from the meteorological services. The route may then be varied depending on the weather.

The proposed route is passed to the departure point of the flight. As part of their pre-flight preparation, the flight crew review the route, taking into account the weather, NOTAMs and any SIGMETs. If the crew wish to vary the route, this instruction is passed to the flight planning officer who then reissues the flight plan and briefing.

On the incident flight, the flight planning officer re-routed the track to the south of Tropical Storm 'Franklin'. Although an alternative route to the north of 'Franklin' was available, the Storm was moving towards this route. The re-routing of the flight by the flight planning officer was annotated on the flight plan.

There is no stipulated training syllabus or qualification set out by the CAA for flight planning officers. The operator provides appropriate training and limits the individual to certain routes under supervision. As experience is gained and ability proven, limitations are gradually lifted. The flight planning officer who performed the planning for the incident flight was an experienced, senior flight planning officer. Only senior flight planning officers are permitted to plan Caribbean routes when tropical storm or hurricane activity may be present. The flight planning manager confirmed that the route planned and offered to the flight crew was consistent with the operator's normal practice.

Analysis

The flight crew had considered the forecast weather and the SIGMETs in relation to their allocated routing. It was decided not to route to the north of Franklin but to use the weather radar and reports from other aircraft to avoid or anticipate areas of turbulence. This was in accordance with normally accepted practice. Also, they were not alerted to the presence of significant turbulence in area K23 (south of Bermuda) before they entered that area.

The onset of the clear air turbulence was gentle and the commander's action in selecting the seat belt signs ON was a routine procedure. The severity of the turbulence increased rapidly and so cabin crew and a third flight crew member were not able to return to their seats before the peak turbulence. Although all the passengers were seated, not all of them had managed to fasten their seatbelts securely before the turbulence encounter reached its peak.

The doctors onboard were able to provide expert opinion on the nature of the injuries and the decision not to divert was medically based.

ACCIDENT

Aircraft Type and Registration:	Boeing 757-200, TF-ARE
No. and Types of Engines	2 Rolls Royce RB211-534E4-37 turbofan engines
Year of Manufacture	2005
Date & Time (UTC):	11 June 2005 at 2030 hrs
Location:	Manchester International Airport
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 8 Passengers - None
Injuries:	Crew - 1 Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's age:	N/A
Commander's Flying Experience:	Last 90 days - N/A Last 28 days - N/A
Information Source:	Aircraft Accident Report Form, Airline internal investigation and AAIB inquiries

Synopsis

Whilst closing the R4 door prior to departure, a cabin crew member trapped her left forearm between the door assist handle and aircraft bulkhead, causing her wrist to fracture in three places. Two safety recommendations were made.

History of occurrence

Cabin crew member's recollection

The aircraft was preparing for a charter flight from Manchester to Antalya but had been delayed by approximately five hours due to its late arrival from London Gatwick Airport. During the pre-boarding checks the cabin crew member adjacent to the R4 door, who had three months experience on type and who was dealing with the catering, noticed the door, through which the caterers had just left the aircraft, begin to move and assumed that it was being pushed closed from the outside. Although the door then stopped moving, she decided to close and lock the door in order to protect herself from any further uncommanded movement. She positioned herself in the normal manner close to the door with her left hand on the door assist handle and her right hand on the locking handle. However, the door then started to move quickly, trapping her left arm between the bulkhead and door assist handle. The attendant believed that the door was being pushed from the outside and, therefore, screamed and shouted for the person outside to stop. Despite her efforts, the door continued to close forcing her left hand to bend around the door assist handle and her wrist to fracture. Figure 1 shows a reconstruction of how a person's arm may become trapped. It was only once the door had moved into the fully closed position that the attendant was able to free her arm. Paramedics treated her at the aircraft before she was taken to hospital by the Duty Station Officer.

Caterer's recollections

The caterer was nearing the end of his shift and had been working on the aircraft for approximately 25 minutes before leaving through the R4 door. He retracted and lowered the bridge on the catering truck until the safety rails were clear of the door, reached up and, with relatively little force, moved the door to the half closed position before driving the catering vehicle away from the aircraft. At no time did the caterer hear the attendant shouting or screaming. He later stated that it is not unusual for the cabin attendants to struggle when closing aircraft doors and it has become a common courtesy for catering staff to help by pushing on the bottom of the door until the door is in the half closed position. The caterer stated that they are not allowed to close aircraft doors and, therefore, always ask the attendants if they require any assistance before helping. The doors will only move once the attendant has disengaged the gust lock. On this occasion, he could not recall if he had asked the attendant if she required any help but, as the door moved, he assumed the gust lock had been disengaged; moreover, from his position on the catering vehicle bridge he could see the attendant closing the door in the normal manner. The caterer only became aware two weeks later of what had happened.

There were no other witnesses to the incident.

Weather

The METAR for the period covering the incident reported the wind as 120°/3 kt.

Figure 1

Reconstruction of a cabin crew member's arm trapped between bulkhead and door assist handle

Aircraft door operation

The doors on the Boeing 757-200 aircraft are heavy and it can be difficult for inexperienced and slightly built cabin crew members to overcome a door's inertia when moving it away from the fully open position. Once the door is moving, however, its momentum will allow it to continue to close at a steady rate until, in the final phase of the closure sequence, the rate at which the door closes appears to increase. Wind pressure, or external assistance, can affect this closure rate. The door gust lock engages automatically when the door is moved to the fully open position and must be manually disengaged before the door can be closed. As part of her training, the cabin crew member involved in this accident had been assessed on her ability to close cabin doors, using a cabin simulator equipped with doors that are lighter than the doors fitted to the aircraft. The simulator does not reproduce the effect of wind loading on doors. It is understood that the potential to fall from the aircraft when closing cabin doors on the Boeing 757-200 can, at times, cause concern to many cabin crew members. It is, therefore, not surprising that cabin crew on a number of airlines, seek help from ground staff, particularly when the cabin floor is wet or there is a strong wind blowing against the open door.

Another major operator of the Boeing 757 advises its cabin crews that, if they experience a problem closing the doors, then they should seek assistance from ground staff. They do, however, emphasise that it is the responsibility of the cabin attendant to retain control of the operation.

Discussion

The flight had been delayed and the cabin crew were preparing the aircraft prior to boarding the passengers. Knowing that the aircraft was late, it is possible that, as the caterer left the aircraft, he asked the attendant if she needed help in closing the door, but she did not hear him above the general noise in the area. Once the bridge on the vehicle had been lowered, the caterer saw the attendant standing by the door and, as it moved, he assumed that she had removed the gust lock and had accepted his offer of help. Once the door was in the half closed position, the caterer left the attendant to finish the task. At this stage, the cabin attendant had positioned herself to close the door and it is possible that its momentum was sufficient to cause her to lose control of it. The attendant does not recall disengaging the door gust lock and, therefore, it is possible that the lock had not fully engaged when the door was moved to the fully open position.

Other airlines inform their cabin crews that if they experience difficulty in closing a door then they should seek assistance from ground staff, with the proviso that they remain in control of the situation. Unfortunately, on this occasion there was a breakdown in communication between the two individuals concerned such that the relatively inexperienced cabin crew member found herself having to quickly position herself in a confined space in order to close the door. It is possible that in quickly changing tasks, she was not mentally prepared, or correctly positioned, to handle the heavy door. The fact that she said the door stopped moving is consistent with the caterer's account that he left the door half open and it is probable that, on this occasion, it was the normal momentum of the door which exerted sufficient force to break her wrist.

Since the accident the airline concerned has issued the following instruction to its cabin crew:

> *'The opening and closing of an aircraft door when cabin crew are on board lies solely with the crew member assigned to a specific door. The crew member should make it very clear to any third party that the crew member alone will open/close the door when steps/hi-loaders are moved away'.*

Safety Recommendations

It has been reported that the closing of cabin doors on the Boeing 757-200 can, at times, cause concern amongst those members of staff authorised to perform this action. It is, therefore, not surprising that cabin attendants in a number of airlines seek help from the ground staff, particularly when the cabin floor is wet, or if there is a strong wing blowing against the open door. The recent instruction issued by the operator to their cabin crews would now seem to preclude an attendant from seeking assistance when a door is difficult to close. This may now put such an attendant in a position of unnecessary risk of injury or falling from the aircraft. Therefore, the following safety recommendation was made.

Safety Recommendation 2005-133

It is recommended that Excel Airways reviews its procedures for the closing of cabin doors, to reflect the fact that there are occasions when cabin attendants may require assistance from ground staff.

In response to this recommendation, the operator has now incorporated the instruction previously issued directly to cabin crew into their Company Operations Manual, Part E (SEPs) Chapter 2, Page 8. In addition, the instruction has been expanded to encompass any requirement for additional assistance, as follows:

> *'Any additional assistance to help with the closing of aircraft cabin doors must be obtained from another cabin crew member on board.'*

Whilst the cabin door on the Boeing 757-200 cabin simulator, used by the operator, physically resembles the cabin doors on the aircraft, it is considerably lighter than those fitted to the aircraft and, therefore, the force required to move and control the door is not representative. Additionally, no provision is made to simulate the effect of wind loading on the door. The following safety recommendation was therefore made:

Safety Recommendation 2005-134

It is recommended that Excel Airways reviews its training with respect to the operation of Boeing 757-200 cabin doors, to ensure that the final assessment of any authorised individual's capability to operate a cabin door safely is carried out on an aircraft under representative conditions.

In response to this recommendation, the operator has stated that representative training is now being carried out on board each Excel Airways aircraft type before cabin crew are signed off as qualified and authorised to operate cabin doors unsupervised.

INCIDENT

Aircraft Type and Registration:	Boeing 757-236, G-BMRE
No & Type of Engines:	2 Rolls-Royce RB211-535C-37 turbofan engines
Year of Manufacture:	1988
Date & Time (UTC):	30 July 2005 at 0819 hrs
Location:	Nottingham East Midlands Airport, Derbyshire
Type of Flight:	Training
Persons on Board:	Crew - 4 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to No 3 wheel and brake assemblies
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	58 years
Commander's Flying Experience:	18,000 hours (of which 8,000 were on type) Last 90 days - 30 hours Last 28 days - 14 hours
Information Source:	Operator's Safety Department Investigation Report and Aircraft Accident Report Form submitted by Operator's Flight Safety Officer

Synopsis

The aircraft had been positioned at Nottingham East Midlands Airport early in the morning of 30 July 2005, following which various maintenance activities took place, including changing the No 3 wheel brake unit. The aircraft subsequently took off to fly training circuits but, on the second touch-and-go, the Control Tower advised the crew that flames were seen to be coming from the right main landing gear. The commander elected to continue the touch-and-go and to fly a circuit with the landing gear down, as he was concerned about stopping the aircraft in the runway distance remaining. After a successful landing, the aircraft was brought to a stop on the runway and inspected by the fire service, prior to being towed to a stand.

The fire was later attributed to a failure in the No 3 brake unit. This was caused by the end cap of the brake torque rod not being refitted during the maintenance activity, thus allowing one end of the brake torque rod to become detached and scrape along the ground during the landing. The brake unit rotated with the wheel during the rollout, causing damage to the wheel, severance of the brake hose and damage to the brake temperature monitoring components.

History of flight

The aircraft had been positioned at Nottingham East Midlands Airport at 0157 hrs on the morning of the incident, following which various maintenance activities were carried out, including changing the No 3 wheel brake unit. It was planned to fly training circuits later that morning, commencing around 0800 hrs with a flight crew consisting of the Operator's Chief Training Captain (the commander), two student co-pilots and a fully qualified co-pilot acting as a safety pilot. The student pilots were to occupy the right hand seat, in turn, with the safety pilot on the jump seat. Later that day, following the crew training detail, it was intended that the aircraft would participate in an air display.

The takeoff and first touch-and-go on Runway 27 were uneventful but, on the second touch-and-go, the Control Tower advised the crew that flames were seen coming from the right landing gear. The commander elected to continue and to fly a circuit with the landing gear down, thus allowing him to assess the situation in the air. This also reduced the risk of an overrun during a rejected takeoff on the runway remaining. The commander instructed the student co-pilot to continue flying the aircraft in a visual circuit so that he could assess the situation. There were no reported abnormal indications on the flight deck but the commander recalled the entry in the technical log relating to a brake change on the right gear leg. He decided to let the student co-pilot continue with the circuit and land the aircraft under his guidance, but to take control during the landing roll.

ATC requested that the aircraft to be brought to a stop on the runway and for the crew to then shut down both engines. Accordingly, the APU was started prior to the approach and, after touch down, the commander took control and brought the aircraft to a stop using reverse thrust and the left wheel brakes. Subsequently, the Fire Officer at the scene reported a hydraulic leak and damage to the right main landing gear but that there was no evidence of smoke or flames having affected the wheels. After an inspection the aircraft was towed to a stand.

Boeing 757 Main Landing Gear Brake installation

The Boeing 757 has two main landing gear legs, each configured with four wheels. Each of the main gear wheels has a brake unit, and each unit is connected to a brake rod to prevent the brake unit rotating when the brakes are operated. A diagram of the installation of a typical brake unit is shown in Figure 1.

The brake rods are attached to the brake units by means of a pin, end cap, lockbolt and a nut, and their installation is illustrated in Figure 2.

Operator's investigation

The Operator's Safety Department conducted an engineering investigation using Boeing's Maintenance Error Decision Aid (MEDA), which included interviews with the relevant shift supervisor and the two maintenance engineers who carried out the brake unit change. During the these interviews, it was emphasised by the operator that the purpose of the investigation was not to apportion blame but to establish what happened in order to prevent recurrence. It was noted by the operator that all personnel interviewed had an open and positive attitude to the investigation and were entirely co-operative throughout.

It was established that the brake rod pin end cap had not been fitted, which resulted in a situation in which the pin worked its way free from the brake assembly. This allowed the brake rod to hang vertically downwards and impact the ground during a landing, and the brake assembly to rotate and sever hydraulic and electrical lines. This sequence of events is corroborated by the operator's report in which it was stated that:

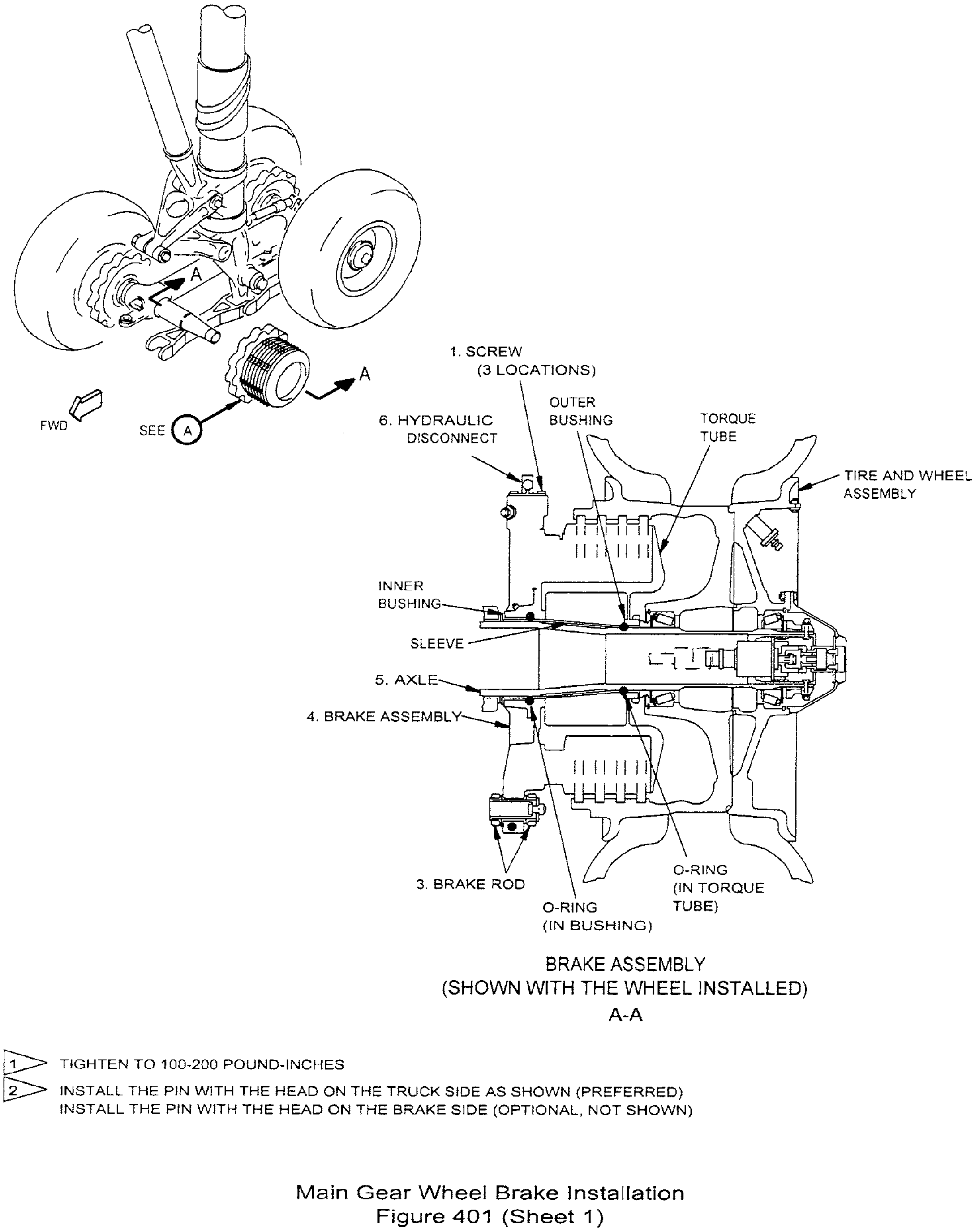


Figure 1

Boeing 757 Main Gear Brake Installation showing brake rod (item 3)

(Ref. Boeing Maintenance Manual 34-41-10)

(Information contained in Figure 1 is for illustrative purposes only)

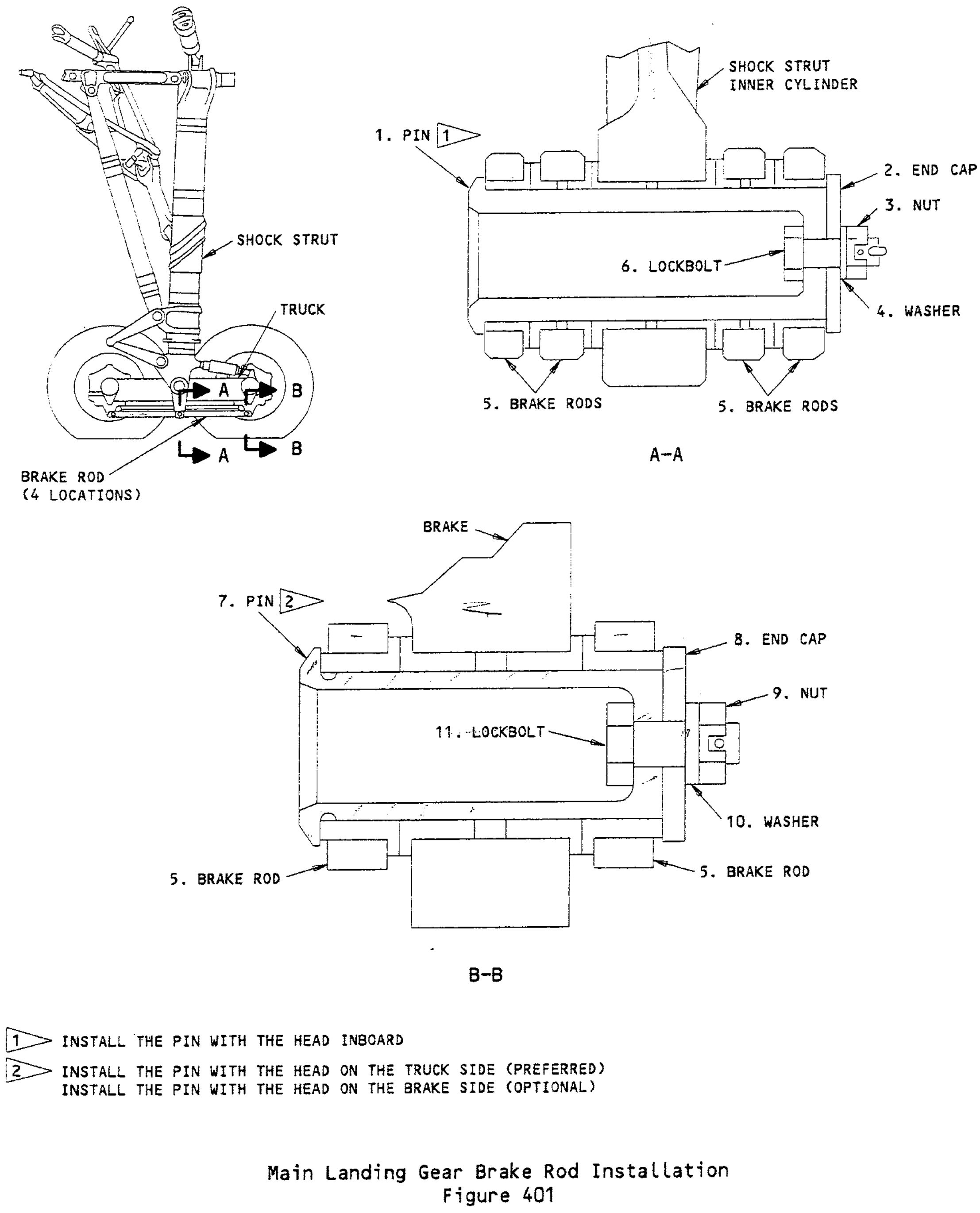


Figure 2

Detail of Boeing 757 Main Gear Brake Installation showing attachment of brake rod. Note end cap (item 8)

(Ref. Boeing Maintenance Manual 34-41-10)

(Information contained in Figure 2 is for illustrative purposes only)

> *'the brake rod was worn down to approximately 60% of it original length during the aircraft landing roll'. The rod, being made from steel, would be likely to have produced a wealth of sparks during the second touch-and-go and the subsequent landing.*

MEDA is an event-based investigative tool and the investigation established that the end cap was missing from the No 3 Wheel Brake Unit following the maintenance activity to replace the brake unit. The circumstances leading to this event were identified as follows:

> On 29 July, the aircraft arrived at Nottingham East Midlands Airport (NEMA) at 2025 hrs where a service check had been scheduled. Routine maintenance and some additional maintenance tasks were planned to be carried out that night on several aircraft, and the shift supervisor had arranged his personnel into two teams for the shift. One of these teams had been allocated to conduct the service check and wheel changes on G-BMRE, and the supervisor considered that this was perfectly acceptable in terms of workload. The team noticed that the brake pin wear indicator on No 3 wheel was below a 'company' acceptable level and, mindful that the aircraft was to conduct a training detail and take part in a flying display later in the day, it was decided to change the brake unit that night. However, the maintenance activity was not carried out immediately as the aircraft was used for two further sectors, returning to NEMA at 0157 hours the following morning. The supervisor then allocated a further two teams to the task, thus providing extra manpower for the required maintenance so that all the tasks could be completed within the shift time period. One of the original team, who were allocated to the aircraft to carry out the brake unit change, recommended that the change be carried out later that morning, in daylight, but this was not considered necessary by the supervisor. No reference was made at this time to the Maintenance Operations Control department.
>
> The work to change the brake was subsequently carried out by torchlight and, although arc lighting was available, they considered it too awkward to use for routine maintenance activities on the line. During this work, the maintenance personnel were subjected to numerous interruptions. One was asked to carry out a duplicate inspection on another item of the service, whilst another team required the use of the jack to change a wheel. Another maintenance engineer was carrying out a greasing task of the service, which resulted in numerous dirty rags lying about the wheel area. Neither of the engineers changing the brake unit realised that that they had not fitted the brake rod pin end cap, partly due to the fact that the lockbolt did not rotate when tightened. From previous experience, they understood that the lockbolt would move when tightened should the end cap not be fitted.
>
> There was no requirement for a duplicate inspection following a brake unit change.

