AAIB Bulletin No: 3/2005 **Ref: EW/C2003/06/04** **Category: 1.1**

Aircraft Type and Registration:	Boeing 777-236B, G-VIIA	
No & Type of Engines:	2 GE90-85B turbofan engines	
Year of Manufacture:	1997	
Date & Time (UTC):	26 June 2003 at 1000 hrs	
Location:	Near Reigate, Surrey	
Type of Flight:	Public Transport (Passenger)	
Persons on Board:	Crew - 14	Passengers - 272
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Access door detached, cabin windows damaged, minor damage to fuselage and fin	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	49 years	
Commander's Flying Experience:	14,750 hours (of which 2,350 were on type) Last 90 days - 190 hours Last 28 days - 36 hours	
Information Source:	AAIB Field Investigation	

Synopsis

A large access door, measuring 4 x 6 feet and weighing 70 lb, detached from the aircraft shortly after takeoff from Gatwick Airport, causing substantial damage to two cabin windows and minor damage to the fuselage and fin. Fragments of the door penetrated into the cabin and large parts of it landed close to persons on the ground. It was likely that only one of the thirteen door catches had been fastened and that the door had suffered overload failure due to aerodynamic forces as the aircraft accelerated, allowing it to open and detach. Multiple walk-round inspections of the aircraft by different personnel had failed to detect the open catches. The inadequate fastening had apparently occurred during a routine maintenance check due to a deviation from standard procedures; a practice that reportedly had been fostered by features of the maintenance system and may have been commonplace. It appeared likely that the human performance factors evident in this event could be affected beneficially by improvements in the operator's maintenance and inspection systems. One safety recommendation has been made.

History of the flight

The aircraft was scheduled to fly from London (Gatwick) to Antigua with a full passenger load. The commander was aware that the aircraft had just completed a period of maintenance when he carried out his external pre-flight check. At 0946 hrs, after a normal engine start, the aircraft was cleared to taxi for Runway 08R. The aircraft took off at 1000 hrs and was cleared by ATC for a 'Southampton Two Papa' (SAM2P) Standard Instrument Departure (SID), requiring it to fly straight ahead for 3.5 nm before turning left to intercept and follow the 263° radial from the Detling (DET) VOR beacon. During the SID the crew contacted London Control and were cleared progressively to 6,000 feet. Before reaching this altitude the aircraft was established on the required radial from Detling, in the clean configuration and at the speed control limit of 250 kt. ATC then cancelled the speed control, allowing the aircraft to accelerate to its optimum climb speed.

Whilst accelerating, in calm flight conditions, both flight crew members briefly felt a slight tremble through the airframe. The cabin attendants seated at Doors L3 and R3 (left and right cabin doors just behind the wing root trailing edges) felt a thump and heard a loud bang; other cabin attendants were aware of a dull thud. The cabin attendants at Doors L3 and L4 moved immediately to the area of Seats 26A to 29A (the left seats in the 1st and 4th rows behind Door L3) where they suspected that the bang had occurred on the side of the fuselage. One of them then informed the flight crew that something had struck the side of the fuselage, whilst the other informed the Cabin Services Director (CSD).

The commander engaged the autopilot and gave control to the first officer (FO), instructing him to maintain 6,000 feet and reduce speed to 250 kt, and summoned the CSD to the flight deck. The commander then went back into the cabin to assess the damage for himself. He saw that the outer pane of the window adjacent to Seat 29A had suffered substantial impact damage but that the inner pane remained intact. There was no obvious damage to other windows or to the fuselage itself. He considered it unwise to continue the flight to Antigua but there appeared to be no reason to land straight away. He reassured the passengers in the immediate area and returned to the flight deck.

The commander briefed the CSD on the nature of the problem, his intention to return to Gatwick and the expected time to landing. He then informed ATC of the situation and requested radar vectors to an area where they could dump fuel, down to the maximum landing weight, before returning to Gatwick. He also made a public address (PA) to reassure the passengers and inform them of his intentions. At the request of ATC the aircraft was climbed to FL 80 before fuel dumping commenced. At this altitude the cabin pressurisation system continued to operate normally.