Safety action

The MEDA process employed by the operator established that the end cap from the brake torque rod of the No 3 wheel brake had not been re-fitted during the maintenance activity to change the brake unit. Contributory factors were identified as:

- *Repetitive task, or the 'know how[1]' principle*
- *Inadequate task planning*
- *Peer and time pressure*

As a result of their investigation, the operator's Safety Department has identified safety actions to the aircraft operator's management, the intent of which is as follows:

- The authority to change the established maintenance programme, to include additional activities, should be reviewed and 'risk managed'.
- Maintenance personnel should be reminded of the need to review maintenance procedures before carrying out maintenance tasks.
- Whilst there is no requirement for a duplicate inspection following a brake unit change, consideration should be given for the need to conduct an independent check following such activity.
- Additional or refresher training for engineering Supervisors should be considered to ensure that correct maintenance procedures are followed at all times, and to make such personnel more aware of the pitfalls of conducting maintenance activity in poor environmental conditions, including poor lighting.

Also, as a result of this incident, a series of safety training days has been organised by the operator, during which this event is used as a case study.

In consideration of the safety action proposed by the operating company, it is considered not necessary to make any formal Safety Recommendations.

Conclusions

The flight crew were unaware of a problem until ATC warned them that flames were seen coming from the right landing gear. The commander's recollection of the entry in the technical log referring to a brake change enabled him to make a prompt and good decision to continue with the go-around and not attempt to stop the aircraft on the runway remaining. A decision to stop could have further jeopardised the aircraft due to the possibility of overrunning the end of the runway.

A combination of factors affecting the maintenance team's performance in carrying out the brake unit change, were identified. These were: multiple interruptions during the task, poor lighting conditions and a change to their routine maintenance tasks, a change that was taken without consultation with Maintenance Operations Control.

Footnote

[1] A situation where a repetitive task is carried from memory, rather than by reference to the maintenance manual, due to the familiarity of the task.

INCIDENT

Aircraft Type and Registration:	Embraer 135, LX-LGK
No & Type of Engines:	2 Rolls Royce AE3007 A3 turbofan engines
Year of Manufacture:	2005
Date & Time (UTC):	1 January 2006 at 1915 hrs
Location:	London City Airport
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 4 Passengers - 29
Injuries:	Crew - None Passengers - None
Nature of Damage:	Two small punctures in the aircraft skin
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	33 years
Commander's Flying Experience:	6,525 hours (of which 3,811 were on type) Last 90 days - 203 hours Last 28 days - 71 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft's parking brake was not set prior to engine start. After engine start, ground crew removed the chocks and the aircraft rolled forwards and struck ground equipment.

History of flight

After they had parked the aircraft on stand and chocks had been inserted, the flight crew noticed that the brake temperatures were close to the amber range, indicating the brakes were hot. To assist cooling of the brakes during the turnaround, the parking brake was selected OFF. A Ground Power Unit (GPU) and its tractor were positioned approximately one metre in front of the aircraft. The weather was windy, with rain, and it was dark.

As departure time approached, a single member of the ground crew arrived to assist in the aircraft's departure. The communication between flight crew and the ground crew was to be by hand signals; no headset was provided.

The flight crew completed the appropriate checks in preparation for engine start, but did not select the parking brake ON (the commander later attributed this oversight to human error). This omission was not identified by either pilot during the before start checklist. The engines were started and the commander signalled to the ground crew that the chocks should be removed. The ground crew removed the chocks from behind the wheels without difficulty, but had to strike the chocks in front of the wheels with another chock to displace them. With the chocks removed, the aircraft began to move forward slowly. It collided with the GPU and its tractor, damaging the aircraft skin in two places. Recognising that a collision had taken place, the commander stopped the aircraft and applied the parking brake. The commander reported that the dark and rainy conditions had prevented him realising that movement had taken place, until the collision occurred, and that in the absence of headset communication the ground crew was unable to instruct the commander to apply the brakes.

The operator believes that this incident would not have occurred if procedures had required the ground crew to use headset communication (or required two ground crew where hand signals were used), or if ground crew were required to obtain confirmation that the parking brake was set prior to engine start, or if the tractor and GPU had not been parked close in front of the aircraft. The operator is in discussion with the ground handling service provider on these matters.

INCIDENT

Aircraft Type and Registration:	Jetstream 3202, G-BYRA
No & Type of Engines:	2 Garrett Airesearch TPE331-12UHR-701H turboprop engines
Year of Manufacture:	1989
Date & Time (UTC):	16 November 2005 at 1542 hrs
Location:	Inverness Airport, Scotland
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 3 Passengers - 4
Injuries:	Crew - None Passengers - None
Nature of Damage:	Hydraulic fluid loss during approach
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	31 years
Commander's Flying Experience:	4,104 hours (of which 1,738 were on type) Last 90 days - 185 hours Last 28 days - 79 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

Whilst in flight, the left wheel brake pressure gauge suffered a failure which caused it to permanently indicate 2,000 psi. This led the crew to believe that the wheel brake might be locked 'on' during the landing. During the same flight, a failure of the pressure delivery pipe from the left hydraulic pump resulted in the total loss of the aircraft's hydraulic systems, but only after the crew fully deployed the flaps and extended the landing gear. The aircraft carried out an uneventful landing, but without the nose wheel steering and main wheel braking systems being available, and came to a halt on the runway.

History of flight

On approach to Inverness, whilst completing the approach checklist, the flight crew noticed that the left brake pressure gauge was reading full scale deflection, 2,000 psi. Fearful that the left wheel brake might be locked 'on', they carried out a go-around, with the intention of addressing this problem prior to attempting a landing. The flight crew closed the hydraulic Low Pressure (LP) cocks, to lower the system pressure, but with zero hydraulic pressure in the system, the left wheel brake pressure indicator still read 2,000 psi. The circuit breaker for the indicator was pulled and reset, but with no effect. Hydraulic power was then restored and the flight crew briefed the cabin crew on the possibility that the landing may be made with the left wheel brake locked 'on'. During the preparations for landing, a passenger reported purple fluid leaking from the left wing. The flight crew selected the landing gear DOWN and the flaps to FULL, after which the hydraulic system pressure indications dropped to zero and the hydraulic pumps could be heard cavitating. After confirming that the landing gear was down and locked, the flight crew called for the passengers to assume the brace position in preparation for the landing. The aircraft touched down gently and, despite the lack of nose wheel steering, the aircraft was able to track the runway heading and was brought to a halt, on the runway, using propeller reverse pitch and the parking brake. After shutdown, the fire service reported that fluid was leaking from the left engine; the aircraft occupants were then evacuated through the left passenger door without injury.

Description of the hydraulic system

The BAe Jetstream 3202 is a development of the Jetstream 31 series of aircraft, and is designed with manually operated flying controls. It is a twin turboprop passenger aircraft certified to carry up to 19 passengers. The hydraulic system of the aircraft has two modes of supply, NORMAL and EMERGENCY. Both the NORMAL and EMERGENCY systems are supplied from a common reservoir which is fitted with a divider plate, which allows both systems to be serviced from a common point. The plate ensures that, in the event of a leak in the NORMAL system, sufficient fluid remains in the EMERGENCY system to operate essential services. The NORMAL system is pressurised by two engine driven pumps and operates all of the aircraft's hydraulic services. The EMERGENCY system allows the hydraulic operation of the landing gear and flaps through the use of a hand pump adjacent to the pilots' seats.

Examination

An inspection of the aircraft was carried out by engineers from the operator's maintenance organisation. The left wheel brake pressure gauge was found to have failed at full scale deflection, and was replaced. The loss of hydraulic fluid was due to the failure of the pressure delivery pipe union which attached this pipe to the left hydraulic pump. It was not possible to carry out a detailed inspection of the failed pipe and union, as they had been discarded during the rectification process. It was not established if the failure of the indicator was connected with the subsequent failure of the pipe union. The aircraft's records confirmed that no recent maintenance activity had been carried out on this system and that no defects had been observed during routine inspections of the relevant area.

ACCIDENT

Aircraft Type and Registration:	CAP 222 (Modified), G-GZOZ
No & Type of Engines:	1 Lycoming AEIO-360-A1E piston engine
Year of Manufacture:	1998
Date & Time (UTC):	8 July 2005 at 1415 hrs
Location:	White Waltham Airfield, near Maidenhead, Berkshire
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:	Airline Transport Pilot's Licence with Flying Instructor Rating
Commander's Age:	43 years
Commander's Flying Experience:	10,149 hours (of which 115 were on type) Last 90 days - 221 hours Last 28 days - 49 hours
Information Source:	AAIB Field Investigation

Synopsis

The experienced aerobatic pilot had briefed to fly four different unlimited aerobatic manoeuvres, practising three of each whilst being watched by his aerobatics instructor. When practising the fourth manoeuvre, a knife-edge spin[1], for the third time, the aircraft entered an inverted spin which was not part of the planned sequence. The aircraft continued spinning until it impacted the ground. It struck the ground in an inverted attitude, with a high vertical rate of descent and with an anti-clock-wise rotational movement when viewed from above. The pilot was fatally injured on impact.

Pilot's flying experience

The pilot was a current Boeing 747 commander. In addition to his UK Airline Transport Pilot's Licence, he held an FAA Commercial Pilot's Licence and a New Zealand Private Pilot's Licence. He started flying competition aerobatics in about 1995, winning the Standard Nationals aerobatic competition in 1997, in a Pitts S1D. He then moved on to advanced aerobatics in 1999 and became the National Aerobatic Champion at this level in 2002. He had been flying 'unlimited

Footnote

[1] A knife-edge spin is not a true spin because the wings are not stalled. Instead, the aeroplane is deliberately yawed and it rapidly rotates in pitch about its lateral axis, under the influence of elevator and gyroscopic forces.

aerobatics'[2] in G-GZOZ since 2003 but he continued to compete at the advanced level. He also held a Flying Instructor rating and a Display Authorisation to perform aerobatics down to a base height of 500 ft agl.

Nine months before the accident the pilot frequently practised aerobatics. He then stopped flying aerobatics on a regular basis whilst he completed, with his airline employer, an aircraft type conversion course followed by a command course. One month before the accident, the pilot resumed his previous aerobatic continuity and was again flying aerobatics frequently.

Other aerobatic types he had flown included the Chipmunk, CAP 10, Tiger Moth, Harvard, Extra 200, Sukhoi 29, Yak 52, various types of Pitts, and the Cessna 150 Aerobat.

History of flight

On the day of the accident, the pilot flew one flight in G-GZOZ prior to the accident flight. He had first flown in the morning to practise some other unlimited aerobatic manoeuvres. On both occasions he was provided with a ground based radio critique, on a quiet frequency, by the part-owner of the aircraft who was a very experienced aerobatic flying instructor and international aerobatic competitor. The instructor was positioned outside the flying club house, about 1 km from the crash site.

Both flights were flown overhead White Waltham Airfield, in pre-booked slots of 20 minutes. White Waltham flying orders state that aerobatics overhead the airfield are to be confined to that part of the aerodrome traffic zone that is to the west of the Heathrow Control Zone. The maximum and minimum heights for aerobatics in the overhead are 2,300 ft agl and 500 ft agl respectively. The weather minima required are 2,500 ft cloud base and 5 km visibility.

The weather was good with a surface wind from 020° at 08 to 12 kt, a visibility of 10 km or more and broken cloud at 3,200 ft and 4,500 ft agl. In accordance with normal practice, the flight was 'booked out' on a 'Waltham Based Aircraft' sheet, showing a planned departure time of 1400 hrs.

The pilot was described as looking fit and well that morning. People who had lunch with him said he was in good spirits and in a happy mood. In the afternoon, the pilot briefed with his instructor, for his second flight of the day. This flight was to practice four different manoeuvres, flying three of each, all of which he had flown before on various occasions. The last manoeuvre was to be a knife-edge spin.

The first three manoeuvres were flown without any problems. He then planned to fly the knife-edge spins, in order to practise the correct amount of aileron to use during the manoeuvre. He intended to complete only one rotation in pitch during each knife-edge spin. The first repetition was not balanced and progressed into a positive flick roll, (sometimes called a snap roll) from which the aircraft recovered normally. The second was flown satisfactorily, with good balance, but the rotation rate was a little slow. His instructor thought this was because he was not putting in full-forward control column. His instructor passed this advice to him by radio. He stated that he accepted the advice and set up to try one more knife-edge spin.

The set up and entry to the third knife-edge spin was flown correctly, at a height of approximately 2,300 ft agl. After one complete rotation in pitch, no recovery action

Footnote

[2] The most proficient aerobatic skill level of the class sequence: standard, intermediate, advanced and unlimited.

was evident. After a further half a rotation in pitch, the instructor called "recover" over the radio. He expected the aircraft to enter a vertical dive from which it would then recover. The pilot did not reply to this call.

The aircraft then continued for a further half to three-quarters of a rotation in pitch, before going onto its back and entering an inverted spin at approximately 1,800 ft agl. The aircraft continued to spin inverted until it impacted the ground. Because this inverted spin initially had a slow rate of descent with a 'flat' pitch attitude, it appeared to the instructor to be one in which right rudder was applied. (A right-rudder inverted spin is generally flatter than a left-rudder inverted spin.) Being aware of the manoeuvre the aircraft was then in, the instructor transmitted over the radio "change feet and stick back". He may have said this twice but there was no reply. The aircraft was by then at a height of approximately 1,500 ft agl. If recovery action was initiated without delay, this should have been enough height to recover from this inverted spin.

The aircraft continued to spin inverted until it went out of sight to the instructor behind a small rise on the airfield, where it impacted the ground. Whilst the aircraft was in the inverted spin, the instructor did not see any change in aircraft attitude or rate of rotation to indicate that there was any input to the flying controls. He also did not hear any radio transmission from the pilot but he also stated that his own transmission could have blocked those of the pilot.

The airfield's emergency services were quickly in attendance and they confirmed that the pilot had not survived the accident. Paramedics from the resident air ambulance, attended soon afterwards. In addition, fire vehicles from Maidenhead attended the scene.

Other witnesses

Many other eye witnesses saw the accident. The majority of them were outside the flying club at White Waltham, near the instructor. They reported seeing the aircraft doing aerobatics and then saw it enter a spin. Most identified the spin as inverted. They also stated that there was no change in attitude or rate of rotation, after the first few turns of the spin, before the aircraft went out of sight and impacted the ground. Another witness was flying into White Waltham while the aerobatics were taking place. He stated that he saw the aircraft at a height of approximately 1,000 to 1,500 ft in a spin. After observing it for a few turns, he soon became aware that if it did not recover soon, it would crash. He added that "it continued spinning with no visible attempt to alter the attitude of the 'plane." He did not notice if the spin was erect or inverted.

Another witness was taxiing his aircraft out to Runway 03, at White Waltham. He stated that, as he was approaching the end of a line of parked aircraft, he suddenly became aware of an aircraft spinning inverted and rotating to the left. At the time he estimated the aircraft's height to be approximately 600 to 800 ft agl. The aircraft appeared to be approximately 45º nose down with the propeller blades rotating slowly. He continued to watch the aircraft until it impacted the ground.

The knife-edge spin

A knife-edge spin is not a true spin, because it is not a 'classic' autorotation; for a successful knife-edge spin, the angle of attack at the wings must remain negligible. During the manoeuvre the aeroplane falls vertically and rotates in pitch about its lateral axis, (a motion sometimes described as tumbling), as it descends. The aircraft will lose about 200 ft of height in the first turn but this height loss per turn tends to increase with successive turns.

In an aircraft with a clockwise turning propeller, a knife-edge spin is usually entered from a stall turn to the left. Initially, a stall turn is flown until, when entering the descent, the moment arises when the pilot should apply opposite rudder to stop the yaw. Instead, left rudder is maintained. This makes the aircraft's nose swing through the vertical to about 45° past the vertical. With the nose in this 45° nose-up attitude, full forward control column is then smoothly applied to start the pitching motion. With high engine rpm, this pitch-down generates a large gyroscopic force which will assist the applied left rudder in holding the nose up against gravity. The forces involved are illustrated at Figure 1.

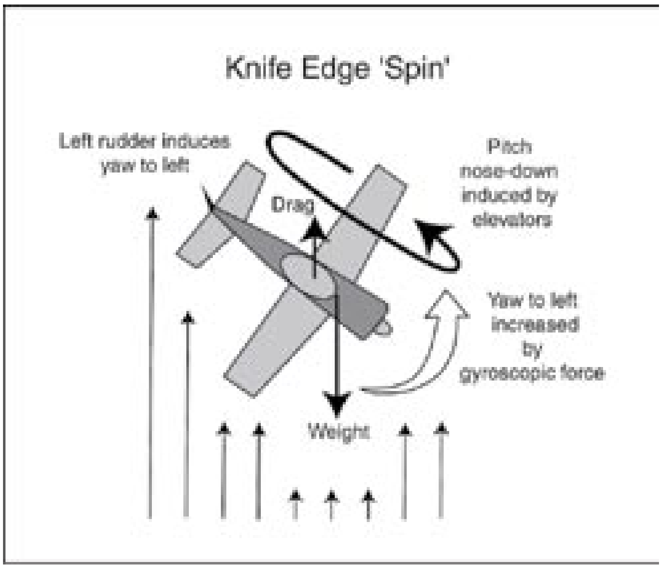


Figure 1
Knife Edge Spin illustration

The control column does not need to be pushed aggressively. However, if there is a delay before pushing whilst on the knife edge, the aircraft's forward speed will accelerate and the aircraft will straighten due to the effect of the stabilising effect of the fin. The pilot will then be exposed to an increased amount of negative g and the manoeuvre could become a descending outside turn. If the control column is pushed too slowly, the aircraft will accelerate with the same result. When the control column is pushed forward, the pilot must apply aileron to keep the wings in the vertical plane. The task with the ailerons is to balance the aircraft so that it falls straight downwards with the wings at right angles to the ground. If an angle of attack is generated by using too much aileron, the aircraft may enter a flick roll. Too much left aileron may lead to a positive flick roll; too much right aileron may lead to a negative flick roll.

The recovery procedure is always the same; apply opposite rudder and move the control column centrally back. It is possible to reduce the power initially, to reduce the gyroscopic effects, before applying the recovery controls but this will also reduce the effectiveness of the rudder in cancelling the yaw.

It is possible to enter an inverted spin from a knife-edge spin if right rudder is applied while full forward elevator is maintained.

Aerobatic limitations

The aircraft was cleared for aerobatic manoeuvres, including unlimited aerobatics, when complying with the limitations prescribed under the Aerobatics Category, up to its MTWA. Calculations show that the aircraft's weight was below the MTOW and the CG position was within the required limits.

Spin recovery technique

The following information was included in the '*Approved Airplane Flight Manual and Operating Handbook*' for the aircraft (See Figure 2):

3.5 Recovery from unintentional spins

The lost of altitude is about 330 ft (100 m) per turn, and 1000 ft (330 m) for the recovery.

WARNING

Before applying the recovery procedure, it is necessary to identify the nature of the spin, UPRIGHT or INVERTED.

The spins are very predictable and the recovery procedure is conventional:

Power .... idle

Ailerons ....neutral

Rudder ....full opposite to the spin

Elevator ....neutral for upright spins slightly backward for inverted spins

Figure 2

Excerpt from Approved Airplane Flight Manual and Operating Handbook

Medical information

The pilot held a current JAA Class 1 medical certificate with a limitation requiring him to wear distant vision lenses while flying and he was wearing a pair of spectacles at the time of the accident. The post mortem examination carried out by a consultant aviation pathologist, revealed that the pilot had died instantly from multiple injuries resulting from a severe vertical force. The pathologist concluded that there was no evidence of any medical condition or toxic substance that may have caused or contributed to the accident.

Aircraft information

The aircraft type was derived from the Giles G202. The French aircraft company, CAP Aviation, undertook to take on the design as a CAP project and obtain JAR 23 certification, renaming it the CAP 222. The accident aircraft, constructor's number C03, was built in 1998 and delivered as an uncertified aircraft but with JAR certification expected within 12 months. However, this did not happen due to funding issues. As delivered, the aircraft was registered in France as F-WWMX. In May 2005 it was transferred to the UK register as G-GZOZ, operating on a CAA Permit to Fly. It was registered as a CAP 222 (Modified) because it would probably vary from any subsequently certificated CAP 222 should JAR 23 type certification be obtained.

The aircraft had accumulated 475.3 hours at the time of the accident. It was fitted with a three-bladed propeller with a constant speed unit and a microprocessor based engine management system. This system displayed engine rpm, exhaust gas temperature, manifold pressure, fuel pressure and cylinder head temperature on a flat panel display. In addition to displaying these parameters, it was able to store the values in non-volatile memory and alert the pilot to significant variations.

Engineering investigation

The aircraft had struck the ground inverted in a fully developed inverted spin to the left, ie to the right relative to the aircraft's vertical axis. The wings were approximately level at impact, and there was very little travel over the ground. The impact was substantially nose down, after which the top of the fin struck the ground and, due to the rotation of the aircraft, there was some sideways movement of the rear fuselage and empennage. The pilot's harness had been fastened at impact but the accident was not survivable.

Evidence of engine speed and power was obtained from the damage to the propeller. This showed that at ground impact, the engine had been turning at low power, consistent with idle, and had stopped in less than one third of a rotation. The non-volatile memory, in the electronic engine management system fitted to the aircraft, was returned to its manufacturer in order for the data to be recovered. The manufacturer confirmed that prior to impact, the engine was working normally and operating at idle rpm.

The aircraft was recovered to the AAIB facility at Farnborough for a more detailed investigation. No pre-impact discontinuity was found in any of the primary flight control systems, much of which could still be functioned. All the breaks identified had been caused in the impact or were deliberate cuts made when the wreckage was recovered.

The aircraft was well constructed (it was a factory-built demonstrator) and the control runs were well laid out. They did not appear particularly vulnerable to interference from foreign objects. No extraneous objects were found in the wreckage and the front seat harness was adequately stowed. The possibility of a control jam could not be entirely ruled out but no evidence of a jam or restriction was found. In brief, no evidence of any flying control system problem was found.

There were no obvious witness marks identifying the position of the ailerons or elevators. However, clear marks were found on the rudder pedal linkage which indicated that full right rudder had been applied at ground impact.

Analysis

Inverted spin recognition and recovery

The accident pilot's aerobatics instructor commented that he had seen the pilot practise planned inverted spins before, but he had not seen him enter an unplanned inverted spin from any other aerobatic manoeuvre.

Because the inverted spin was inadvertently entered at a low height, the pilot only had a few turns to identify that he was in an inverted spin, identify the direction of the spin and apply the correct recovery technique in time to recover from the ensuing dive and avoid the ground. In this case, it is estimated that he had no more than three turns in which to commence the recovery. The elapsed time between spin entry and initiating a successful recovery was, perhaps, as little as 5 seconds. This was a very short time in which to resolve any unexpected confusion.

A turn indicator is the only instrument that can be used to identify the direction of an erect or an inverted spin. There was no turn indicator fitted to G-GZOZ and there was no requirement for one to be fitted because it was only cleared for VFR flight. In addition, a turn indicator would not necessarily be fitted to an aerobatic aircraft because the instrument panel might not have sufficient installation space. Also, the delicate gyro assembly in the turn indicator would be susceptible to failure whilst flying high-performance aerobatics.

If the direction of an inverted spin needed to be identified in an aircraft with no turn indicator fitted, the pilot would have to look over the nose of the aircraft and use visual cues alone. This introduces the possibility of confusion, particularly if the entry was sudden and unexpected. Another generic technique to identify turn direction is to remove any foot pressure from the rudder pedals, press each pedal in turn, determine which pedal requires more effort, and then push the 'heavy' pedal. However, the CAP 222 Flight Manual states that during spins, there is no aerodynamic pressure on the controls, so the technique could have been ineffective on this aircraft type.

Pilot incapacitation

The accident occurred because the pilot did not recover from the inverted spin. In the absence of evidence for a mechanical problem, this suggests he may have been confused or incapacitated. Entry to the inverted spin was unintentional and the pilot's intention was to complete only one rotation in the knife-edge spin. In fact, he did between one and a half and two and a quarter rotations. This suggests that the pilot's difficulties may have started during the knife-edge spin.

After his previous attempt, the pilot had been advised to increase the rate of rotation in the knife-edge spin. The rotation rate he achieved on his third attempt is estimated at about one turn in less than a second. The pilot's head was about 1.2 m from the axis of rotation, which passed through or close to his body. At 1 second per rotation, the acceleration at his head would have been minus 4.8g.

At 0.8 seconds per rotation, his head would have been subjected to a negative acceleration of 7.5g whilst his feet would have been close to the axis of rotation; see Figure 3 below:

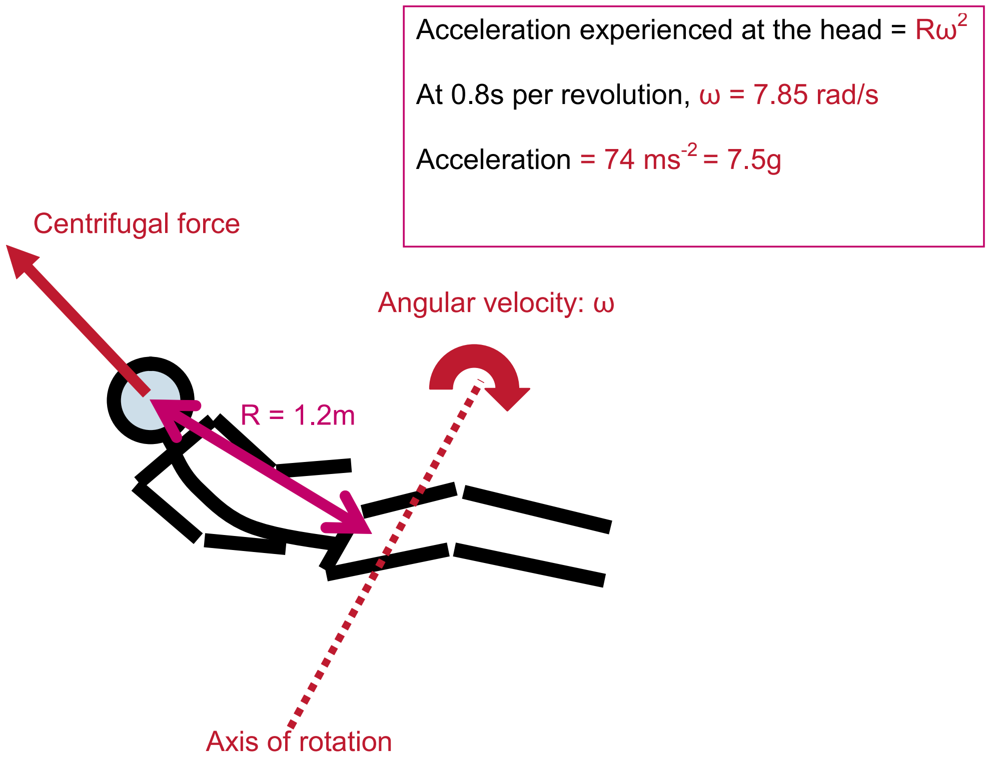


Figure 3

Forces acting on pilot's head

Positive g sends a pilot's blood towards the lower body; negative g sends the blood upwards towards the head. The equations above illustrate that a small increase in the speed of rotation would have brought about a significant increase in the acceleration experienced.

Negative g is uncomfortable and less well tolerated than positive g. Exposure for more than six seconds to between minus 4g and minus 5g is reported to cause confusion and unconsciousness[3].

As an experienced aerobatic pilot, the accident pilot might have been expected to tolerate minus 4g relatively well, at least for a few seconds. If he was unused to higher levels of negative acceleration, a sudden and unexpected exposure to minus 7.5g could have been very disturbing and painful, delaying his attempt to recover, making that attempt inaccurate and, perhaps, provoking an unthinking retardation of the throttle.

After possibly as long as 1.5 seconds at minus 7.5g, the pilot may then have experienced even higher levels of negative g, very briefly, as the aircraft transitioned to the inverted spin, due to the sudden increase in drag from the wings. Once stabilised in the inverted spin, the pilot would then have been exposed to a lower level of negative g which might have had continued effects on his cardiac efficiency and, therefore, on cerebral blood flow and cognitive function.

The unintentional entry into the inverted spin would, of itself, have presented the pilot with a challenge in terms of determining the direction of the manoeuvre and the correct recovery action. A response time of a few seconds would not have been unlikely even in the absence of the acceleration-induced physiological effects. In addition, the transition from the knife-edge spin to the inverted flat spin is likely to have been accompanied by vestibular overload; the pilot may have experienced illusory feelings of rolling in addition to the actual gyrations involved in the transition. This sensation is familiar to the competitive aerobatic community. They refer to this feeling as "wobbly head".

If the pilot did have normal levels of cognitive function during the inverted spin, he would have been faced with an increasingly alarming situation. Given that he was a fairly experienced aerobatic pilot, it is unlikely that he panicked. But the preceding few seconds would have been confusing as well as painful and disturbing, and he would have been presented with a dilemma: Should he persevere with a control strategy that is failing or change a strategy that might be about to work? In such a situation, unless there is a clear, positive, indication that the strategy is wrong, perseverance may persist by default – even if it appears clearly inappropriate to an observer who has the benefits of distance, hindsight, and a comfortable 1g, upright viewpoint.

In summary, the pilot may have been exposed to an unexpected, disturbing and painful level of negative acceleration by his attempt to make the knife-edge spin slightly brisker in terms of speed of rotation. As a result, his exit from the manoeuvre was delayed and the aircraft entered an inverted spin. His cognitive efficiency was likely to have been impaired by: the initial negative acceleration, any transient accelerations experienced in the transition from the knife-edge spin to the inverted spin, and by the continued exposure to negative acceleration during the inverted spin. The entry to the inverted spin was likely to have been confusing, in terms of both visual and vestibular sensations, so that a rapid

Footnote

[3] Aviation Medicine (third edition) by Air Vice Marshall J Ernsting, Air Commodore A N Nicholson and Air Commodore D J Rainford (eds). Butterworth-Heinemann, Oxford, 1999.

corrective reaction was not likely. If the pilot did recover normal levels of cognitive function as the inverted spin progressed, he would have faced an increasingly alarming situation with no clear options for recovery.

Conclusion

During a practice session of unlimited aerobatic manoeuvres at low altitude, the aircraft entered an unplanned inverted spin. The aircraft did not exhibit any indications of recovery consistent with application of the control movements required to effect recovery. Moreover, pro-spin rudder was still applied at ground impact. No reason for this failure to recover could be positively identified. However, the circumstances of the accident could be explained by some form of brief and temporary pilot incapacitation. Alternatively, confusion, disorientation and lack of time may have been contributory factors.

ACCIDENT

Aircraft Type and Registration:	1) Casa 1-131E Series 2000 Jungmann, G-BECW 2) Stolp Starduster SA 100, N40D
No & Type of Engines:	1) 1 Tigre G-IV-B piston engine 2) 1 Lycoming 0-320-B3B piston engine
Year of Manufacture:	1) 1953 2) 1974
Date & Time (UTC):	22 January 2006 at 1605 hrs
Location:	Old Hay Airfield, Kent
Type of Flight:	Private
Persons on Board:	1) Crew - 1 Passengers - 1 2) Crew - 1 Passengers - None
Injuries:	1) Crew - None Passengers - 1 (Minor) 2) Crew - None Passengers - N/A
Nature of Damage:	Extensive damage to both aircraft
Commander's Licence:	1) Private Pilot's Licence 2) Commercial Pilot's Licence (Australian)
Commander's Age:	1) 52 years 2) 61 years
Commander's Flying Experience:	1) 2,591 hours (of which 377 were on type) Last 90 days - 25 hours Last 28 days - 8 hours 2) 1,780 hours (of which 225 were on type) Last 90 days - 4 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Forms submitted by the pilots

Synopsis

Two tail wheel aircraft landed at this unlicensed airfield at the same time but on reciprocal runways and subsequently collided in the centre of the airfield.

History of flight of aircraft G-BECW

This aircraft departed Old Hay Airfield on the afternoon of the accident and flew to various local airfields before returning to Old Hay. The pilot checked the windsock prior to his approach, it indicated a northerly wind of approximately 5 kt which was almost straight across the grass Runway 10/28. In accordance with his normal practise when the wind direction did not favour a particular runway, this pilot made an approach to Runway 28 as he considered its approach area to be less obstructed than that of Runway 10. A normal landing was achieved and the aircraft was kept on the centreline whilst the pilot completed his rollout and taxied towards his exit point. Approximately 50 m prior to his exit point, the aircraft collided with another aircraft which, due to the head-on nature of the collision and restricted forward vision of this tail wheel aircraft, was unseen prior to the collision. Both occupants, who were wearing 5-point harnesses, were able to evacuate the aircraft through the normal exits.

History of flight of aircraft N40D

This aircraft departed from Runway 10 at Old Hay for a local flight with the pilot having estimated the surface wind as 020-030º at 5-7 kt. He returned to the airfield 15 minutes later and made a normal approach and touchdown on Runway 10. With the landing speed under control, the pilot taxied the aircraft on the runway centreline towards his intended exit point which was the intersection with Runway 13/31. Before reaching this point, he collided with a previously unseen aircraft taxiing the opposite way. The pilot, who was wearing a 4-point harness, was able to vacate the aircraft through the normal exit. This aircraft was a tail wheel design and as such, also had restricted forward vision on the ground.

Airfield

Old Hay Airfield is an unlicensed airfield with no air traffic control or aerodrome signals square. Runway selection is therefore at the discretion of the pilot and according to the Rules of The Air Rule 17 (7):

> *'a flying machine shall take-off and land in the direction indicated by the ground signals or, if no such signals are displayed, into the wind, unless good aviation practise demands otherwise.'*

In 2005, the airfield was allocated its own radio frequency to enable pilots using the airfield to make blind transmissions of their position and/or intentions. Although no provision was made for regular air-ground control, the airfield operator felt that a dedicated radio frequency would reduce the risk of collision. There are about six aircraft based at Old Hay and visiting aircraft are allowed on a 'prior permission required' basis. On the day of the accident, it is believed that these were the only two aircraft operating from this airfield and neither used the airfield's radio frequency.

Discussion

This accident occurred when the only two aircraft using the airfield at the time decided, unbeknown to each other, to land at the same airfield, at the same time, but using reciprocal runways. Both pilots had valid reasons for using the different landing runways and although they should have been able to see each other whilst airborne, once on the ground the tail wheel design of both aircraft would have hindered visual acquisition of the other. Although this particular series of events is unlikely to be repeated, it could have been prevented had both pilots used the airfield's radio frequency which was acquired for just such a scenario. The airfield operator is also considering standardising circuit procedures for nil/cross wind conditions.

ACCIDENT

Aircraft Type and Registration:	Cessna 210M Centurion, G-TOTN
No & Type of Engines:	1 Continental Motors Corp IO-520-L piston engine
Year of Manufacture:	1977
Date & Time (UTC):	31 October 2005 at 1642 hrs
Location:	Cambridge City Airport, Cambridgeshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to propeller and underside of fuselage
Commander's Licence:	Private Pilot's Licence
Commander's Age:	48 years
Commander's Flying Experience:	2,400 hours (of which 150 were on type) Last 90 days - 40 hours Last 28 days - 15 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and report by engineering maintenance facility

Summary

The aircraft was on a short positioning flight during which the pilot was unable to successfully deploy the landing gear, either by normal control selection or by using the manual pump. The pilot elected to divert to Cambridge City Airport and made a successful gear-up landing; the aircraft sustaining damage to the propeller and the underside of the fuselage. The inability to deploy the landing gear has since been attributed to incorrectly installed wiring for the squat switch on the nose landing gear. The squat switch had recently been replaced.

History of flight

The aircraft was on a short positioning flight to Top Farm. According to the pilot's report he was unable to successfully deploy the landing gear, either by normal control selection or by using the manual pump. He could see from the wing mounted mirror that the landing gear doors had opened successfully.

The pilot elected to divert to Cambridge City Airport where the visibility was 10 km, with a 4 kt wind and with no significant weather being reported. He made a successful gear-up landing, sustaining damage to the propeller and the underside of the fuselage. No injuries were sustained and the pilot reported that *'ATC and Fire Services were all magnificent'*.

Engineering Investigation

The landing gear had been subjected to recent maintenance and this included the fitting of a new squat switch, which is mounted on the nose gear actuator. This was documented in the airframe log book and was dated 17 October 2005.

After the incident the aircraft was taken to a maintenance facility at Cambridge City Airport where it was jacked for inspection. When the engineers attempted to deploy the gear by operating the gear down switch, they found that the nose gear partially deployed and then started to retract. The nose gear was trapped in a cycle of partial retraction and deployment and this continued until gear up was selected.

Further inspection of the nose gear revealed that the two wires from the squat switch had been incorrectly routed and had become trapped in the nose gear down-lock hook. The spiral wrap that protected the two wires was damaged and they had been squashed exposing the cores. The damaged wires were replaced and the gear was then found to function satisfactorily.

A review of the wiring diagram revealed that if either of the two wires from the squat switch went to earth this would energise the gear up solenoid, causing the gear to retract. There is therefore substantial evidence that the incorrectly routed wiring, which had subsequently become damaged, was causing an earth when the nose gear was partially deployed and that this was causing the gear to become stuck in a cycle of partial retraction and deployment when gear down was selected.

Further analysis of the hydraulic and electric system schematic diagram showed that the relevant circuit breaker would not have tripped in this situation and was not of a type which could be tripped manually. It also showed that the only way that the pilot could have deployed the landing gear was by switching off all the electrics and using the hand pump. There was no operating procedure for this case in the Pilot's Operating Handbook, and the pilot acted in accordance with the Handbook.

ACCIDENT

Aircraft Type and Registration:	Cessna F177RG Cardinal, G-BFPZ
No & Type of Engines:	1 Lycoming IO-360-A1B6D piston engine
Year of Manufacture:	1973
Date & Time (UTC):	28 November 2005 at 1639 hrs
Location:	Swansea Airport, West Glamorgan
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to propeller, engine cowlings, nose gear doors and nose landing gear. Engine shock loaded
Commander's Licence:	Private Pilot's Licence
Commander's Age:	53 years
Commander's Flying Experience:	666 hours (of which 125 were on type) Last 90 days - 14 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft was returning to Swansea from Exeter following repairs after a heavy landing. After completing one 'touch and go' the pilot rejoined the circuit. When the landing gear was selected 'down' the pilot observed a 'gear unsafe' warning light. After recycling the landing gear, the control tower reported that the nose leg had not extended. The pilot then made several unsuccessful attempts to lower it using the normal electrically powered system, before trying the emergency hand pump. After several minutes of pumping the control tower advised that the nose gear was only partially extended. The pilot then elected to carry out a landing with the nose landing gear in this condition, but it collapsed as the nose wheel touched the runway. With the possible exception of the landing gear system circuit breaker, no pre-accident defects were identified with the landing gear operating system.

History of flight

On 28 November 2005, following completion of maintenance work at Exeter Airport, the aircraft departed for Swansea with no reported problems. The pilot joined the circuit at Swansea and carried out an uneventful 'touch and go' on Runway 28. On the aircraft's second approach, the pilot observed a landing gear 'unsafe' light together with a 'low voltage' warning light and a 'burning' smell, after he selected the landing gear down; the landing gear circuit breaker had also tripped. The pilot then reset the circuit breaker and recycled the gear.

The main landing gear units extended normally but the 'gear unsafe' light remained illuminated. The control tower then reported that the nose landing gear (NLG) had not extended.

The pilot carried out a go-around and tried, unsuccessfully, to lower the NLG by recycling the landing gear selector lever several times. He then used the emergency hand pump to extend the landing gear. During this time the pilot made several passes of the control tower, to confirm that the landing gear was extending, but was told that the NLG had only partially extended. When subsequently informed by the control tower that there appeared to be no further extension of the NLG, despite continued use of the hand pump, the pilot elected to land the aircraft with the NLG partially extended.