As the fuel weight reduced the cabin crew perceived a gradually increasing hissing noise in the area of the damaged window and informed the flight crew of this change. A slight vibration through the floor of the cabin was also reported in the area around Seat Rows 26 to 29. At the same time cabin attendants found that a lighting trim fitting had been dislodged from its housing and was lying on the floor near Seat 29A, together with small items of debris that they did not recognise. They also found a larger piece of debris, approximately 2 inches square and painted dark blue, which they passed to the flight deck. The commander considered that these changes could collectively indicate a deteriorating situation and therefore decided to cease dumping fuel and to return to Gatwick immediately for an overweight landing. He organised this with ATC and was given radar vectors for an ILS approach to Runway 08R. The aircraft completed a normal approach and landed at 1047 hrs, approximately 10 tonnes above the maximum normal landing weight.

Fire and rescue services

At 1040 hrs the airfield fire and rescue services (AFS) were notified that an aircraft would be landing overweight with suspected damage to its fuselage. Once the aircraft had landed safely and vacated the runway the Fire Chief, using an external jack point, contacted the flight crew on the interphone system. He informed the aircraft commander that the landing gear appeared normal following the overweight landing but that a panel was missing from the fuselage just behind the left wing root. The commander confirmed that all cockpit indications for the landing gear system were normal and decided to taxy to the allocated stand with the AFS in attendance and maintaining a listening watch on 121.6 MHz.

Flight Recorders

Satisfactory recordings were obtained from the Flight Data Recorder (FDR) and the Cockpit Voice Recorder (CVR). However, power supplies to the CVR had not been isolated after the incident and the recording of the incident was overwritten. The FDR provided no information relevant to the incident.

Aircraft Description

General

The Boeing 777-200 is a twin-engined aircraft of conventional layout approved for ETOPS (Extended Twin-Engine Operations). Certificated maximum take-off weight is 590,000 lb (267,619 kg). G-VIIA was Aircraft Line No 41.

Air Driven Unit bay access door

Hydraulic power is generated in part by two Air Driven Units (ADUs) powered by engine bleed air. The units are installed in the aft end of the left wing-body fairing (Figure 1) and can be accessed via a large rectangular door (No 197JL). This has a curved vertical profile to match the fairing and is 4.18 ft wide, 5.95 ft high (along the curve, Figure 3), generally 1.3 inch thick and weighs around 70 lb. It is constructed of laminated carbon-fibre skins bonded to a 'nomex' honeycomb core. The inner and outer skins are laminated directly to each other around the periphery of the door, providing a lip which fits into a recessed part of the doorframe. The door is attached to the fairing by 3 steel hinges on its top edge and is retained closed by 13 push-release catches (Part No (PN) HA260-3), numbered in this report as in Figure 3. The lower catches are accessible from the ground by a moderately tall person.

When unlatched, the door hangs partially open on its hinges. It can be propped open in either an 'Intermediate, No 1' or 'Fully Open, No 2' position by a stay fitted in one of two doorframe brackets. A red-painted placard on the lower part of the outside of the door warns 'CAUTION - DO NOT OPERATE FLAPS WITH DOOR IN THE INTERMEDIATE POSITION'.

Each catch consists of a mechanism attached to the inner face of the door lip by 4 bolts (Figure 4). Cut-outs in the door skin provide external access to each catch and clearance for it to open. When the catch is closed, a pivoting latch lever bears against a latch pad fixed to the doorframe and fitted with a wear plate. Door adjustment is achieved by fitting different thickness wear plates; those on G-VIIA were between 0.015-0.040 inch thick.