The touchdown was normal, with the pilot holding the aircraft's nose high until the elevator became ineffective as the aircraft's speed decreased. As the nose lowered, the NLG collapsed, causing the propeller and forward fuselage to strike the runway. The aircraft came to rest on the runway and both occupants left the aircraft unaided. There was no fire.

Previous maintenance activity

On the 1 November 2005, the owner of the aircraft called his maintenance organisation at Exeter Airport to report that the aircraft had suffered a heavy landing at Swansea Airport. The aircraft was inspected by the maintenance organisation on 9 November 2005, and no obvious damage to the airframe or landing gear was observed, with the exception of the nose wheel. This was found to be fractured and replaced. On 16 November 2005, the aircraft was flown 'gear down' to Exeter Airport for a routine 50 hour check and a more detailed inspection of the landing gear and aircraft structure. No further damage was identified during the inspection; however, the NLG drag links and main attachment bolts were replaced as a precaution. The landing gear was tested using both the normal and emergency systems and found to function correctly.

Aircraft examination

Immediately after the accident, the aircraft was inspected at Swansea by its maintenance organisation and the insurer's loss adjuster. The aircraft was jacked up and the main landing gear (MLG) was found to be fully down and locked in position. However, the NLG was jammed in the nose gear bay by the remains of the NLG bay doors. After these were removed, the NLG was released from the bay but, due to a damaged torque link, caused by the NLG collapse, its oleo had become overextended and had to be restrained to prevent it falling from the landing gear leg. The NLG was found to retract normally, using the normal electric system, although the overextended oleo and damage to the NLG bay door mechanisms resulted in it becoming jammed in the bay. After freeing the NLG, an attempt was made to extend it electrically. No movement of the NLG occurred until the landing gear circuit breaker was rocked from side to side, after which the NLG extended normally. The NLG was partially retracted and then extended, using the emergency hand pump, to the fully down and locked position with no apparent problems.

Current status

At the time of writing, the aircraft is still at Swansea, awaiting repair, after which it is to be ferried to Exeter to further investigate the failure of the NLG to extend normally. The outcome of this will be reviewed, and any relevant information will be published as an addendum to this report in a future edition of the AAIB Bulletin.

ACCIDENT

Aircraft Type and Registration:	Cessna U206 Super Skywagon, G-ATCE
No & Type of Engines:	1 Continental Motors IO-520-A piston engine
Year of Manufacture:	1965
Date & Time (UTC):	9 October 2005 at 1500 hrs
Location:	Lewknor, Oxfordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Propeller strike and failed nose leg
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	38 years
Commander's Flying Experience:	414 hours (of which 123 were on type) Last 90 days - 26 hours Last 28 days - 7 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft was returning to the strip at Lewknor. Shortly after touchdown the aircraft encountered a bump in the runway surface and the nose landing gear leg collapsed.

History of the flight

This aircraft was normally used for carrying sport parachutists and the pilot was returning on his own to the grass strip at the Lewknor dropping zone (DZ) after a brief trip to refuel at Wycombe Air Park. The weather was clear, with a wind from the south-west at about 7 kt. The pilot contacted Lewknor DZ and notified them of his intention to do a straight-in approach to land on Runway 33 as he was well placed to do so. This was the runway which he had been using during that day.

The pilot reported that the initial approach was uneventful and stable. In the final approach he selected the flaps to 40º and trimmed for 70 mph with minor power changes and, after experiencing a small amount of turbulence as he passed over a ridge, the final approach was very stable, with the left wing held slightly low for the crosswind.

The touchdown was at about 65 mph but, after a short ground roll, the aircraft was "pushed back" into the air by a pronounced bump in the ground about one-fifth of the distance along the runway. The pilot recalls pulling back slightly on the control column and the aircraft returned to the runway. The subsequent landing did not appear to the pilot to have been particularly heavy but he recalled having heard an unusual mechanical noise at that time. Shortly afterwards he became aware that the nose had dropped and the propeller blades started to hit the ground. The pilot stated that the nose continued to drop until the aircraft slid off the right side of the runway and came to a halt. The pilot was able to perform the shutdown drills before leaving the aircraft through the sliding side door. There was no fire and the pilot noticed that the nose landing gear had detached and was lying further back along the runway.

No evidence of pre-existing damage in the nose landing gear strut or support structure was observed. It was considered that the failure had probably been due to overload as a result of the encounter with the bump along the runway.

ACCIDENT

Aircraft Type and Registration:	Europa, G-SYCO
No & Type of Engines:	1 EA-81/118 piston engine
Year of Manufacture:	1996
Date & Time (UTC):	9 December 2005 at 1430 hrs
Location:	Draycott Farm, near Swindon, Wiltshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Fracture in rear fuselage and damage to right landing gear leg
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	69 years
Commander's Flying Experience:	846 hours (of which 33 were on type) Last 90 days - 5 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft bounced on landing and the right landing gear leg failed, causing the aircraft to 'ground loop'.

History of the flight

The pilot was landing on Runway 18 at Draycott Farm, which is a grass runway 700 m in length. The weather was fine, with good visibility and light winds, though the runway surface was damp. A curved approach to the runway was required due to the presence of farm buildings in the approach area. The pilot reported that full flap had been selected and that the approach was normal. However, the aircraft bounced on landing and, as it touched down again, the right landing gear leg failed just above the wheel axle. The damaged leg then dug into the runway surface and the aircraft ground looped, coming to a stop. The first part of the landing roll was uphill and the pilot opined that this, together with the handling characteristics of the type and the rough grass surface, could have contributed to the accident.

ACCIDENT

Aircraft Type and Registration:	Grumman AA-5 Traveller, G-BBSA
No & Type of Engines:	1 Lycoming O-320-E2G piston engine
Year of Manufacture:	1974
Date & Time (UTC):	19 November 2005 at 1011 hrs
Location:	Durham Tees Valley Airport, Co Durham
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Nose landing gear strut bent, propeller tip damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	29 years
Commander's Flying Experience:	136 hours (of which 32 were on type) Last 90 days - 4 hours Last 28 days - 0 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

After lift-off, the aircraft appears to have developed a 'porpoising' motion and the nose landing gear and propeller struck the runway. No reason for the pitch oscillations has been found.

History of flight

The pilot and a passenger were intending to fly from Durham Tees Valley Airport to Chichester (Goodwood) Airfield. The pilot had done extensive flight planning at home prior to leaving for the airport but he checked the weather again upon arrival. The aircraft was refuelled and, after the normal pre-flight checks, the aircraft was taxied to line-up on Runway 23. The wind direction was 210° at 3 kt.

The pilot applied full power and the aircraft started to accelerate. With the sun low on the horizon and very bright, he had to move his head to the right to avoid being dazzled, although he could still see the runway centre line. He was expecting the take-off distance to be fairly long in the calm conditions but, when he glanced at the airspeed indicator, he saw that it was reading 80 mph. As he had intended to rotate the aircraft at 70 mph, he pulled back on the control column at this point and the aircraft lifted-off but then suddenly the nose pitched down and, despite full back movement of the yoke, he was unable to arrest the pitch rate and the nosewheel and propeller struck the runway. The pilot, aware that two other aircraft were intending to land, said he deliberately steered the aircraft to the left and onto the grass before it came to rest. After securing the aircraft, the pilot and passenger vacated the aircraft normally.

The reason for the uncommanded pitch-down is not clear, since no defects were found during the subsequent repair, which included a new propeller, nose landing gear strut and a shock-load check of the engine. Eyewitnesses in the control tower have stated that they observed a number of oscillations in pitch before the impact with the runway.

ACCIDENT

Aircraft Type and Registration:	Jodel D112, G-BMIP
No & Type of Engines:	1 Continental Motors Corp A65-8F piston engine
Year of Manufacture:	1964
Date & Time (UTC):	28 January 2006 at 1538 hrs
Location:	Inglesham, Gloucestershire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Canopy and canopy hoop damaged, propeller destroyed, engine shock loaded
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	49 years
Commander's Flying Experience:	528 hours (of which 28 were on type) Last 90 days - 3 hours Last 28 days - 0 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent telephone enquiries

Synopsis

While taxiing in gusty conditions the aircraft's tail lifted and the aircraft pitched onto its nose.

History of flight

The pilot had not obtained a weather forecast before the short flight from Inglesham to Oaksey Park and back, but had listened to the Fairford ATIS weather report by telephone and noted that the wind was from 060° at 9-11 kt . Whilst at Oaksey Park Airfield the pilot observed that the wind was strengthening and he departed immediately for Inglesham. The landing on Runway 06 at Inglesham was normal. The pilot began to turn the aircraft to backtrack after landing, using into wind aileron and 'appropriate' elevator. With the aircraft heading roughly across the wind the tail lifted and the pilot applied power and up elevator to prevent the aircraft pitching further. However, the tail continued to lift and the aircraft pitched onto its nose, destroying the propeller and shock loading the engine. The pilot turned off the fuel and engine switches, vacated the aircraft, and attempted to pull the tail down. He found that he was unable to pull the tail down before another gust of wind blew the aircraft onto its back, damaging the canopy and its supporting hoop. In a frank report, the pilot stated that he had not appreciated how vulnerable the Jodel can be to strong winds.

The Fairford forecast for the period beginning at midday on 28 January included information that the wind would temporarily gust up to 28 kt.

ACCIDENT

Aircraft Type and Registration:	Mooney M20J, N201YK
No & Type of Engines:	1 Lycoming IO360 A3B6D piston engine
Year of Manufacture:	1978
Date & Time (UTC):	13 August 2005 at 1517 hrs
Location:	Dirleton, East Lothian
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to engine
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	56 years
Commander's Flying Experience:	12,000 hours (of which 25 were on type) Last 90 days - 85 hours Last 28 days - 24 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot, and AAIB enquiries

Synopsis

During a local flight the engine began to run roughly and then emitted smoke. The pilot turned towards his departure airfield but before he reached it, the engine stopped overhead a large field, leading to a forced landing in that field with no damage to the airframe. The AAIB wanted to examine the engine but was unable to do so because it was sent to the USA. The cause of the engine failure has not been determined.

History of flight

The pilot, who was also the owner of the aircraft, reported that during a local flight from Archerfield, the engine began to run roughly. He turned the aircraft back towards Archerfield and while approaching the airfield he overflew a large adjacent field, which coincidentally was proposed as a future airstrip and which was therefore suitable for a forced landing. At about this time the engine failed completely, with smoke coming from the engine compartment and a smell of smoke in the cockpit. The pilot deployed the flaps and landing gear, and carried out a successful forced landing in the field, touching down more than halfway into it and stopping in about 170 m, close to the end. He had selected the magnetos and battery master switch to off shortly before touchdown.

Engine failure assesment

The initial assessment of the engine failure by the pilot was that it had experienced a loss of oil contents as a result of a hole in the crankcase. The oil level had been satisfactory during the pre-flight inspection carried out by the pilot. Other information received by the AAIB indicated that an internal failure had occurred causing the crankshaft to fail and a connecting rod to penetrate the crankcase.

The AAIB considered that an examination of the engine was required, and contacted the pilot with a view to arranging for it, together with the engine log book, to be sent to the AAIB facility at Farnborough, where a metallurgical examination would be arranged. Unfortunately, due to a misunderstanding, the engine was subsequently shipped to a supplier in the USA. The owner has requested that a copy of the supplier's report be forwarded to the AAIB. To date, the AAIB has been unable to trace or contact the named US supplier. Should their report be forthcoming, it is unlikely to contain the required information in the necessary depth to allow a considered judgement to be made as to whether further safety issues concerning this engine type exist.

Additional information received by the AAIB indicated that the aircraft had been laid up for about three years. It had subsequently received an annual inspection and been flown for a small number of hours between that time and the accident. There was no record, in the engine log books, of any of the necessary preventive maintenance, such as inhibiting or periodic ground running, having been done during the period the aircraft was laid up and this could lead to possible reasons for the engine failure.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28-140 (Modified) Cherokee, G-EEKY
No & Type of Engines:	1 Lycoming O-320-D3G piston engine
Year of Manufacture:	1969
Date & Time (UTC):	5 November 2005 at 1144 hrs
Location:	Heathlands Farm, Kings Lynn, Norfolk
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Nosewheel, propeller and right wing tip damaged, engine shock loaded
Commander's Licence:	Private Pilot's Licence
Commander's Age:	29 years
Commander's Flying Experience:	90 hours (of which 4 were on type) Last 90 days - 4 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

Synopsis

After a short descent from 2,000 ft altitude with the carburettor heat control set to HOT, the pilot was unable to advance the throttle sufficiently to sustain level flight and a forced landing into a field ensued. A subtly different throttle restriction was present two hours after the forced landing but the repair agency was unable to reproduce a throttle restriction a few hours later. A subtle and temporary mechanical restriction or an unusual form of carburettor icing seem the most likely explanations.

History of flight

The pilot was undertaking a local area flight from RAF Marham, Norfolk at 2,000 ft agl. Before descending to 1,200 ft agl to join the circuit, she set the carburettor heat to HOT and retarded the throttle to 1,500 rpm. Upon levelling the aircraft she set the carburettor heat to COLD and attempted to open the throttle but its range of travel was restricted to between closed and half open which limited the engine speed to 1,500 rpm. At this power setting the aircraft was unable to maintain level flight. She attempted to clear the restriction by selecting the fuel pump ON, changing the fuel tank selector and reselecting the carburettor heat selector to HOT, but all without success.

The pilot then flew a forced landing into a field 5 nm north-west of RAF Marham while her passenger assisted her by transmitting a MAYDAY message.

Upon touchdown, after a ground run of approximately 30 m, the nose wheel dug in to the soil and the propeller struck the ground, stopping the engine instantly. Having secured the aircraft both occupants vacated it uninjured.

The pilot and her passenger, who had extensive military aircrew experience, added that initially they thought the restriction might have been caused by carburettor icing. However, they later discounted this theory because the engine was running smoothly throughout the descent and forced landing.

Aircraft damage

The Chief Flying Instructor (CFI) from the flying club at RAF Marham attended the landing site approximately two hours after the accident. Upon inspecting the aircraft, he too found a restriction with the throttle. He found he could move the throttle lever only from half travel to fully open; he found a restriction when he tried to retard the throttle from half travel to closed.

The aircraft and its engine were inspected by the repair agency. The agency found damage to the underside of the engine cowl, the nose wheel, the right wing tip and the propeller. Although the carburettor was found pushed up against the fire wall as a result of the landing, the agency found no restriction with the throttle linkage from the throttle quadrant to the carburettor. Subsequently the engine and carburettor were sent to another repair facility for shock-load testing. Upon testing the throttle linkage and the carburettor, nothing was found that might have caused a restriction.

Weather

An automatic METAR recorded at RAF Marham at 1150 hrs was provided by the Met Office. It showed a surface wind of 220º/11 kt, visibility in excess of 10 km, with an air temperature of +11ºC and a dew point of +6ºC. The pilot reported the surface wind was 230º/15 kt, a temperature of +11ºC and a dew point of +8ºC.

Carburettor icing

The aftercast temperature and dew point, for the time of the accident, were plotted on the Carburettor Icing Chart in Safety Sense Leaflet 14 found in LASORS and AIC 145/1997. The combination falls in the '*Serious Icing - Cruise Power'* sector.

Despite the use of carburettor heat in the descent, icing could have formed downstream of the accelerator pump in the vicinity of the discharge valve and discharge nozzle inside the carburettor. In this situation the throttle could behave as if it had some form of restriction without necessarily inducing rough running.

Analysis

The throttle restriction discovered by the Chief Flying Instructor was different to that reported by the pilot but it could have been caused by damage sustained during the forced landing. However, no mechanical interference with the linkage was identified by the repair agency. Nevertheless, irrespective of how carefully the agency examined the aircraft in-situ, it is possible that some unintended easement of the damaged engine bay components alleviated a subtle mechanical restriction.

One explanation for the throttle restriction in the air was an unusual form of carburettor icing. Given the ambient meteorological conditions and the flight profile preceding the discovery of the throttle restriction, carburettor icing in the vicinity of the discharge valve and discharge nozzle might have caused a mechanical restriction. However, it seems very likely that ice formed in this way would have dissipated after two hours in the 11°C ambient air temperature. Ice formation could explain why the pilot was unable to open the throttle but the CFI was able to open it fully two hours later. However, ice in the air does not explain why the CFI was unable to close the throttle on the ground after the ice would have melted.

Conclusion

The accident was attributable to a throttle restriction but the origin of the restriction could not be identified. Either a subtle and temporary mechanical restriction or an unusual form of carburettor icing seem the most likely explanations.

ACCIDENT

Aircraft Type and Registration:	Piper PA-34-200T Seneca, G-BNEN
No & Type of Engines:	2 Continental TSIO-360-EB piston engines
Year of Manufacture:	1980
Date & Time (UTC):	21 April 2005 at 1205 hrs
Location:	Oxford Kidlington Airport, Oxfordshire
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nose wheel, propellers and engines
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	71 years
Commander's Flying Experience:	16,000 hours (of which 1,979 were on type) Last 90 days - 83 hours Last 28 days - 26 hours
Information Source:	AAIB Field Investigation

Synopsis

As a result of the progression of damage from a previous nose landing gear collapse, which remained undetected during subsequent repair, the aircraft suffered another nose landing gear collapse during pre-takeoff power checks.

History of flight

The aircraft was to have operated a training flight from Kidlington Airfield. After taxiing to the runway and receiving clearance to take off, the aircraft entered the runway, lined up and stopped. The throttles were advanced to achieve 2,000 rpm on each engine, whereupon the nose landing gear collapsed, resulting in significant damage to both propellers and the shock loading of both engines. The occupants were uninjured and vacated the aircraft through the forward and rear doors.

Damage to aircraft

This aircraft had previously been involved in a nose landing gear collapse incident on 22 February 2003, the report on this event being published in AAIB Bulletin 11/2005. A review of the aircraft's documentation showed that the aircraft had been repaired in accordance with the relevant manufacturer's requirements and recommendations valid at that time. During an assessment of the aircraft, prior to repair, no damage to any of the landing gear mounts or associated bulkhead was identified. The aircraft was released under 'fitness for flight' documentation by the repair facility prior to an annual inspection being carried out by its normal maintenance organisation.

As a result of the collapse on 21 April 2005, the lower section of the nose landing gear had moved aft, causing damage to the bulkhead and the lower nose landing gear mount located behind the bulkhead. Consequently, in order to gain access to the lower mount, significant disassembly of the lower forward fuselage was required.

The nose landing gear upper and lower drag links together with the landing gear support frame, Figure 1, showed no signs of deformation or damage although the downlock link showed some deformation of its cross-pin slot. The lower landing gear mount is secured by three rivets at its lower face to the inside of the fuselage skin and, on its upper face, by four rivets to the lower crossplate located between the left and right keel beams, Figure 2. All the rivet heads on the lower mount were found sheared off. The condition of the shank sections of the lower rivets associated with this mount indicated that these had failed during the landing gear collapse but discolouration of the remains of rivet shanks of the upper four rivets indicated that they had failed at some point prior to the collapse.

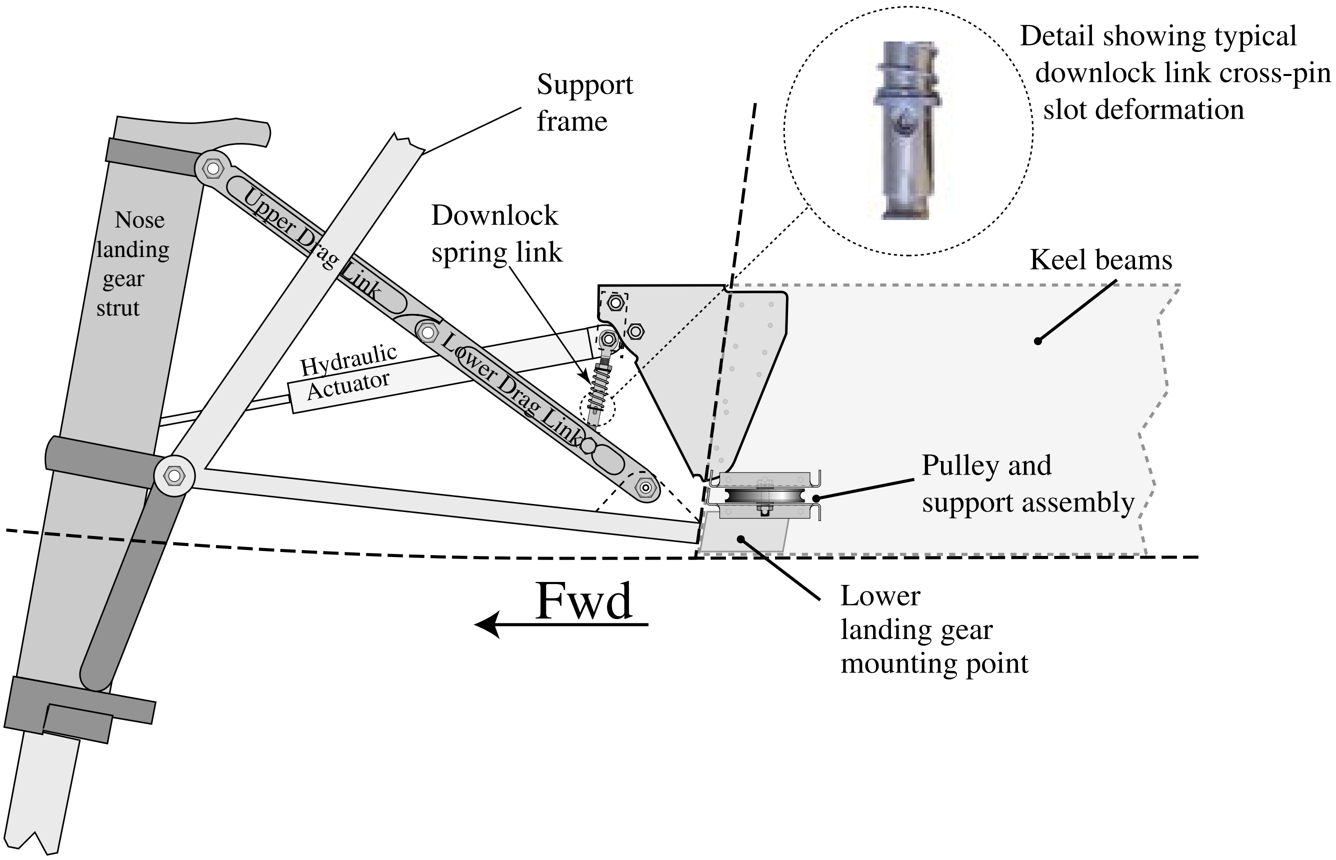


Figure 1

Side view showing general arrangement of the nose landing gear and its support structure in the forward fuselage

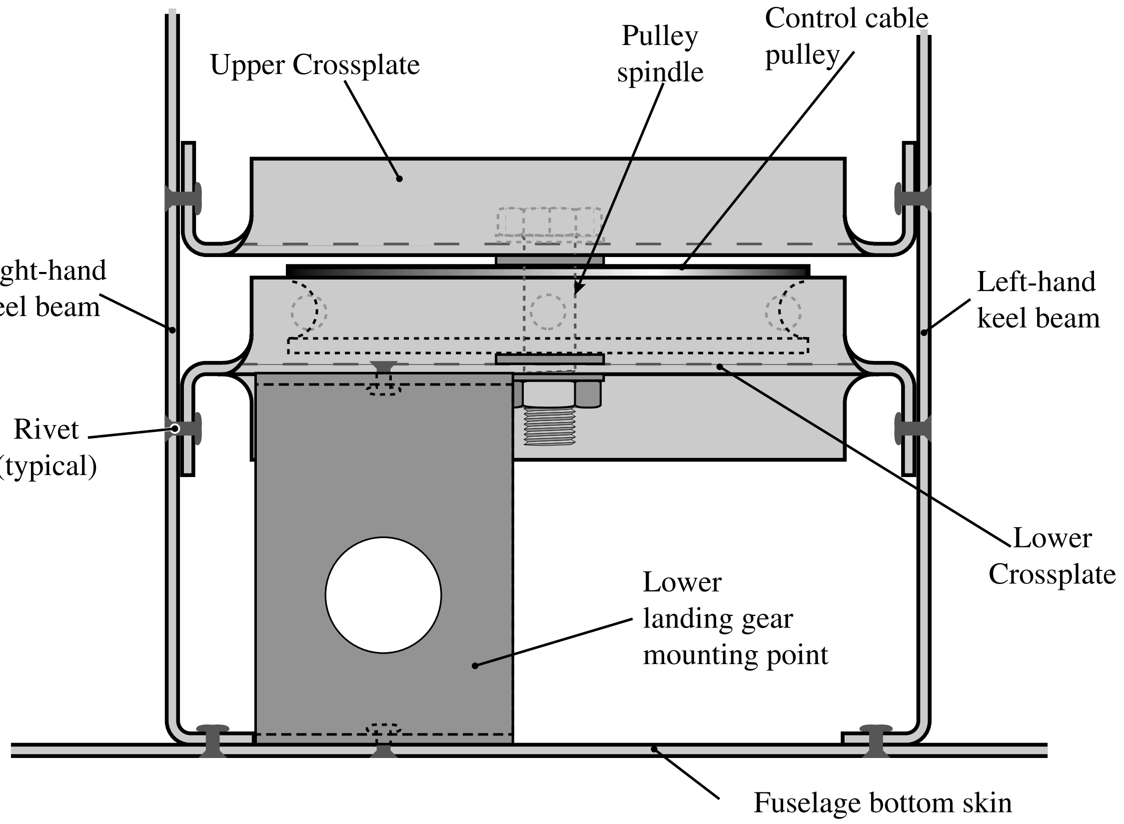


Figure 2

View of keel assembly - looking aft from fuselage front bulkhead

Examination of the upper crossplate revealed the presence of a crack extending through all four rivet holes, with the forward-most rivet holes showing signs of deformation. Also, the right side keel beam had cracked between the web and the lower flange, the crack extending aft from its forward edge over a distance of 18 cm (see Figure 3).

In its normal position, the casting that forms the lower landing gear mount is located immediately behind the bulkhead, sandwiched between the left and right keel beams. The mount is secured to the inside surface of the lower fuselage skin and, on its upper surface, to the lower crossplate positioned between the left and right keel beams. A control cable pulley is mounted on the top of this crossplate which, together with an upper crossplate, support the pulley spindle, (see Figure 4). A 12 cm diameter access panel, located immediately aft of the pulley and mount assembly, provides access to this area. In order to determine if it would be possible to carry out a visual inspection of the lower mount and its fasteners in an assembled condition, tests were carried out on another aircraft using both standard and specialist inspection equipment. The results of these tests showed that, whilst the conditions of the mount's lower fasteners could be assessed, the upper fasteners could not be readily viewed through the access panel and, therefore, an assessment of their condition could not be made.

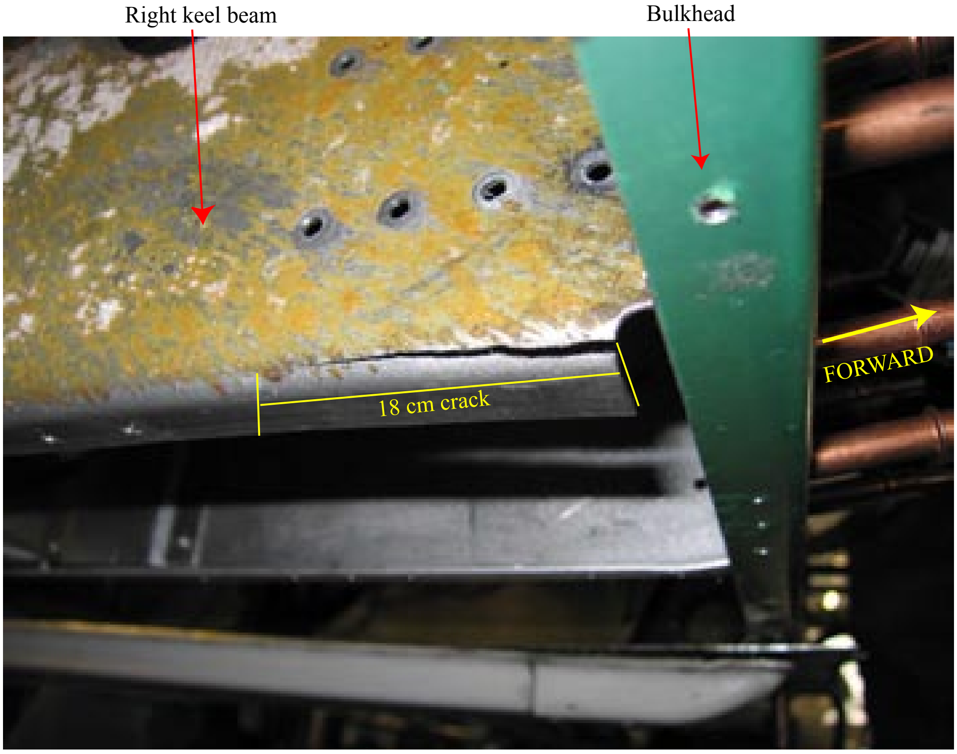


Figure 3

Right keel beam crack

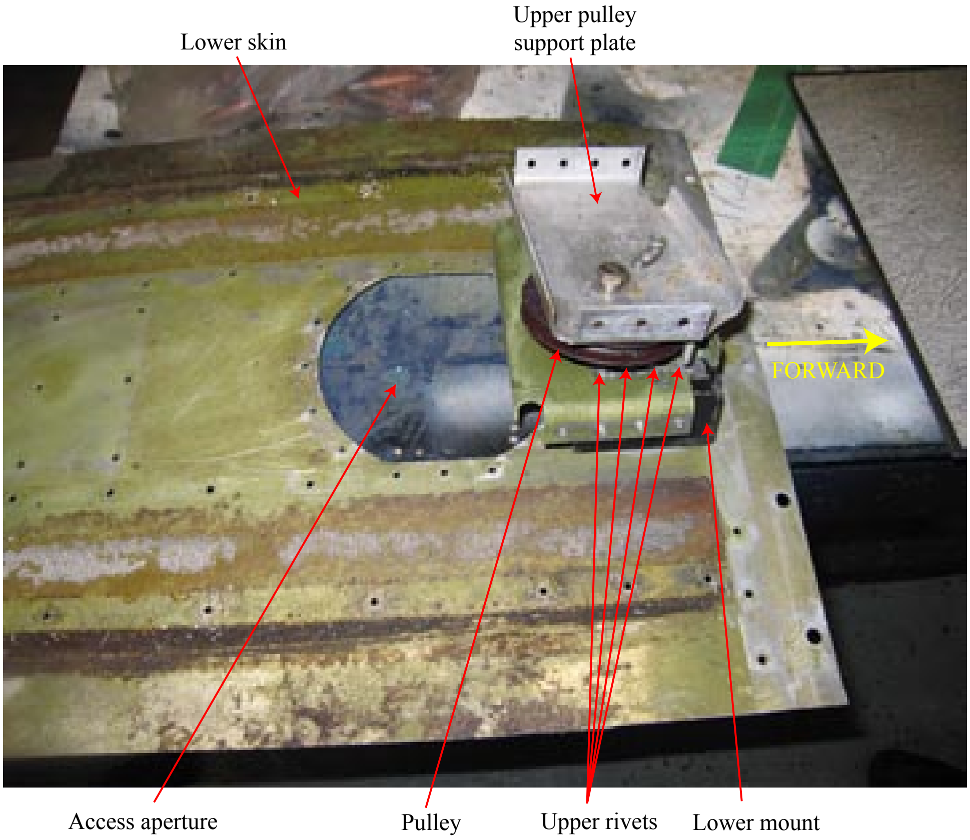


Figure 4

Lower mount with control pulley and support plates in position

Analysis

The cracking of the plate and the discolouration of the sheared rivet shanks at the upper surface of the landing gear lower mount, indicated that the damage to the mount and its supporting structure probably occurred as a result of the aircraft's previous landing gear collapse. Once the aircraft had been returned to service it is likely that the damage progressively increased, resulting in the overloading of further rivets and crack propagation in the upper crossplate and right keel beam lower edge.

The progressive increase in damage to the surrounding structure would have allowed an increase in the flexibility of the lower landing gear mount, which can affect the nose landing gear's downlock mechanism. As described in AAIB Bulletin 11/2005, small decreases in the rigidity of the landing gear downlock mechanism can lead to the drag link moving from the over centre position, resulting in the collapse of the noseleg.

A review of the Maintenance Manuals for the Piper Seneca showed that they contained no data which either highlighted the possibility of damage to structure behind the bulkhead, or which called for an inspection of this area, following a nose gear collapse.

Conclusions

Based on the condition of the nose landing gear lower landing gear mount fasteners and the downlock mechanism, it is likely that the collapse of the nose landing gear resulted from the progression of undetected and undetectable damage to the fasteners securing the landing gear lower mount. This was precipitated by the aircraft's previous nose landing gear collapse on 22 February 2003. The condition of the aircraft's internal structure after the previous gear collapse, visible through the one access panel in this area, gave no indication that any damage had been caused to the lower landing gear fasteners. In the absence of any specific requirements to dismantle the aircraft's structure in this area, and in consideration of the volume of work that would be required to dismantle the aircraft sufficiently to carry out an inspection of the lower mount, following a nose gear collapse, there was no reason or incentive for a comprehensive inspection to have been carried out.

Therefore, it seems likely that the previous damage remained undetected, and that it had progressed to the point where sufficient play in the downlock mechanism allowed the drag link to move away from the over centre position, which then allowed the nose gear to collapse.

Safety action

In response to the findings of this investigation, New Piper Aircraft Incorporated have confirmed that they will publish amendments to all of the PA-34 Seneca series Aircraft Maintenance Manuals which will introduce in-situ inspection procedures to look for damage to the lower nose landing gear mount, surrounding structure and fasteners, following a nose gear collapse. In view of this response, it is not considered necessary to make any formal safety recommendations.

ACCIDENT

Aircraft Type and Registration:	Taylorcraft F-21, G-BPJV
No & Type of Engines:	1 Lycoming O-235-L2C piston engine
Year of Manufacture:	1980
Date & Time (UTC):	28 November 2005 at 1510 hrs
Location:	Corndean Wood, Cleeve Hill, Gloucestershire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	52 years
Commander's Flying Experience:	340 hours (of which 220 were on type) Last 90 days - 7 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft was returning to Enstone Airfield from Shobdon when the weather rapidly deteriorated and the aircraft entered a snow storm. In extremely difficult conditions, with severely reduced visibility, the pilot attempted to maintain a wings-level attitude on instruments. The aircraft gradually lost height and it crashed into Corndean Wood, at an elevation of 1,000 ft, 5 km to the north east of Cheltenham, and suffered significant damage. The pilot, who was injured, was able to escape from the aircraft and summon the emergency services using her mobile telephone.

History of flight

The pilot had planned to carry out a return flight from Shobdon Airfield, near Leominster, to Enstone, near Oxford. The forecast weather for the planned route indicated that, although there was the possibility of rain showers during the afternoon, the weather was suitable for the flight. The aircraft arrived at Shobdon at approximately 1230 hrs where the pilot took a friend for a 10 minute flight in the local area. After spending some time on the ground, and confirming that the weather appeared suitable for the return flight, the pilot took off from Shobdon at approximately 1400 hrs.

As the aircraft approached Worcester, at an altitude of 2,400 ft, the pilot noticed clouds building up along her intended flight path. She turned the aircraft to the south, which appeared free from cloud, to avoid this weather but was rapidly enveloped in a heavy snow storm. With severely reduced visibility and having lost sight of the ground, the pilot attempted to maintain a wings-level attitude on instruments and fly clear of the storm. Whilst focussing on flying the aircraft in these extremely difficult conditions, the pilot became too occupied to issue a distress call. The aircraft gradually lost height and, at approximately 1500 hrs, it struck trees at an elevation of 1,000 ft on the southerly edge of Corndean Wood, some 5 km to the north east of Cheltenham. The left wing was torn from the aircraft before it fell through the trees, coming to rest with the fuselage upright. Despite her injuries, the pilot managed to escape from the aircraft unaided and summoned the emergency services on her mobile telephone.

Meteorological information

On 28 November an area of low pressure covering the North Sea and Scandinavia was producing a cold northerly flow of air across the UK, resulting in a line of heavy cloud and precipitation southwards.

The Meterological Office forecasts for airfields close the pilot's intended route showed that, from approximately 1300 hrs, there would be a possibility of encountering rain showers and a decreasing cloud base. This forecast was revised at midday to show that, after 1500 hrs, there was the possibility of encountering both rain and snow showers. A further update was issued at 1343 hrs notifying pilots of the possibility of a further deterioration in the conditions. Given the time of the aircraft's departure from Shobdon, it is unlikely that the updated forecast released at 1343 hrs would have been available to the pilot whilst she was preparing for the return flight to Enstone.

The reported weather conditions at Gloucester airport showed that, between 1420 hrs and 1520 hrs, the weather had deteriorated from 'broken' cloud at 4,500 ft, with greater than 10 km visibility, to overcast at 1,200 ft, with rain and snow showers and a ground level visibility of 2.5 km.

ACCIDENT

Aircraft Type and Registration:	Eurocopter AS350B2 Squirrel, G-BXGA
No & Type of Engines:	1 Turbomeca Arriel 1D1 turboshaft engine
Year of Manufacture:	1991
Date & Time (UTC):	20 January 2006 at 1530 hrs
Location:	Corrie of Clova, 16 nm north-west of Forfar, Scotland
Type of Flight:	Aerial work (load lifting)
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to all three main rotor blades
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	38 years
Commander's Flying Experience:	4,100 hours (of which 511 were on type) Last 90 days - 7 hours Last 28 days - 6 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by AAIB

Synopsis

Following a load lifting task the helicopter was hovering beside a steep hillside slope when the main rotor blades struck a nearby boulder.

History of the flight

The aircraft had been employed on an underslung load lifting task, transferring bags of stones from a scree slope to a footpath a kilometre away. On completion, the pilot manoeuvred the helicopter to land and pick up the two ground personnel who had been attaching the loads to the helicopter's external hook. The first landing site he considered was deemed unsuitable because of its rocky surface, so the pilot manoeuvred the helicopter to hover over another possible site, which was at an elevation of 1,900 ft amsl and of limited size. This had a more acceptable surface but was adjacent to a steep slope that included a boulder in the pilot's two o'clock position.

The pilot stated that the surface wind was from 250º at 20 to 30 kt which, with the helicopter on a heading of about 350º, generated a turbulent crosswind from the left. While assessing this landing site from the hover, the pilot felt a vibration through the cyclic control. He realised that the main rotor blades had struck the boulder and immediately manoeuvred the helicopter up and away from the hover. He considered that the controls felt normal so he selected a third site where he landed successfully. The ground personnel were then embarked, while the helicopter's rotors remained running, and G-BXGA was flown one nautical mile to the refuelling landing site without further incident.

Noticeable vibration was felt as the helicopter was shut down and an initial inspection revealed damage to the tips of each of the three main rotor blades. Subsequent engineering examination found no other damage.

The pilot attributed the accident to the drift of the helicopter while attempting to land on a small landing site in a turbulent crosswind.

The aircraft flight manual states that:

> *hovering with wind from any direction has been substantiated over the entire flight envelope up to winds of 17 kt, although this is not to be taken as a limit. For example hover at sea level at maximum weight, for all CG locations, has been substantiated at 30 kt.*

The operator has since issued a memorandum to all pilots reminding them that they should land immediately and shut down if they suffer a blade strike. The commander of the helicopter was one week into a contract with the operator, but no longer works for them.

ACCIDENT

Aircraft Type and Registration:	Robinson R22 Beta, G-CBPT
No & Type of Engines:	1 Lycoming O-360-J2A piston engine
Year of Manufacture:	2002
Date & Time (UTC):	26 August 2005 at 1537 hrs
Location:	Near the Prince Consort Buoy, ½ nm off Cowes, Isle of Wight
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Helicopter sank intact
Commander's Licence:	Private Pilot's Licence
Commander's Age:	44 years
Commander's Flying Experience:	416 hours (of which 84 were on type) Last 90 days - 4 hours Last 28 days - 1 hour
Information Source:	AAIB Field Investigation

Synopsis

Whilst flying north of Cowes on a private sightseeing flight, the pilot heard a loud bang and found that the helicopter was no longer flying normally. He immediately entered an autorotation and was able to make a controlled touchdown beside the Price Consort Buoy, at the entrance to Cowes harbour. He and his passenger were rescued almost immediately. The helicopter sank quickly and was not recovered. The symptoms reported by the pilot were consistent with the failure of one of the two drive belts transmitting power from the engine to the main transmission. One safety recommendation has been made regarding advice to pilots in the event of ditching.

History of the flight

The pilot intended to conduct a sightseeing flight, with a friend, in a helicopter hired from a flying training organisation at Blackbushe. Earlier in the day he had flown with an instructor in order to satisfy the currency requirements of the training organisation. During this flight the pilot practiced several manoeuvres including simulated engine failures. He then refuelled the helicopter and departed at 1110 hrs for a flight of approximately 30 minutes duration to a private landing site near Lee-on-Solent, Hampshire, where he had arranged to meet his passenger. He subsequently departed at 1525 hrs and planned to fly along the nearby coast; however, on approaching Lee-on-Solent he found that there was gliding activity at that airfield and he therefore decided to fly south towards the Isle of Wight.

Approaching Cowes from the north, the pilot turned to the right in order to return to the private landing site. The pilot reported that after completing the turn there was a loud bang which appeared to come from above and behind his head; the helicopter lurched and the controls became slack. It was apparent that power to the rotors had been lost and the helicopter was no longer flying normally. Although he did not recall the manoeuvre clearly, the pilot believed that the helicopter had turned left from a northerly onto a westerly heading. He immediately lowered the collective and entered an autorotation, noting that the airspeed indicator was reading zero. As ditching was inevitable, the pilot told his passenger to loosen his seatbelt and open his door while making the same preparations himself. His priority was to land the helicopter as close as possible to one of a number of boats present in the area to increase the chance of a rapid rescue. He was able to make a controlled touch down beside the Prince Consort Buoy, at the entrance to Cowes Harbour. The helicopter started to fill with water immediately and sank quickly below the surface; however, both occupants were able to vacate the helicopter unaided and without injury. They were rescued almost immediately.