The latch lever is spring-loaded to open and is retained closed by contact with a trigger lever, which itself is spring-loaded to close against a stop on the catch frame. The latch lever/trigger lever contact point is positioned so as to over-centre the mechanism; ie an increased latch lever opening force provides an increased trigger lever closing force.

The catch is released by manually pushing the trigger lever inwards until it disengages from the latch lever, allowing the latch lever to rotate under spring loading and disengage from the pad (Figure 5). The latch lever rotates 90°, its inner end passing through the door cut-out and protruding 0.85 inch beyond the outer surface of the door. The protruding portion has a generally rectangular cross section of approximately 0.7 x 0.4 inch; on G-VIAA the exterior face (when closed) was painted the same dark blue as the door and the side and inner faces were generally unpainted silver-coloured aluminium. It was noted that the side faces of the latch levers on the replacement door were painted orange. The trigger lever returns to its flush position when released. The outer face of the trigger lever was generally painted dark blue; in G-VIIA's case this paint had disappeared from some of the catches, leaving the silver-coloured metal surface of the trigger levers visible (Figure 6).

Cabin windows

Each cabin window unit consists of two transparent acrylic panes fitted into an elastomeric edge seal (Figure 2). The seal bears against a fuselage sidewall flange formed around the window aperture and the unit is held in place by 10 small steel clips, each fixed by a single bolt, which bear against the inner pane. A third pane, fitted into the cabin trim panel, forms an inner protective cover. The outer pane has a bevel around its exterior edge and, with the cabin unpressurised, is recessed approximately 0.12 inch from the outer surface of the fuselage skin.

Aircraft examination

Examination of the aircraft revealed the absence of the ADU bay door and the presence of paint deposits, scraping and gouge markings on the side of the fuselage just below and aft of L3 Cabin Door. All three ADU door hinges were found fractured. The markings showed that the ADU bay door had rotated open on its hinges until its outer surface had struck the fuselage skin immediately above the door aperture. The hinges had over-travelled and failed in overload and the door had travelled upwards and rearwards with parts of its outer surface in firm contact with the fuselage. Six deep gouges in the fuselage skin, with progressively increasing spacing, were evident near the forward edge of the scrape markings. With the catches closed, the outer surface of the door is smooth and it appeared highly likely that the gouges corresponded to sequential contact by the protruding latch levers of the six catches on the door forward edge. The spacing suggested that the door had rotated as it had translated and accelerated upwards and rearwards relative to the aircraft.

The fuselage scrape marks passed over the lower aft corner of Door L3 and over the first two cabin windows aft of the door. A piece of blue-painted carbon-fibre laminate, approximately 2 x 2 inch in size, reportedly entered the cabin at the first window ('Window A', Figure 1), adjacent to Seat 26A. It was clearly part of the external skin of the ADU bay door, although its original location on the door could not be established. Inspection indicated that it had been forced in between the window unit seal and the window frame. Some of the retaining clips for Window A had been distorted or displaced and the retaining screws bent, allowing the window unit to displace inwards at its aft top corner. The sidewall trim panel adjacent to Seat 26A had been displaced slightly and a sidewall light cover in the area had detached.

A portion of carbon-fibre laminate approximately 3 x 6 inch in size was found at the fourth window ('Window B', Figure 1) embedded between the window unit seal and the aft upper corner of the fuselage window aperture. This piece, identified as the outer skin of the aft lower corner of the ADU bay door (Piece 6, Figure 3), protruded partially into the cabin at Seat Row 29. The outer pane of Window B exhibited heavy scrape marks terminating in an approximately 3.5 x 0.7 inch irregular penetration hole, with associated local fracturing of the pane. The damage profile and paint deposits on the pane were consistent with impact by a latch lever protruding from one of the catches. Additional damage consisted of an approximately 6 inch long gouge in the composite skin forming the left side of the fin, about one third of the way up.