Additional information

Clutch system observations

The pilot recalled that on start up at Blackbushe, he had observed that the main rotor took longer than usual to start turning. During the flight to the private landing site, the clutch caution light illuminated several times but for less than six seconds on each occasion. On shutdown at the private landing site, the clutch light took longer than usual to extinguish.

The pilot also reported that, during the accident flight, as the aircraft headed across the Solent, he thought he heard what he described as "whining" sounds. At the time he judged that he may have been imagining this since he had some trepidation about flying over water in a single-engine aircraft.

Fuel

Records provided by the fuel supplier at Blackbushe Airport indicated that the helicopter uplifted 40 litres of AVGAS at 0857 hrs and a further 55 litres at 1103 hrs. Entries in the aircraft's technical log indicating fuel onboard and fuel uplifted correspond to these amounts, and indicate that on the flight prior to the accident flight the helicopter departed from Blackbushe with approximately 20 US gallons (USG) of fuel. The pilot stated that, having refuelled the helicopter at Blackbushe, he also inspected the fuel tank contents visually on arrival at the private landing strip, and estimated that there were 14 USG remaining. The pilot estimated that the helicopter had been in flight for no more than 20 minutes before the accident, which suggests that, at an average cruise consumption rate of 10 USG/hr or less, there would have been at least 10 USG of fuel remaining.

Meteorological information

The pilot reported a south-westerly surface wind of 15 to 20 kt with broken cloud at 3,000 ft and visibility in excess of 5,000 m. Historical information provided by the Met Office confirmed the pilot's assessment and indicated that the outside air temperature and dew point were approximately +18°C and +11°C respectively. Consequently, there would have been a possibility of moderate carburettor icing at cruise power.

Wreckage location

A survey of the seabed, using side-scan sonar, commenced on the fourth day after the accident in order to assess the possibility of recovering the helicopter or its wreckage. Nothing was identified that was considered likely to be part of G-CBPT. The average tidal movement in a twelve hour period was assessed as approximately 1 kt to the west, indicating that any wreckage which had not become anchored or obstructed would have travelled 6 nm or more downstream of the point of impact since the time of the accident. Had parts of G-CBPT been located after such movement, it was considered likely that they would have been so disrupted as to provide no assistance with the investigation, and the survey was terminated. No wreckage was recovered.

Survival aspects

Safety Sense leaflet 21B – *General Aviation Ditching*, is published by the Civil Aviation Authority. It states:

> *It is vital TO WEAR a suitable lifejacket whilst flying in a single engined aircraft over water beyond gliding range from land.*

Neither the pilot nor the passenger wore a life jacket, and none were carried in the helicopter. In this instance, both occupants were fortunate to have been rescued almost immediately by one of a large number of boats that were present.

The leaflet contains further information about what to expect in the event of ditching. Although there is no specific reference to the use of seatbelts, the text makes clear that the forces of impact can be severe and it follows that adequate restraint is vital to reduce the likelihood of injuries. The aircraft was equipped with lap and inertia reel shoulder harnesses which were designed to lock in the event of an accident. The pilot of G-CBPT was able to touch down in full control of the helicopter and loosening of the seat belts did not result in injury in this case. However, it is usual in the event of an emergency for seatbelts to remain securely fastened until the aircraft has come to rest.

The pilot's decision to unlatch the doors prior to touchdown was prudent. In the event of a violent touchdown, distortion of the structure may have made it difficult or impossible to open cabin doors. Prior opening of the doors enabled the cabin to flood immediately, thus equalising pressure either side of the doors and allowing them to be opened very shortly after touch down. Appropriate advice is included in the Emergency Procedures section of the Pilot's Operating Handbook (POH) under the heading "*DITCHING – POWER ON"* but not under the heading *"DITCHING – POWER OFF"*. It is therefore recommended that:

Safety Recommendation 2006-04

The Federal Aviation Administration should ensure that Robinson Helicopter Corporation includes, in each of the ditching procedures published in the Emergency Procedures section of the R22 Pilot's Operating Handbook, an instruction to unlatch the doors prior to touchdown.

Technical Investigation

No wreckage from the helicopter was recovered; however, some (if not all) of the symptoms reported by the pilot would be consistent with failure of one of the two drive belts transmitting power from the engine to the main transmission. A comprehensive discussion of the known problems which can afflict these belts, particularly those which have been fitted relatively recently, is contained in the account of an accident to a similar helicopter, G-LEDA, in AAIB Bulletin 1/2004. This report noted the vulnerability of low-time belts to failure due to stretching after installation, which can allow the belts to partially ride-up out of the pulley grooves during clutch engagement and incur damage eventually leading to failure.

Of particular note is the pilot's statement that it took longer than normal for the rotors to start turning after the clutch was engaged prior to takeoff. The POH states, in the Normal Procedures section covering Engine Starting and Run-up:

Clutch switch…………Engaged
Blades turning………..Less than 5 seconds

The reason for the 5 second limitation is to check whether the drive belts have stretched. Although the clutch actuator should always maintain the correct belt tension when engaged, an abnormally long time interval between selection and rotor movement indicates that the actuator is having to travel further before the correct tension value is reached (or that the action of the actuator is slow for some reason). It is during this period that damage can be caused.

The G-LEDA report mentions the particular vulnerability of drive belts with less than 50 hours running time since new and that most failures were occurring within 20 hours. G-CBPT had had a matched pair of new belts fitted some 20 hours prior to this accident, although a check of the clutch rigging and adjustment of belt alignment had been carried out 6 hours prior to the flight.

ACCIDENT

Aircraft Type and Registration:	Robinson R44 Raven, G-ODHG
No & Type of Engines:	1 Lycoming O-540-F1B5 piston engine
Year of Manufacture:	2001
Date & Time (UTC):	1 December 2005 at 0915 hrs
Location:	Sywell Airfield, Northants
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	59 years
Commander's Flying Experience:	104 hours (of which 11 were on type) Last 90 days - 21 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

Whilst lifting into the hover the helicopter yawed and rolled to the left, pivoting around the rear of the left skid landing gear. The main rotor blades struck the ground and the helicopter rolled onto its right side.

History of the flight

On the day before the accident the pilot had flown from Ireland to Cannock in a Robinson R22. He had been forced to abandon his flight to the intended destination of Sywell due to bad weather. On the day of the accident, the pilot and an instructor planned to fly G-ODHG to Cannock to recover the R22 back to Sywell.

The pilot intended to hover taxi G-ODHG to the eastern side of the airfield in order to collect the instructor before departing for Cannock. The surface wind was from 200° at 10 kt, and the visibility was 8 km with a cloudbase between 800 and 1,000 ft. The helicopter was refuelled to full in both the main and auxiliary tanks. It was parked on the main parking area on the western side of the airfield adjacent to another R44, which was behind and to the left, and an R22, which was to the right. The pilot completed his pre-flight inspection, started the helicopter and, having carried out the pre-takeoff checks, raised the collective lever. The helicopter yawed to the left and the nose pitched up. The pilot lowered the collective lever whilst correcting the left yaw with right tail rotor control pedal and the helicopter settled on the ground. Following the yaw to the left, G-ODHG was then facing the R44 which had previously been behind and to the left.

The pilot again raised the collective lever to lift the helicopter into the hover and moved the cyclic control aft in order to prevent movement towards the parked R44. The helicopter again yawed to the left and the nose pitched up. He continued to raise the collective lever and attempted to correct the yaw and nose-up pitch but the helicopter pivoted around the rear of the left skid landing gear. It rolled to the left and the main rotor blades struck the ground; the helicopter came to rest on its right side. The pilot was uninjured and was able to release himself; he vacated the helicopter through the front left door. The AFRS attended the scene immediately.

Pilot experience

The pilot had learned to fly on the R22 and had flown 92.4 hours on the type, of which 16.4 hours were as PIC. He converted to the R44 and had flown 11.6 hours on the type, of which 3.2 hours were as PIC. All his flying, on both the R22 and R44, was from the PIC seat, which is the front right seat.

Having converted to the R44 the pilot had not flown the type solo, with a full fuel load, prior to the accident flight.

Weight and CG

The weight and CG calculation for the accident flight is set out below with the CG envelope included at Figure 1.

The CG range at 1,909 lb is from 92 inches to 102.5 inches aft of the datum, which is 100 inches forward of the main rotor shaft centreline.

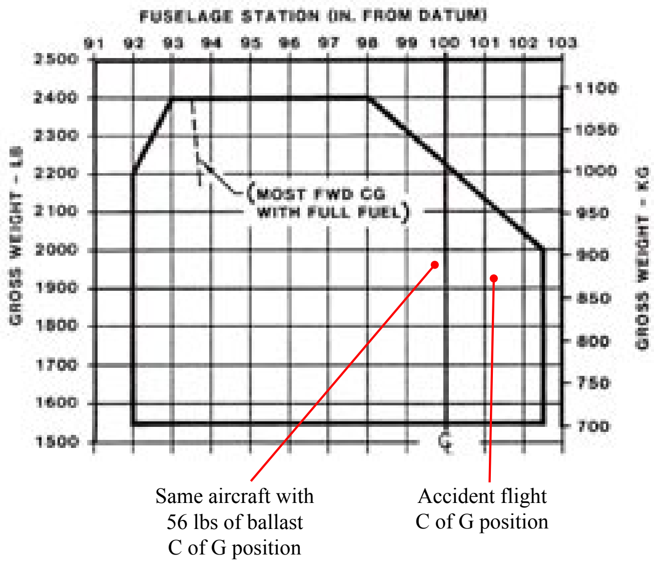


Figure 1

Analysis

The accident flight was the first occasion on which the pilot had flown the R44 solo with a full fuel load. As a consequence, the CG was close to the aft limit but within the CG limits for the All Up Weight (AUW).

Given the close proximity to the other parked helicopters the pilot wanted to ensure that when he lifted into the hover his helicopter did not drift towards them. It is

		Arm (inch)	Weight (lbs)	Moment (in/lb)
Basic Weight		—	1460	154890
Pilot		49.5	155	7672.5
Fuel	**Aux**	102	110	11220
	Main	106	184	19504
TOTAL		—	1909	193286.5

CG Inches from the datum = 193286.5 ÷ 1909 = 101.25

possible that he put in too much left tail rotor control pedal on the first attempted lift into the hover. This created the marked yaw to the left prior to lowering the collective lever.

The second lift into the hover was made facing the parked R44 and the combination of aft CG, left pedal and increased aft cyclic caused the helicopter to yaw to the left and adopt a high nose-up attitude. The pilot had not experienced such extreme attitudes and motion before and despite his attempts to control the helicopter he was unable to prevent the main rotor blades striking the ground.

Conclusions

The pilot considered that the aft CG was a major factor in the accident. To address the problem he now places 56 lb of ballast in the left front seat when flying solo with full fuel. This moves the CG forward to 99.7 inches which reduces the need to counter nose-up pitch when lifting into the hover. Additionally when flying the R22 solo with full fuel, less forward cyclic is required than in the R44.

ACCIDENTS

Aircraft Type and Registration:	Medway Eclipser Microlight, EI-CTC
No & Type of Engines:	1 Rotax 912 ULS piston engine
Year of Manufacture:	1999
Date & Time (UTC):	26 December 2005
Location:	Aghavilly Road, Armargh, Northern Ireland
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Minor) Passengers - 1 (Minor)
Nature of Damage:	Extensive
Commander's Licence:	Private Pilot's Licence
Commander's Age:	39 years
Commander's Flying Experience:	294 hours (of which 137 were on type) Last 90 days - 5 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft struck telephone wires on approach whilst making a precautionary landing in a field.

History of the flight

The pilot and passenger were conducting a private flight from Clonbullogue, in the Republic of Ireland, to a private strip at Coalisland in Northern Ireland. About 15 nm south of his destination, the pilot observed a lowering cloud base and fog ahead on track. He decided to make a precautionary landing and, after choosing what appeared to be a suitable field, commenced his approach to land. In the latter part of the approach, the pilot became aware of telephone wires running along the edge the field, but was unable to avoid them. The aircraft struck the wires and was pitched nose down into the field. Although the aircraft was extensively damaged, the pilot and passenger escaped with minor injuries.

The local weather conditions according to the pilot's report were: wind from the north-east at 10 kt, temperature +2ºC and visibility of 5 km, with low cloud and localised fog.

The pilot believed that the accident had been caused by him not seeing the wires soon enough on the approach to take avoiding action and that the cold weather might have slowed his reactions.

ACCIDENT

Aircraft Type and Registration:	Rans S6-ES Coyote II, G-CCNB
No & Type of Engines:	1 Rotax 582-48 piston engine
Year of Manufacture:	2004
Date & Time (UTC):	28 March 2005 at 1530 hrs
Location:	Weston Park near Shifnal, Shropshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Minor) Passengers - 1 (Minor) Public - 1 (Serious)
Nature of Damage:	Substantial aircraft damage plus minor damage to two vehicles
Commander's Licence:	Private Pilot's Licence
Commander's Age:	44 years
Commander's Flying Experience:	109 hours (of which 9 were on type) Last 90 days - 3 hours Last 28 days - 2 hours
Information Source:	AAIB Field Investigation

Synopsis

During a go-around, the aircraft stalled and crashed into two parked motor caravans, seriously injuring the owner of one of them. Investigations revealed that the pilot, who had qualified and trained on flex-wing aircraft, had not received adequate training to fly a three-axis aircraft, and was not in current flying practice. The approach had been flown towards rising ground and an illusory visual horizon was a contributory factor. The aircraft was overweight at the time of the accident and its elevators were incorrectly rigged. Pilot training requirements did not differentiate between control system types and so safety recommendations were made to address this aspect.

History of flight

A 'Festival of Transport', attended by several thousand people, was taking place in the grounds of Weston Park, a country house. The Festival activity included Microlight flying and static displays of aircraft. A landing area, some 680 m by 100 m was in use (see Figure 1).

The pilot flew a flapless approach with the intention of landing in a north-easterly direction. He reported that the approach was normal, but that he saw a flex-wing microlight manoeuvring on the western side of the landing area, and was concerned that it might infringe the landing area. As the approach continued, he saw a three-axis microlight aircraft taxi onto the opposite end

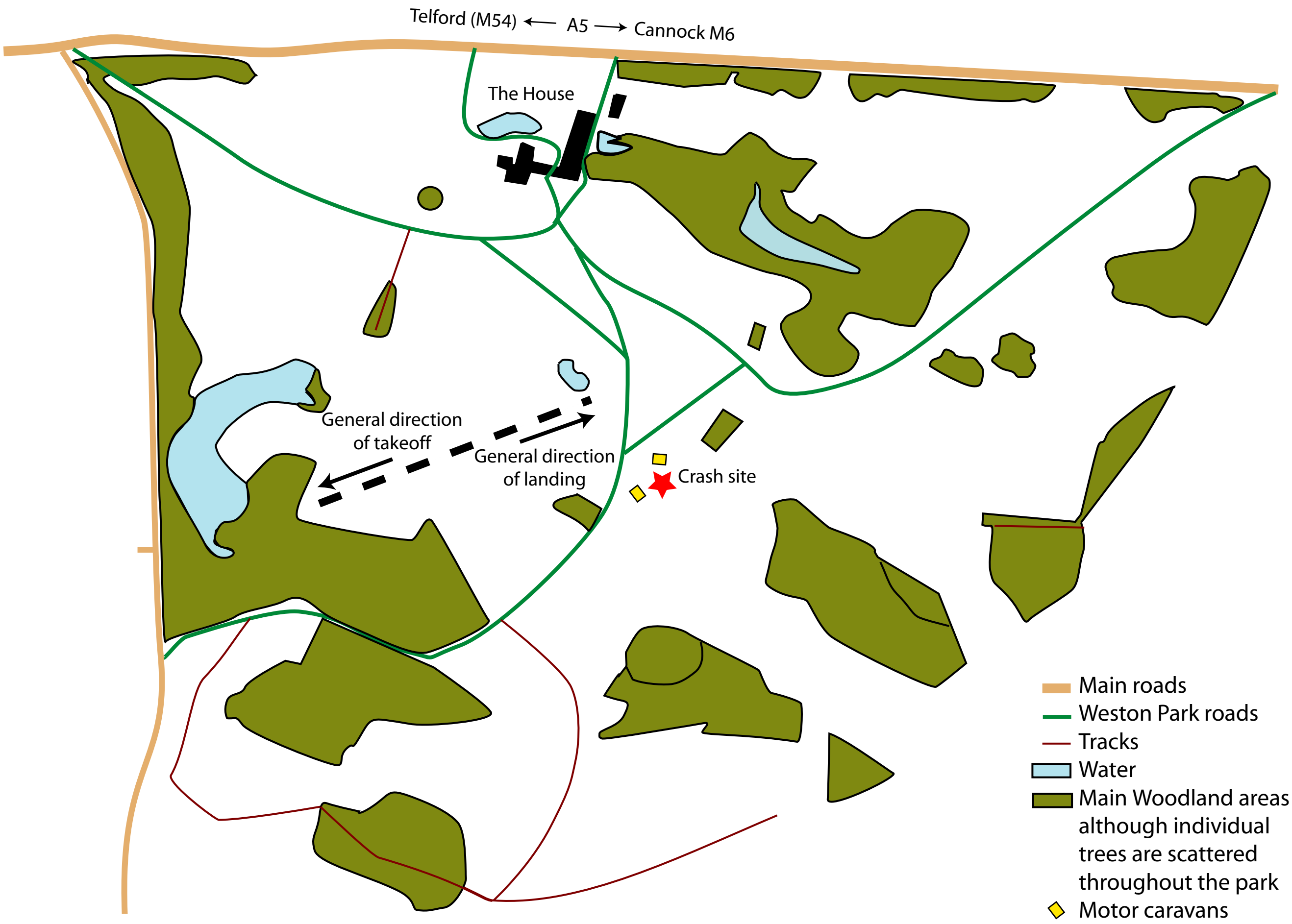


Figure 1

Weston Park

of the landing area, and he judged that this aircraft might shortly commence a takeoff. The pilot decided that it was unsafe to continue the approach so he applied full power and pitched the aircraft nose-up to go around. Shortly after he commenced the go-around, the left wing dropped suddenly. The pilot used aileron and rudder to re-establish wings-level flight but very soon afterwards, the right wing dropped, and despite full control inputs to regain normal flight, the aircraft continued to roll to the right and pitch down. The pilot saw a clear area some distance ahead and attempted to raise the aircraft's nose in order to reach it.

The aircraft struck the ground immediately between two motor caravans and hit them both with its wings. An awning was attached to the left side of the motor caravan struck by the left wing and the owner of the motor caravan was sitting immediately adjacent to the awning. After striking the vehicle's front bumper, the aircraft destroyed the awning and struck the owner, causing serious injuries to his head, chest, and ankle. The aircraft sustained substantial damage and came to rest erect, some 30 m beyond the position of its initial simultaneous collision with the ground and the motor caravans, having yawed left through some 200º. The pilot and passenger, who had both been wearing lap straps and diagonal harnesses, exited the aircraft without difficulty. Fire crews, some of whom had been exhibiting appliances at the Festival, attended the scene and assisted in providing first aid and containing spilt fuel from the aircraft.

Aircraft information

The Rans S6-ES Coyote II is a home-built, two-seat, strut braced high-wing monoplane constructed primarily of aluminium and steel tubing covered with sailcloth. The accident pilot purchased the completed aircraft in October 2004. He was not the constructor and the aircraft was first registered in September 2003. The aircraft type has conventional, three-axis flying controls and trailing-edge flaps which have four settings, from fully up, to 43º in the fully down position. The fuel system comprises two 34 litre (9 USG) tanks, one in each wing, with fuel being gravity fed to the engine. The feed pipes from both fuel tanks are joined via a tee-piece, the outlet of which feeds the engine, so that it receives fuel from both tanks. The fuel supply to the engine may be isolated via a shutoff valve located in the cockpit.

The aircraft was equipped with a 65-horsepower, two cylinder, two-stroke engine driving a two-bladed fixed pitch wooden propeller through a reduction gearbox. The flight instrumentation included airspeed, vertical speed and turn/slip indicators, with additional displays for engine parameters, such as engine rpm. Pitot pressure is sensed by a probe mounted in the left wing leading edge, with pressure being transmitted to the airspeed indicator via polyurethane tubing. The tubing should be attached to the probe with a ratchet-type plastic hose-securing clamp. On the ground the probe may be partially retracted manually to reduce the likelihood of it being damaged whilst the aircraft is parked.

Landing area and accident site

The landing area was a reasonably smooth grass area clear of trees and other obstructions, within the parkland of the Estate. The area had been used for occasional flying operations for many years. The landing area had a significant slope, with the south-western end some 39 ft lower than the north-eastern end. This slope dictated that landings were commonly conducted in a north-easterly direction, and takeoffs were in a reciprocal direction.

Around the landing area were displays of vintage vehicles, an 'auto-jumble', an arena in which various activities took place, and other attractions. Caravans and motor caravans were parked around the site, a number of these being present throughout the weekend of the Festival. Approximately 4,000 people visited the Festival each day.

The accident site shown in Figure 2 was to the east of the north-eastern end of the landing area. From the ground impact marks it was deduced that the aircraft contacted the ground out of control, in a slightly nose-down pitch attitude. It passed between two motor caravans, parked approximately 19 ft apart, colliding with an awning attached to the left vehicle and striking the owner of the vehicle. The nose and left main landing gear were torn off during the ground slide.