The ADU bay doorframe had not been damaged and all the latch pads were in place and undistorted. Most of the pad wear plates had been severely worn by frettage against the latch lever of the associated catch. Seven of the plates had been completely penetrated and the wear had continued into the respective pads, in one case reducing the pad thickness from 0.112 inch to 0.046 inch, but none of the pads had failed. Within the ADU bay a duct insulation blanket had been disrupted and severely damaged. With this exception, the components in the bay showed no signs of damage.

Debris lying in a wooded area near Reigate, discovered by a dog walker, was identified as part of the missing door. A search of the area located other parts and a large portion was found when a couple who had been out walking described having seen it fall nearby after their attention had been drawn by another substantial part of the door impacting the ground around 20 feet from them. Around 60% of the door was recovered (Figure 3), all from the ground beneath the flight path, apart from the small portions of door skin that remained with the aircraft. Much of the ground area was covered with dense, high undergrowth and in spite of a prolonged search the remainder was not located.

The recovered parts included 9 of the 13 catches. Five of these were found in the open state, with no apparent damage. The other four catches had been distorted. In the case of two of these (Catches 2 and 10) the damage was consistent with the effects of door fractures that passed through their location. Catch 10 also had marks suggesting that some damage had resulted from impact on the protruding latch lever. One (Catch 5) was located immediately adjacent to the door skin piece that had penetrated the cabin at Window B. The evidence suggested that the protruding latch lever of this catch had caused the hole in the window's outer pane and that the catch had been damaged in the process. The remaining distorted catch (Catch 6) had not been in a region of appreciable door damage; the evidence was consistent with it having been damaged by an inward overload applied to the closed latch lever.

Detailed examination of the catches revealed no plausible mechanism by which they either could only partially engage or could spontaneously release.

Maintenance background

At the time of the accident the operator was in the process of modifying its Boeing 777 maintenance programme to align it more closely with the aircraft manufacturer's programme. The realignment had occurred over a period of approximately a year, during which time the schedule of check items had varied. Some personnel interviewed during the investigation considered that the changes in the schedule of check items over an extended period increased the likelihood of errors, although no evidence was found positively to show that this was the case. G-VIIA was the first of the fleet to become aligned with the new programme. The first maintenance operation in accordance with the new programme, a 'B+2A Check', had been carried out on G-VIIA in a hangar at Gatwick Airport between 22-25 June 2003. The accident flight was the first since completion of the check.

Detailed inquiries were made in an attempt to establish the sequence of possibly relevant events during the check. The personnel involved in the incident provided full assistance with the investigation and their approach suggested that it had been their intention to be conscientious.

Standard practice was for the maintenance check to be carried out in accordance with a 'Work Pack', where each item of scheduled work was specified on an individual 'Work Card'. Four boxes on each card required an identity stamp, respectively signifying authorisation, completion and clearance of the task and clearance of the Work Card. It was intended that the mechanic or engineer carrying out a task would stamp the completion box and a Licensed Aircraft Engineer (LAE) would then stamp the boxes certifying clearance of the work and the card.

To enable the progress of the check to be controlled, the cards were generally stored in a number of racks. The racks for the cards covering avionics and cabin tasks were located on the mezzanine floor of the maintenance docking stands and the racks for the cards covering the other items were on the hangar ground floor to one side of the aircraft. The cards were thus not in the immediate vicinity of individual work sites and task completion stamping therefore tended to occur in batches.

The Work Cards included a considerable number that specified the opening of individual access panels, to enable the required work to be done in accordance with other individual Work Cards. Further cards each specified the inspection of an opened bay after completion of the work, followed by closure and re-securing of the access panel. It was reported that some complication was typically introduced by the inclusion in the Work Pack of duplicated cards and of cards requiring the opening of a number of bays without any subsequent requirement to carry out work within them. Additionally, while the Work Cards requiring access panel opening or closing specified the panel identity number, they did not provide an illustration of the location of the panel on the aircraft. The location could be determined from access panel diagrams in the Aircraft Maintenance Manual (AMM) but this reportedly tended to be a lengthy process.

Discussion with a number of the maintenance personnel indicated that in practice some access panels would be re-secured after the work in the associated bay had been completed but the completion boxes in the relevant panel closure Work Cards would remain unstamped. In other cases, where a number of separate work items in the bay could possibly be required, the panel would remain open.

Thus the LAE supervising the check typically would be left towards the end of the check with a number of cards with unstamped panel closure boxes for panels that had already been closed.

As was usual, G-VIIA's check had been conducted by three shifts of workers over each 24 hour period; shift rotation patterns and absences meant that the personnel forming a particular shift could vary from day to day. Thus tracing an individual who had closed a panel but not stamped the associated card was difficult. In such a case the panel should be re-opened, the bay inspected and the panel re-closed, but some of the personnel reportedly felt that such a practice could invoke management criticism of unwarranted delay in the completion of the check. The available evidence indicated that it was thus apparently normal practice, when all the maintenance tasks had been completed, for the LAE to instruct all access panels remaining open to be closed and then to visually inspect the aircraft and, on this basis, stamp the remaining panel closure cards.

G-VIIA maintenance

The only routine maintenance requiring the opening of the ADU bay door was to allow for checking of ADU gearbox oil levels, specified at 6,000 hour intervals by the manufacturer's maintenance programme. Inquiries indicated that during the check G-VIIA's ADU door had been opened to the No 1 position for this purpose early on 22 June. It was reportedly seen to be closed before the trailing edge flaps were retracted on 25 June but it was not possible to establish how the closure had been carried out. The Work Card for ADU bay inspection and door closure had been cleared on the basis of 'the panel being seen to be secured'.

At completion of the work in the early hours of 25 June, G-VIIA had been towed to the apron outside the hangar where the responsible LAE and another engineer each conducted a walk-round inspection. It had then been towed to a stand near the cargo area (Stand 178), where it remained for approximately 24 hours. This stand, although in a somewhat remote area of the airport, was immediately adjacent to a continuously manned security checkpoint, from where it was clearly visible.

Early on 26 June a 3-man maintenance crew had replaced a passenger seat set in the rear cabin, using a high-loader vehicle at Door L3. This operation would have placed the vehicle and crew directly in front of the ADU bay door before the vehicle body was raised. After the seats had been fitted, G-VIIA had been towed to the departure stand. Crews towing the aircraft to and from Stand 178 were required to conduct a pre-tow walk-round check. At the departure stand an Engineering ETOPS Transit Check had been conducted, requiring an engineer to make a preliminary inspection, a detailed inspection and a final walk-round inspection. The captain had then conducted his pre-flight walk-round inspection, followed by a further walk-round check carried out by each of the two push-back crew members.

All of the walk-round checks were carried out in daylight and in fine weather. All were reportedly carried out in the same direction; ie moving rearwards down the right side of the aircraft and forward along the left side.

Previous events

Information on previous cases of problems with the ADU bay door catches was obtained from the aircraft manufacturer. Cases of catches being found open after flight were experienced during Boeing 777 type certification flight testing; these were attributed to catch deformation under in-service loads and an improved higher-strength catch (PN HA260-3) was introduced. G-VIIA was fitted with the improved catch. The manufacturer has received no reports of this type of catch opening in flight. Based on the manufacturer's test results, forcible door opening would be expected to cause substantial deformation of the catch mechanism.

Cases of excessive in-service wear of the catch pads on the ADU bay doorframe associated with the PN HA260-3 catches had been reported to the aircraft manufacturer. The latter had issued a Fleet Team Digest (777-FTD-53-02002) on 12 April 2002, requesting operators to inspect the pads at the earliest maintenance opportunity, to report back on cases of excessive wear and to replace worn components. A revision of the FTD issued on 11 July 2003 noted that a Service Bulletin on the matter would be issued and that this would also advise that a further improved design of catch (PN HA745-1) was available for aircraft fitted with a previous standard. This improvement was apparently aimed at reducing pad wear and improving adjustability.