The aircraft's left wing struck and damaged the bumper of the motor caravan on its left. Smear marks of black plastic from the bumper were visible on the leading edge of the left wing and the wing leading edge tube was deformed over a spanwise distance of about 6 ft, approximating to the width of the vehicle. The roof of the right motor caravan exhibited damage consistent with it having been struck by the right wing. From

Figure 2

Crash Site

measurements of the impact marks on the vehicles, it was deduced that the aircraft was in a 10º to 15º left wing low orientation when it struck the vehicles.

Evidence was found of propeller rotation and engine power at impact, including propeller strike marks in the soil and corresponding mud spattering on the side of the right motor caravan. Both propeller blades had broken off near their roots and fabric from the awning had become tightly wrapped around the propeller drive shaft. A significant quantity of fuel had leaked onto the ground and in excess of 20 litres of fuel were drained from the aircraft prior to it being recovered.

Aircraft examination

The flight controls and engine controls were found to be intact and appeared to operate correctly when checked at the accident site. The flaps were in the fully retracted position, corresponding to the flap selector lever's position.

On further examination, it was established that the elevators had been incorrectly rigged during construction of the aircraft, such that the elevator range of travel was 25º up and 34º down, instead of 30º up and 20º down as specified in the aircraft build instructions. When reviewed, the elevator rigging instructions were found to be ambiguous and open to misinterpretation.

After installing a new propeller, the engine was test run several times using the fuel recovered from the aircraft. It developed significant power and showed no signs of hesitation, even with rapid movements of the throttle control.

The polyurethane pitot pressure sense pipe was found disconnected from the pitot probe and the pipe was kinked at a point 55 mm from the end. Tests showed that a considerable amount of energy was required to produce a kink in the pipe, given its flexibility and even folding the pipe over double on itself did not cause it to kink. It was noted that the pipe had been secured to the probe using wirelocking around the circumference of the pipe, instead of a hose clamp as specified in the aircraft build instructions. Notwithstanding this deviation from the standard, when tested, the wirelocking held the pipe on the pitot probe with a reasonable degree of security. The greater portion of the pitot probe was missing, having broken off in the impact with the bumper of the left-hand vehicle. Calibration checks of the airspeed and vertical speed indicators proved acceptable.

Types of microlight aircraft

Microlight aircraft are categorised by their control system, which is either 'flex-wing' or 'three-axis'. Flex-wing aircraft typically have a one-piece wing or 'sail', from which a pod is suspended. The pod accommodates the pilot and, in some cases, passenger. These aircraft are flown by weight-shift, with the pilot applying a force on a control bar to shift the weight of the pod relative to the wing. The pilot has no control of the aircraft in yaw. Three-axis aircraft are flown with a control column, which provides control in pitch and roll, and rudder pedals, providing control in yaw.

The fundamental differences between weight shift and three-axis control systems are the diametrically opposed control movements for pitch and roll and the provision or otherwise of yaw control using pedals.

The pilot's experience

The pilot gained a Private Pilot's Licence, endorsed *'(Aeroplane) (Microlight only)'* (PPL(M)), in 2002 after training in flex-wing aircraft. He stated that he undertook five hours conversion training in 2002 with a local flying instructor in order to fly three-axis aircraft. His log book showed 90 minutes of this training in late 2002. The flying instructor who undertook this training recorded 75 minutes of training on a three-axis Spectrum aircraft.

Pilot training requirements

A holder of a PPL (M) is entitled to fly any microlight aircraft, regardless of the control system. The current CAA *'Licensing, Administration and Standardisation Operating Requirements and Safety'* (LASORS) document is the official source of pilot licensing information for holders of PPL(M) licences, and it makes no mention of different control systems.

Civil Aviation Publication CAP53 (which was the equivalent document until superseded by LASORS in 2002) stated:

> *'Microlight pilots converting from weight shift to 3-axis control systems, or the reverse, not having gained at least 1 hour PIC gained prior to 1 July 1993 in an aircraft having the appropriate control system, should undertake adequate conversion training and pass the Additional Control System Test (ACST) conducted by an appropriately qualified microlight examiner.'*

The use of the word 'should' in this context indicates that this was a recommendation, not a requirement.

Pilots learning to fly microlight aircraft are no longer able to obtain PPL(M) licences, as the National Private

Pilot's Licence (Microlight) (NPPL(M)) has replaced the PPL(M). The British Microlight Aircraft Association (BMAA) oversees training and testing for the issue of a NPPL(M). The BMAA Instructor and Examiner Guide stated:

> *'Microlight pilots completing a course of NPPL (M) training and subsequently granted a NPPL (M) may only fly aircraft with the same control system (ie weightshift or 3-axis) as used during the course. Appropriate Control System Differences Training with a Flight Instructor must be completed in order to fly a microlight aircraft with the alternate form of control system.*
>
> *'Both the BMAA and the CAA strongly recommend that PPL M and PPL SEP Holders undergo Control System Differences Training as well.'*

Meteorology

An aftercast supplied by the Meteorological Office indicated that an area of low pressure to the west of the British Isles was feeding a light, dry, south to south-easterly airflow over the Midlands. The aftercast indicated that there was haze at the accident site, with visibility between 8 and 12 km, a mean sea level pressure of 1012 mb, no cloud below 3,000 ft, and a variable, mainly south-easterly, wind at 3 kt. The temperature was 12°C and the dewpoint 5°C, giving a relative humidity of 62%.

An experienced microlight pilot and instructor who flew into the Festival at about midday and remained until after the accident stated that he assessed the weather conditions during the day using his experience, and the surface wind by observing the windsock. He stated that the wind was light throughout the period, not exceeding 5 kt, and that about the time of the accident the wind was from the north-west.

Illusory horizon

The significant slope of the landing area caused the visual horizon to appear above the local horizontal when viewed from the south-western end of the area. This aspect would, for a period, present a false or illusory horizon to a pilot going around from low height in the north-easterly direction because the visible horizon would be above the true horizon. Mature tall trees just beyond the end of the landing area, some 177 ft higher than the lower end of the landing area, could add to the illusion.

Where an illusory horizon is present, the pilot must use skill and judgement to fly the aircraft accurately with reference to the local horizontal ignoring the illusory horizon. If the aircraft is flown by reference to an illusory horizon, the nose will be pitched higher than is desired. Where the angle between the local horizontal and the perceived horizon is more than a few degrees, the pilot may unwittingly pitch the nose up too far, possibly placing the aircraft in a condition approaching the stall.

Stalling - general principles

As an aircraft enters a stall, one wing may drop; that is, the aircraft may suddenly roll, without any control input having been made by the pilot. In most cases, the aircraft nose pitches down at the same time. The approach to the stall usually occurs whilst the pilot is applying rearward pressure on the control column, and is typically identified by a high nose attitude and buffeting felt through the airframe and flight controls.

When a wing drops, the pilot may apply rudder and aileron control in an attempt to regain wings-level flight, but this in turn requires more lift from the down-going wing and may cause it to stall more deeply. Typically, this causes the aircraft to roll further in the direction opposite to the control input.

Various factors affect the rapidity of onset of the stall, and the nature of entry into a stall. Generally, stalls at high power have a more rapid onset than stalls at low power.

Stalling - the accident aircraft

The Rans S6 Build Manual[1] stated *'Stalls have a warning buffet due to turbulent air from the wing root flowing over the elevator'*.

An experienced Rans pilot had flown the aircraft a shortly before the accident. He commented that the aircraft did not unstick during takeoff as he expected, and when he attempted to stall the aircraft, it did not decelerate as he expected. He reported that he *'could not get the nose into an attitude in which it would stall'* and that the aircraft *'would not stall'*. He did not attempt a stall with full power selected. He explained that other Rans aircraft he had flown stalled easily, with clear pre-stall buffet, and that the stall was often accompanied by a wing-drop.

G-CCNB held a current Permit to Fly, which was valid until 7 June 2005. It had flown less than 35 hours since construction. Before the Permit was issued, the aircraft was test flown by a pilot approved by the Popular Flying Association. The test flight was completed on 28 May 2004. No significant handling issues were noted and stall testing at the maximum gross weight gave a power-off, flaps-up stall speed of 44 mph, with the onset of buffet occurring at 48 mph. A slight right wing-drop was observed at the stall, but this was not considered to be abnormal.

At the time of the accident, the aircraft's weight was approximately 465 kg whereas the maximum approved gross weight of the aircraft was 450 kg. Post-flight calculations showed that the centre of gravity was in the middle of the allowable range.

Organisation of the flying activity

The estate at Weston Park was managed by a Limited Company on behalf of the owners, an Educational Trust. The Festival organisers had a commercial agreement with Limited Company to use the park land. A considerable number of years before, the same Festival organisers had arranged flying displays at the site, with appropriate permissions from the CAA.

The Festival organisers had been approached some years before the accident by a local microlight pilot who had asked whether it would be possible to display some microlight aircraft at the annual Festival. He was permitted to do so along with some of his acquaintances. Over a period of years, this activity had expanded to include flying from the site.

The accident pilot, other pilots who attended the Festival and a manager of the Limited Company all referred to this individual as the organiser of the flying activity. When interviewed, this individual denied that he was an organiser of the flying activity, but stated that he willingly communicated details of the show to local microlight pilots. He spoke to people who attended the show about the flying activity, including providing details of the customary procedures for the flying operations. Prior to the Festival, he had placed a windsock adjacent to the landing area, and had pegged down a wire fence, which crossed the landing area.

A letter sent some weeks before the accident from the Festival organiser to this individual stated, (inter alia):

Footnote

[1] There was no Operating Manual for the aircraft, but information regarding operation and flying technique was included in the Build Manual.

'I hope that we can look forward to your company at the forthcoming Midlands Festival of Transport. I am enclosing some passes and posters… everything remains the same, same positions etc; I have told a few people who plan to fly in to contact you nearer the time for final instructions. I'm sure there will be some who just "arrive" as well. Don't forget to invite as many of your acquaintances as possible'.

The Rules of the Air and the Air Navigation Order

Rule 5(1)(d)(i) of the Rules of the Air Regulations 1996 (valid at the time but since amended) stated:

'an aircraft shall not fly over, or within 1000 metres of, any assembly in the open air of more than 1000 persons assembled for the purpose of witnessing or participating in any organised event, except with the permission in writing of the Authority and in accordance with any conditions therein specified and with the consent in writing of the organisers of the event'.

In this context *'the Authority'* was the CAA.

Flying displays are formally regulated by the CAA and stringent requirements are in place to ensure public safety at such events. Article 129 of the Air Navigation Order defined a flying display as follows:

'Flying display' means any flying activity deliberately performed for the purpose of providing an exhibition or entertainment at an advertised event open to the public'.

Although flying activities were an attraction at the Festival, and publicity material featured an image of a flex-wing microlight, the organisers did not believe that the flying activity constituted a 'flying display'. Moreover, all parties concerned with the organisation of the event confirmed that they had not sought permission from the Authority.

Previous recommendation

AAIB Safety Recommendation 98-62, made following a fatal accident to a Kolb Twinstar Mk III Microlight aircraft in July 1998, stated:

'This accident may have resulted from a loss of control by the pilot. The pilot had no training and limited experience on the type of aircraft control system that he was using. Given the fundamental differences between weight shift and 3-axis control systems, notably the diametrically opposed control movements for pitch and roll, it is recommended that the CAA should consider making the guidance contained in CAP53… a mandatory requirement.'

Initially the Authority took the view that Alternate Control System training should be made mandatory for pilots of microlight aeroplanes converting from weight shift to 3-axis control or vice-versa but ultimately it did not accept the recommendation. The Authority stated that mandating the guidance contained in CAP 53 was not justified because examination of the pilot's flying experience demonstrated that he was fully competent with the control of the aircraft throughout its flight envelope.

Analysis

The flight progressed normally until the approach to the landing area, when the pilot perceived that another aircraft was lining up on the landing area to take off, and decided it was not safe to land. He executed a go-around, during which one wing, and then the other dropped; the aircraft went out of control and lost height rapidly. The loss of height and the wing drop were entirely consistent with a stall.

The pilot held a valid Private Pilot's Licence, gained following a course of training on flex-wing microlight aircraft. However, he was inexperienced, both in terms of his total flying experience and his experience on three-axis types. He had not undertaken any training on the Rans S6, and the 'three-axis' training he had undertaken with a Flying Instructor had taken place on a different type of three-axis aircraft. Moreover, it took place more than two years before the accident flight. The pilot had flown the accident aircraft for fewer than 9 hours, and had only flown 3 hours in the 90 days preceding the accident. As such, he was neither in current flying practise, nor trained to fly the aircraft.

Flex-wing and three-axis aircraft have very different flying control systems. The control inputs are diametrically opposed in pitch and roll, and a pilot who transitions from flex-wing to three-axis controls must also develop the new skill in controlling an aircraft in yaw. It is possible, therefore, that inappropriate control of the aircraft in yaw may have contributed to the wing drop as the aircraft stalled immediately before the accident.

The position of the false horizon, perceived by the pilot at the time of the go-around, may have caused him to pitch the aircraft higher than normal thus allowing the airspeed to decay to that approaching the stall. This illusion is considered to have contributed to the inappropriate handling of the aircraft during the go-around.

The incorrect rigging of the elevator made the aircraft difficult to stall, and this was reflected in the account of the experienced Rans pilot who flew the aircraft. This 'unwillingness' to stall might have imbued the owner with confidence that the aircraft was docile at low speed, and that it was unlikely to stall.

It is possible that the pitot pressure sense pipe could have become detached from the probe prior to the accident flight. Had this been the case, the pilot would not have had any air speed indication. However, given the kink in the pipe and the obvious severity of the impact of the left wing with the vehicle bumper which damaged the pitot probe, it seems more likely that the pipe became disconnected as a result of the accident.

Safety Recommendations

Only by consistently demonstrating the necessary skills can a pilot be assessed as being competent to operate an aircraft. Therefore, it may be argued that both training and testing should be required before microlight pilots are permitted to fly unsupervised in an aircraft with an unfamiliar control system. Consequently, the following Safety Recommendation was made:

Safety Recommendation 2005-128

The Civil Aviation Authority should require holders of the Private Pilots Licence (Aeroplane) (Microlights) converting from weight shift to three-axis control systems, or the reverse, to undertake adequate conversion training and pass a Flight Test conducted by an appropriately qualified microlight pilot examiner.

During the course of the investigation, it became apparent that the requirements placed upon the holder of an NPPL(M) are contained only within the BMAA's Instructor and Examiner Guide. This guide is effectively an internal document within the BMAA and has no mandatory effect. Therefore, the following Safety Recommendation was made:

Safety Recommendation 2005-129

The Civil Aviation Authority should mandate the arrangements for grant of National Private Pilots Licence (Microlights) qualifications which are presently published in the British Microlight Aircraft Association's Instructor and Examiner Guide and incorporate them into LASORS.

Taking into consideration the BMAA's present requirements regarding Control System Differences Training, together with the remarks about demonstration of skills above, the following Safety Recommendation was made:

Safety Recommendation 2005-130

The Civil Aviation Authority should mandate that, where holders of an NPPL(M) are required to undertake Control System Differences Training in accordance with the Air Navigation Order 2005, they should also be required to demonstrate an adequate level of flying skill on an aircraft possessing the previously unfamiliar control system before flying unsupervised in an aircraft with such a control system.

Advice to show organisers

Although in this case the serious injuries to the motor caravan owner were caused by the aircraft's crash, light aircraft accidents rarely injure third parties. However, aviation legislation has many purposes including the protection of the public from accidental injury or death as a consequence of flying activities. Given the provisions of the Rules of the Air and the Air Navigation Order, it would have been reasonable to expect the organisers of the Festival to seek advice and perhaps permission from the CAA for the flying activity. Had an application been made for the flying activity to be a 'flying display' (given that the definition of 'flying display' would appear to encompass the flying activity at the Festival), it is possible that efforts to minimise the hazard to the public might have prevented injury to the owner of the motor caravan.

ACCIDENT

Aircraft Type and Registration:	Team Himax 1700R, G-CCAJ
No & Type of Engines:	1 Rotax 447 piston engine
Year of Manufacture:	2003
Date & Time (UTC):	30 August 2005 at 1216 hrs
Location:	Rhigos, South Wales
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Serious) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	67 years
Commander's Flying Experience:	846 hours (of which 80 were on type) Last 90 days - 14 hours Last 28 days - 9 hours
Information Source:	AAIB Field Investigation

Summary

The aircraft took off, carried out an abbreviated circuit and stalled at a low height on the base turn. The ground impact was in a steep nose-down attitude and the pilot suffered serious injuries. One safety recommendation was made.

History of flight

Two microlight aircraft, a Team Minimax and a Team Himax (G-CCAJ), departed from a private site in Gloucestershire and flew to Rhigos. One of the pilots had previously telephoned the airfield operator to confirm that weather conditions were suitable. Both pilots carried handheld radio transceivers and were in radio communication and occasional visual contact with each other during the flight. The weather conditions were good although there was some broken cloud en-route which they were able to avoid.

On arrival at Rhigos, at around 1050 hrs, both aircraft flew circuit patterns and landed in an easterly direction at the start of the grass landing strip. They then taxied along the landing area and parked close to the clubhouse. The surface wind conditions were reported as south-south-east at 8 kt.

The pilots spent about an hour on the ground before they prepared to depart. The intention was to fly on to Shobdon Aerodrome and then to return home to Gloucestershire. While on the ground they had some discussions with the Chief Flying Instructor (CFI) of the resident gliding club about the local terrain, area flying conditions and possible departure routings. He advised that they should not fly too close to the high terrain to the south of the airfield following an easterly departure as there could be strong downdrafts and turbulence. He also pointed out that the options for a forced landing when taking off to the east were limited because of two lines of pylons directly ahead, and therefore favoured a right turn.

There was also present at the airfield another pilot who had been involved in building some parts of G-CCAJ. This was the first time that he had seen the aircraft since it had been completed. He discussed with the pilots some options for take-off direction in the prevailing conditions. He then stood and watched their departure from in front of the clubhouse.

The pilots decided to take off as much into wind as possible; it was still from the south-south-east but now at around 10 kt, across rather than along the east/west strip. The first aircraft departed and after gaining sufficient height, turned left on to the planned course to Shobdon. G-CCAJ departed in turn and was seen to climb to around 400 ft before starting a turn to the right. The aircraft flew on approximately a downwind course and started descending. The pilot watching from the ground became concerned that it was too low and might get caught in downdrafts created by the high terrain to the south. He saw it start a right turn onto a base leg and then saw the right wing drop and the aircraft go into a steep nose-down attitude before disappearing from his view.

Inside the clubhouse the CFI was on the telephone and saw G-CCAJ once it was airborne. His view was restricted but he saw the aircraft climbing out initially and then turning right and flying downwind. He was concerned about its course and watched it through the window. He saw it turn to the right and drop into a steep nose-down attitude. He realised it must have crashed and ran to his car to drive to it.

On reaching the accident site he saw the aircraft tipped on its nose with the tail up in the air. He heard sounds coming from the aircraft, rang '999' on his mobile telephone, reported the accident and then went to assist the pilot. He was able to push the fuselage off the pilot to help him sit upright and he stayed supporting him for about 15 minutes until the emergency services arrived. The pilot was taken by air ambulance to a nearby hospital.

Pilot information

The pilot started flying in gliders some 30 years ago. In 1990, he qualified for his Private Pilot's Licence (Microlight). Since then he had owned and regularly flown flex-wing type aircraft, accumulating some 700 hours of flight time. He then decided to build a Himax aircraft, which has conventional three-axis controls. This aircraft, which was part built when he bought it, took him some nine months to complete. Before flying it he undertook a conversion/refresher course in a three-axis microlight aircraft. The initial test flights for G-CCAJ were completed in March 2003 and over the next two years he had flown some 85 hours in it.

The pilot, who was interviewed one month after the accident, could recall taking off from Rhigos and turning to the right, but was unable to remember anything after that moment. He was unsure as to why he had turned to the right but thought it likely that he was planning to fly over the airfield to perform a 'flypast' before departing on course. He could not recollect having experienced any problems during either the flight inbound to Rhigos or on departure.

Wreckage and impact information

It was reported that following the crash the leading edges of both wings were resting on the ground and the tail was pointing upwards. During the rescue of the pilot the tail was lowered, the engine and cockpit items moved, the control column was broken and the fuel taps were selected to 'OFF'. The throttle lever was found close to the idle position; it is not known whether it was moved when the emergency services made the aircraft safe prior to treating the pilot.

From the wreckage and ground marks it was established that the aircraft crashed within the airfield boundary approximately 42 m south of Runway 07 on a of heading of 231º. Ground marks from the left wing tip, which broke off on impact, and broken fragments from the cockpit floor indicated that the aircraft struck the ground left wing first at a nose-down angle of between 60º and 80º. The left wing, the fuselage forward of the cockpit and the left side of the cockpit were totally destroyed. There was minor damage to the leading edge of the right wing; however the landing gear and structure aft of the cockpit were undamaged. The fuel tanks, which were 2/3 full, were intact. One of the propeller blades had broken off close to the hub and fragments of the blade were discovered in a hole approximately 0.6 m wide and 0.12 m deep. The aircraft was equipped with a four-point harness of which the shoulder harness securing cable had failed at its anchor point. There were no ground marks beyond the immediate vicinity of the aircraft. See Figure 1.