One previous case of in-flight detachment of the ADU bay door, in 1998, had been reported but the cause was not established. Damage had reportedly been confined to loss or disruption of insulation blankets in the bay.

It appeared that G-VIIA's accident could have had similarities with three other known recent cases of uncompleted maintenance operations on other aircraft in the operator's fleet that had led to serious incidents. The incidents, which involved a Boeing 757 on 7 September 2003, a Boeing 757 on 19 November 2003 and a Boeing 777 on 10 June 2004, are under investigation by AAIB.

Discussion

Airframe damage

It was evident that G-VIIA's ADU bay door had opened violently as the aircraft was accelerating and climbing towards 6,000 feet amsl. Over-rotation of the door had caused its three hinges to fracture and the door to detach and fracture. Corners of the door skin had snagged on the edge of the window frame at Windows A and B as the door slid up the side of the fuselage and been driven between the frame and the window unit. This had allowed small parts of the door skin to enter the cabin and caused minor displacement of the cabin trim.

The window unit displacement was unsurprising as the fastening arrangement did not appear to be particularly robust, consistent with the lack of a design requirement for the fasteners to normally withstand substantial inward forces. The usual forces on the window unit are predominately outward-acting cabin differential pressure loads reacted by the frame flange. At the time of the door detachment only a small differential pressure would have been present to assist in reacting the impacts. The slight recessing of the window unit in this condition, together with the effect of the outer pane bevel, may have assisted in the snagging of the door. At greater altitudes a higher differential pressure would be expected both to reduce these effects and to increase the resistance to both window seal and window unit displacement.

Door Detachment

The door detachment was consistent with the effect of normal aerodynamic forces acting on an inadequately restrained door, causing any catches that were fastened either to disengage because of door distortion or to fail under overload. The doorframe and the latch pads remained undistorted and the wear on many of the pads, while severe, would not have allowed the catches to disengage. It did not appear likely that a lack of engagement of a few catches would significantly compromise door retention. It was therefore evident that multiple catches had either failed, spontaneously come open or been left open.

The state of the four recovered catches that had been distorted could not be ascertained with certainty from examination but damage to the aircraft indicated that at least two of them (Catches 5 and 10) had been open. The damage to one of the others (Catch 6) was consistent with the effects of overload while the catch had been fastened. The remainder of the other five recovered catches were found undamaged but open. In addition, as the catches are flush with the door outer surface when closed, the deep regular gouge markings on the fuselage skin indicated that all six of the catches on the forward edge of the door were open. The evidence therefore indicated that 11 of the catches, and possibly all of them except No 6, had been open when the door detached. As examination of the catch mechanism identified no way in which it might spontaneously release, it appeared that 11 or 12 of the 13 catches had been open at the time G-VIIA had left the departure stand and that Catch No 6 had probably been fastened. This conclusion was supported by previous service history.

The last known occasion on which the ADU bay door had been opened was during the maintenance check preceding the flight and there appeared to be no plausible reason for the latches to have been disturbed during subsequent aircraft preparations. Most of the catches could not be reached from the ground. The aircraft had been parked on a remote stand for a period after the check, but this was in an area of the airport intended to be highly secure and the aircraft had been in clear view of a nearby security post. The aircraft had subsequently been located on the departure stand at the airport terminal. It was therefore concluded that unauthorised interference with the catches after the check was improbable.

Post maintenance inspections

It would be expected that a door, inadequately secured at the end of a maintenance check, with apparently at least 11 of the catches open, should have been detected by the 11 subsequent walk-round inspections, conducted in good ambient conditions by 9 different individuals. However, a number of factors may have influenced this.

The square, perpendicular appearance of the released latch levers and their regular spacing might appear less abnormal than a more irregular, angulated mechanism. The trigger levers would have been in their normal closed position and the metallic finish of some of them might have made protruding latch levers somewhat less conspicuous. The orange paint found on the latch levers of some other ADU bay door catches did not appreciably add to their conspicuity and could be considered likely to have been of only marginal benefit.