Figure 1

Crash site

Recorded information

A Garmin GPS III Pilot was recovered from the wreckage and appeared undamaged by the accident. The stored data was downloaded to a computer and interpreted. The GPS was set up to record samples of latitude, longitude, magnetic track and ground speed whenever there was a significant change in these parameters. Altitude was not recorded by this model of GPS.

There were 11 track logs recorded on the GPS, the first recorded on 7 August 2005 and the last covered all the flying carried out on 30 August 2005. The flying on 30 August started at 0944 hrs near Gloucester. The aircraft landed at Rhigos at1053 hrs. The take-off roll of the accident flight started at 1216:08 hrs with the aircraft's track varying between 107°M and 122°M. The aircraft became airborne and the ground speed peaked at approximately 33 kt. It then started to decrease as the aircraft turned to the right, reducing to 28 kt on a track of 195°M. The ground speed then quickly increased to a maximum of 48 kt as the aircraft turned through west, reducing again to 41 kt as it then turned north. After this, no further track points were recorded. Figure 2 shows the GPS sample points of the final flight.

Meteorological information

The 'Airmet' area forecast contained the following information; visibility generally 15 km with broken cumulus and stratocumulus cloud between 2,000 and 5,000 ft. The forecast wind at 1,000 ft was from 140º at 15 to 20 kt and at 3,000 ft from 150º at 15 kt.

On the morning of 30 August the airfield was covered in fog but this had cleared by around 0930 hrs, leaving the grass damp. The wind observed at the airfield was from the south-south-east at 8 kt.

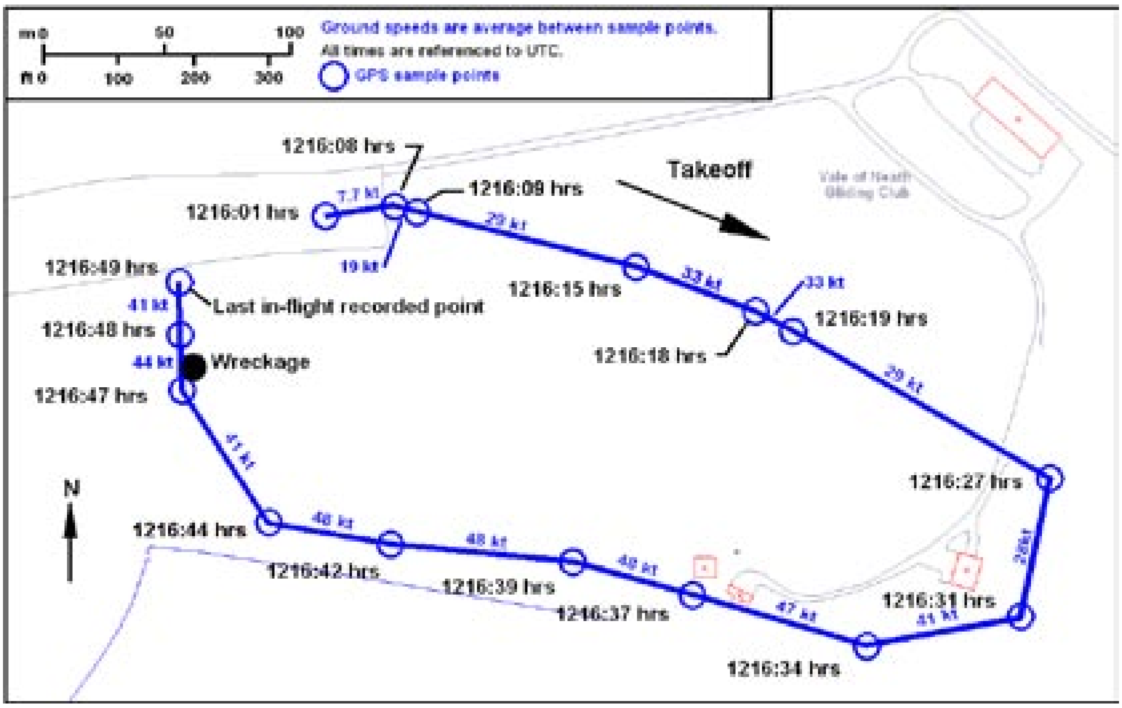


Figure 2

GPS plot

Airfield information

Rhigos Airfield is located on a small ridge of high ground at an elevation rising to 790 ft amsl (240 m). The surface of the runway is grass and the total length is some 2,950 ft (900 m); it is curved but the landing direction is generally aligned west/east and there is an upslope from west to east. To the south of the airfield there is a valley and then terrain rising sharply to 1,970 ft amsl (600 m). This terrain can give rise to significant local wind effects, particularly in southerly wind conditions. To the north and east there are lines of pylons close to the airfield. There was a description of the airfield on a website which included the following information;

> *"The airfield is in the hills, difficult to spot and can be particularly demanding particularly in Southerly winds. It is also curved, narrow, drops off steeply each side, has a pronounced slope down from East to West and is often too soft to operate off.*

Visiting pilots are encouraged to discuss the weather conditions and prior permission is required before landing there.

Aircraft information

a The aircraft

The Team Himax is a high wing version of the single seat mid-wing Team Minimax. It is constructed from wood and fabric and has conventional flying controls, elevator control movement being transmitted via a pair of Teleflex cables. It has no flaps, is not fitted with, nor required to have, a stall warning system and has a maximum take-off weight of 254 kg. G-CCAJ was constructed as a Popular Flying Association (PFA) Homebuilt Project and was originally intended to be built as a Team Minimax; however part way through its construction the owner obtained permission from the PFA to convert it into a Team Himax. G-CCAJ was equipped with a two-stroke Rotax 447 engine, which was operated on MOGAS. The aircraft undertook its first flight in February 2003 and the Permit to Fly was revalidated by the PFA on 22 April 2005. At the time of the accident the aircraft had flown approximately 94 hours.

b The airspeed indicating system

The aircraft is equipped with a conventional pitot static system, with the pitot probe mounted on the left wing strut and the static ports mounted either side of the fuselage forward of the tailplane. The Air Speed Indicator system is checked during the flight test by comparing the expected stall speed with the actual stall speed and by using GPS to check the indicated air speed against the ground speed. The flight test undertaken on 17 March 2003 showed that the stall occurred at an indicated 31 mph in straight and level flight with a loss of 50 to 75 ft during recovery. It was also observed that, when stalling, the aircraft occasionally suffered a wing drop to the left and that this could occur even when the aircraft was in a right turn. The stall speed was last checked during a flight test undertaken in April 2005, as part of the Permit to Fly revalidation, when it was again measured at 31 mph. This figure is consistent with the 30 mph stalling speed specified in the aircraft manual. The pilot who undertook both flight tests considered the airspeed recorded on the ASI to be accurate.

c The restraint harness system (See Figures 3 & 4)

The aircraft was equipped with a four-point harness consisting of a lap strap and two shoulder straps. The shoulder straps should have been connected to a galvanised steel cable which looped back through the elevator control support bracket fitted at the rear of the fuselage. The design drawings showed that one shoulder strap should have been attached to each end of the cable

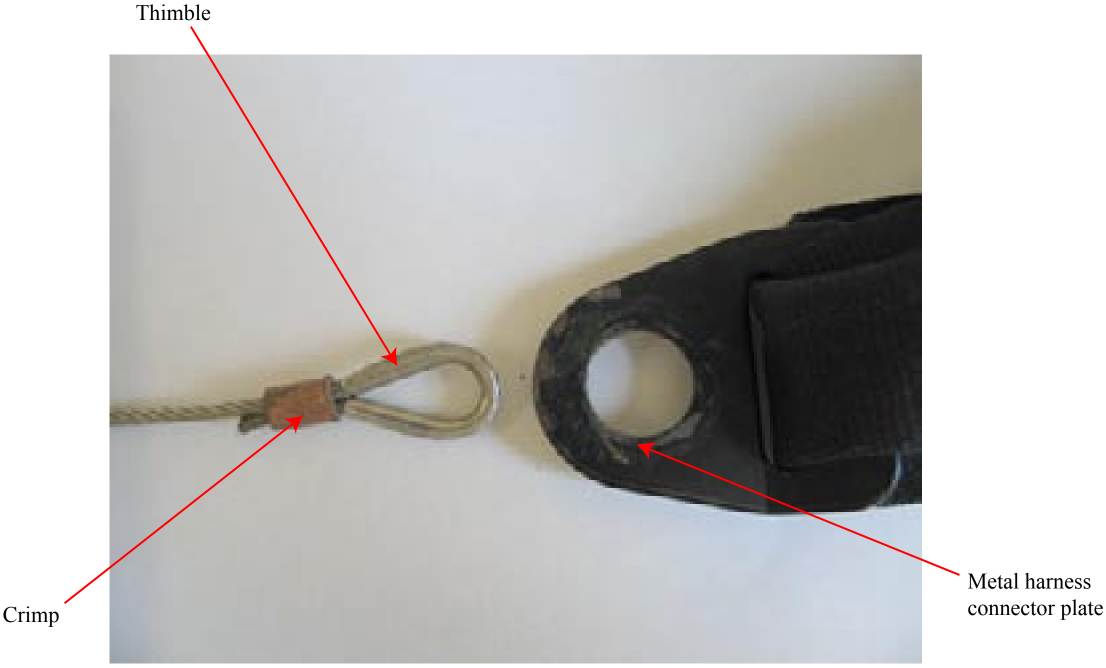


Figure 3

Connection of harness to cable (Note the thimble should be fitted over the lug of the harnesses connector, joining the cable directly to the connector plate)

by crimping the cable end around a thimble inserted through the lug of the harness connector plate. (Fig. 3) It did not indicate that the connector plates of the two shoulder straps should be constrained to stay together.

At the aft end of the fuselage, the cable passed downwards, with a tight 90º bend, through one hole in the horizontal flange of the bracket which supported the aft ends of the two elevator Teleflex cables. The harness cable then was looped underneath the Teleflex outer sheath end fittings before passing up through another hole in the horizontal flange and, with another tight 90º bend, forward again to the pilot's shoulder harness. (Fig. 4)

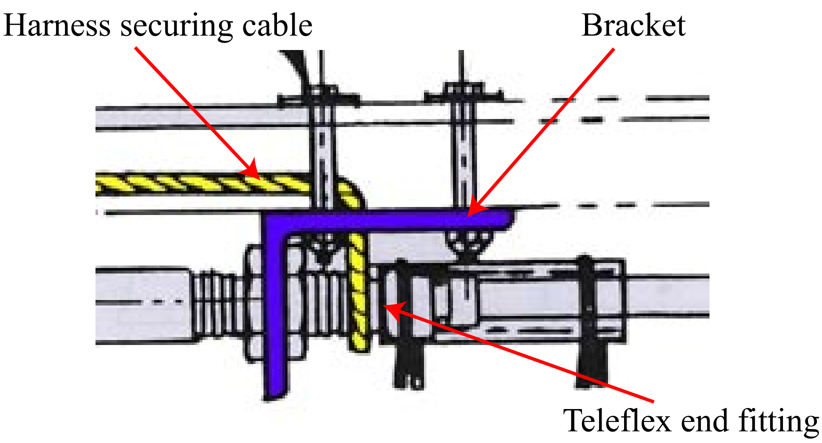


Figure 4

Routing of shoulder harness securing cable in rear fuselage

It was noted that whilst the design called for the harness cable to be made from galvanised carbon steel with a breaking strength of 1,000 lbs; the cable fitted to the aircraft was stainless steel and had a nominal breaking strength of 920 lbs. Subsequent testing of this cable and attachment, conducted for the PFA, showed that the strength of the arrangement, as fitted to G-CCAJ, exceeded the requirements of BCAR Section S, 561(b).

Detailed examination of wreckage

a General

The front of the aircraft had been badly disrupted in the accident making it difficult to establish the position of the engine controls and the condition of the instruments and pitot static system. Nevertheless, it was possible to establish control continuity on all the primary controls and to confirm the integrity of the fuel system between the tank and gascolator. It was noted that the rubber seal between the gascolator bowl and upper fitting had been damaged during assembly, thereby allowing small pieces of rubber to enter the fuel bowl. However, there was no sign of rubber debris downstream of the mesh filter in the gascolator in either the carburettor fuel bowl or jet.

b Engine and propeller

Whilst there was no damage to the leading edge of the broken part of the blade, which had shattered on impact, mud had been driven into the exposed part of the grain on the hub which was consistent with the hub rotating when the aircraft struck the ground. The position of the broken fragments of the blade found in the hole made by the propeller also suggested that the engine was turning prior to impact. Overall the damage to the propeller was consistent with the aircraft impacting the ground in a very steep nose-down attitude, whilst the engine was still turning.

The impact had damaged the engine controls, external pipe work and electrical components; consequently, it was not possible to test the components in the ignition system. Nevertheless, the engine control cables were still connected to the carburettor, which had been knocked off the engine. Whilst any fuel that might have been in the fuel bowl had drained away, the carburettor was relatively undamaged, the jets were clean and the valve and needle operated smoothly.

Both spark plugs were found to be finger tight; the rear plug could be hand tightened by a further 2 turns and the front plug by approximately 1/2 turn. The rear plug was normal in colour and appearance whereas the front plug was light grey with a grey deposit bridging the gap between the electrodes. The front plug was subsequently tested and a strong spark between the electrodes was observed. It was also noted that very little torque was required to undo the cylinder head securing bolts. Both cylinder barrels and both pistons appeared to be in good condition and the engine turned over freely. There was no evidence of hot gasses leaking out of the cylinder heads or from round the spark plugs. Whilst the condition of the front plug suggested that this cylinder was running on the lean side, there was no evidence of mechanical damage that would have caused the engine to stop prior to the crash.

c Shoulder harness

The shoulder harness attachment cable was found to have failed at the two points where it passed through the holes in the elevator Teleflex cable mounting bracket. (See Figure 5.) The failed shoulder harness cable and attachment bracket were subjected to further analysis.

Energy dispersive x-ray analysis of the cable material determined that the cable was stainless steel rather than the galvanised carbon steel specified in the design.

Further examination by optical and scanning electron microscope techniques revealed that the cable was in good condition with no evidence that any of the strands in the cable had broken or been subject to fretting prior to the accident. Assessment of the failure of individual strands indicated that the cable had failed in shear. It was concluded that the damage to the cable was consistent with a tensile load having been applied to the cable and the cable failing in shear at the edges of the holes where the cable turned through a tight radius.

It was also observed that, at its forward end, the cable had not been connected to the shoulder straps in accordance with the design drawing. Instead both ends of the cable had been crimped around thimbles and both thimbles had then been connected to both shoulder straps using a single shackle passing through all four apetures. Whilst there was slight distortion to the pin in the shackle, the connection between the two straps remained intact. This deviation from the drawing had not been authorised by a concession issued by the PFA.

Discussion

The reason why the pilot turned to the right after take off in an apparent attempt to return to the airfield could not be definitely determined. There was no evidence to suggest that there was a mechanical problem although it is possible that the looseness of the spark plugs, or a lean running front cylinder, might have resulted in the engine producing less than normal power. However, not only does the pilot not recall having a problem with the engine, but the rate of climb of the aircraft prior to it turning downwind suggests that the engine was operating normally. The circuit he flew was short and the base turn started from a position that would have taken the aircraft over the centre of the airfield. If the pilot had encountered a minor problem or for some other reason wished to return to land on the airfield, it would be expected that he would fly a complete circuit, as he had done on his initial arrival. It therefore seems likely that either he had a major problem and was making a forced landing, or that he was attempting to perform a 'flypast' over the

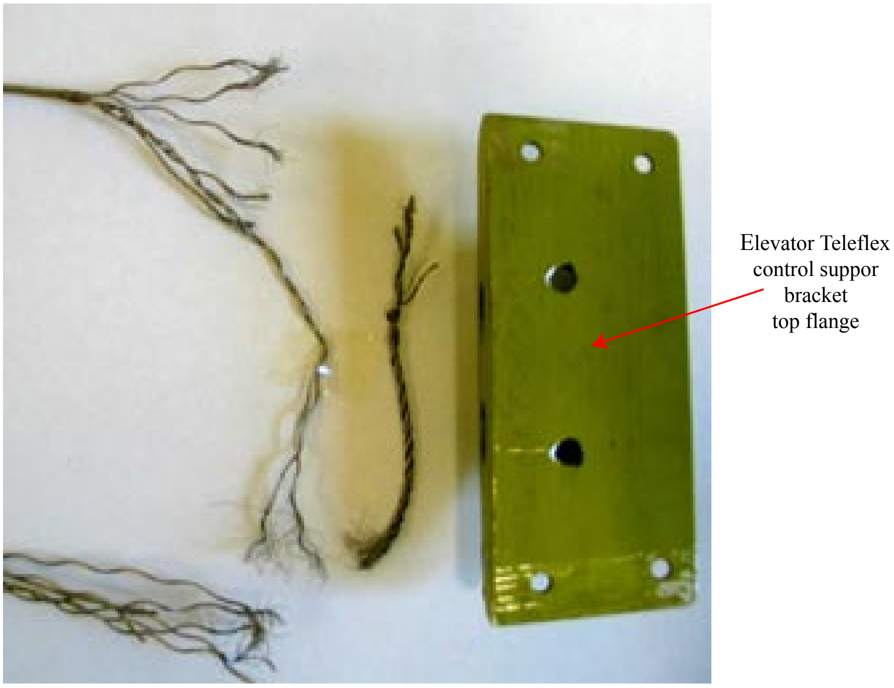


Figure 5

Shoulder harness cable and elevator Teleflex cable mounting bracket centre of the airfield before departing en-route. The fact that someone who was involved in building the aircraft was out on the airfield watching, and the pilot's own view of his actions, makes an attempted flypast the most probable explanation. The pilot, in discussion, pointed out that because he was unfamiliar with the airfield most of his attention would have been on looking out, rather than looking in at his airspeed indicator.

The evidence suggests that the aircraft stalled during a right turn at the end of the downwind leg. It appears that the left wing dropped, away from the original turn direction, and the aircraft entered a steep nose-down attitude. With very little height available there would have been insufficient time to recover.

There is no reason why a 'flypast' such as this should not have been successful but it was probably carried out 'off the cuff' and thereby lacked a pre-consideration of the environment and any plan to avoid associated problems. The aircraft was flying at a low level with a significant tailwind which would have created an illusion of speed. There is always the risk in such conditions, of flying too slowly and stalling while turning. Without the benefit of a stall warning system, and with the low inertia of a microlight aircraft, an inadvertent stall can occur very quickly. It is possible that the presence of a stall warning system could have prevented this accident.

The PFA confirmed that the design called for a galvanised carbon steel cable rather than the stainless steel cable fitted to this aircraft. Notwithstanding this discrepancy, the damage to the cable indicates that it was a combination of the tensile load and the tight radius through which the cable turned around the holes in the mounting bracket that caused it to fail in shear. It was considered unlikely that the change of material of the harness cable had significantly affected its mode of failure or the load at which it failed. Whilst the method used on this aircraft of securing the shoulder harness to the forward ends of the cable, by a shackle, had a number of advantages over that required by the design, there was no evidence that the owner had either sought a concession, or undertaken any analytical work before selecting the particular shackle used. It is considered, however, that the intent of this deviation from design resulted in the shoulder restraint being more effective by reducing the likelihood of the straps slipping sideways off the pilot's shoulder. The following recommendation is made in order to improve the effectiveness of the safety harness on the Team Himax and Minimax aircraft:

Safety Recommendation 2006-006

It is recommended that the Popular Flying Association reviews the design of the attachments of the shoulder harness and its securing cable in the rear fuselage of Team Himax and Minimax aircraft, to reduce the possibility of the shoulder harnesses slipping off the pilot's shoulders and to ensure that all bends in the restraining cable are of greater than the minimum bend radius recommended by the cable manufacturer and not routed over sharp edges.

Safety action

Following circulation of this Report and Safety Recommendation, in draft form, the PFA has issued an approved modification (MOD/186/009) which introduces an improved fixing of the aft attachment of the harness cables.

FORMAL AIRCRAFT ACCIDENT REPORTS ISSUED BY THE AIR ACCIDENTS INVESTIGATION BRANCH

2004

1/2004 BAe 146, G-JEAK
during descent into Birmingham
Airport on 5 November 2000.

Published February 2004.

2/2004 Sikorsky S-61, G-BBHM
at Poole, Dorset
on 15 July 2002.

Published April 2004.

3/2004 AS332L Super Puma, G-BKZE
on-board the West Navion Drilling Ship,
80 nm to the west of the Shetland Isles
on 12 November 2001.

Published June 2004.

4/2004 Fokker F27 Mk 500 Friendship,
G-CEXF at Jersey Airport,
Channel Islands on 5 June 2001.

Published July 2004.

5/2004 Bombardier CL600-2B16 Series 604,
N90AG at Birmingham International
Airport on 4 January 2002.

Published August 2004.

2005

1/2005 Sikorsky S-76A+, G-BJVX
near the Leman 49/26 Foxtrot Platform
in the North Sea on 16 July 2002.

Published February 2005.

2/2005 Pegasus Quik, G-STYX
at Eastchurch, Isle of Sheppey, Kent
on 21 August 2004.

Published November 2005.

3/2005 Boeing 757-236, G-CPER
on 7 September 2003.

Published December 2005.

2006

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

Published January 2006.

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