Additionally, the routine nature of the inspection task and the knowledge, by each of the 'inspectors' that others had made, or would make, similar checks might subconsciously have led to a reduced level of attention. All of the aircraft walk-round inspections were apparently conducted in the same direction (clockwise as viewed from above). When approaching the rear of the left wing during the inspection it appeared possible that an 'inspector's' attention could transfer directly from the left horizontal stabiliser to the left wing, No 1 engine and left main gear consequently reducing the attention paid to the apparently less complex wing/body fairing region.

General

Satisfactory completion of the complex maintenance operations relied on the procedures being followed and the accident apparently resulted from an omission made when there had been a departure from procedures. The changes in the schedule of check items over an extended period, occasioned by the maintenance programme realignment, reportedly may have increased the likelihood of errors, but this could not be confirmed. However, the available evidence suggested that some features of the maintenance system could have made it difficult to both follow the procedures exactly and carry out the work expeditiously. These features, which included the duplication of scheduled tasks, the scheduling of unnecessary tasks, the separation of maintenance and panel closure tasks and the lack of a ready means of identifying panels, had apparently reduced the likelihood of strict adherence to the procedures.

A considerable amount of research has been carried out in recent years into the human factors involved in maintenance errors. General conclusions have been that improvements to maintenance systems and to the corporate culture in which they operate can help to ensure that procedures are followed and thus the likelihood of human errors can be reduced. In many instances the possibility for errors to occur cannot be entirely eliminated and it must be incumbent on any system to detect errors and to limit their consequences. Whilst disciplinary action taken against individuals for non-conformances can have an isolated and sometimes short term effect it has been widely accepted that this is likely to be less effective in preventing recurrence than systematic improvements. Furthermore, in cases where disciplinary action is considered appropriate, conflict of interests can often result from the attribution of this responsibility to a department responsible for quality.

Conclusions

Although major airframe damage did not occur in this case, the loss of the door constituted not only a hazard to those on the ground but it also had the potential to hazard the aircraft.

While it appeared improbable that multiple open catches would not have been detected during the numerous inspections following the maintenance check, elimination of other possible scenarios indicated that this had in fact been the case. In the absence of other plausible explanations, it was concluded that the door had probably been temporarily closed and secured with Catch 6 during the maintenance check, possibly to allow operation of the trailing edge flaps, and that the remaining catches had subsequently remained unfastened. The excessive wear of a number of the doorframe pads, although not relevant to the detachment of the door, was indicative of an inappropriate level of maintenance in this area.

The available evidence suggested that the maintenance personnel involved in this event had intended to be conscientious. Standard procedures were in place aimed at ensuring the inspection of the ADU bay and the correct re-securing of the door before completion of the maintenance check, but the evidence suggested that the LAE supervising the check could experience difficulty in assiduously following these in practice. It appeared that this had led to a lack of proper bay inspection certification and to the door having been inadequately secured and that the omissions had been missed by the subsequent inspections.

The available evidence did not positively indicate the extent to which maintenance practices may generally have deviated from specified procedures. However, a number of areas where there appeared to be scope for improvement of the system were identified and it appeared likely that addressing these may be more effective in preventing recurrence than attributing the failures solely to individual error. This conclusion was reinforced by the preliminary evidence that similar maintenance issues to those indicated above may have been involved in three other serious incidents to the operator's aircraft in a 10 month period.

Safety Recommendation

The company agree that it is prudent to continually review its management systems and practices to ensure the correct completion of maintenance operations. The following recommendation is therefore made to bring to the company's notice areas, within their maintenance operations, where focussed attention should be considered:

Safety Recommendation 2004-77

It is recommended that British Airways, when reviewing their maintenance inspection and management systems and practices should consider:

(a) reviewing work packs to ensure that no duplicate or unnecessary tasks are specified;

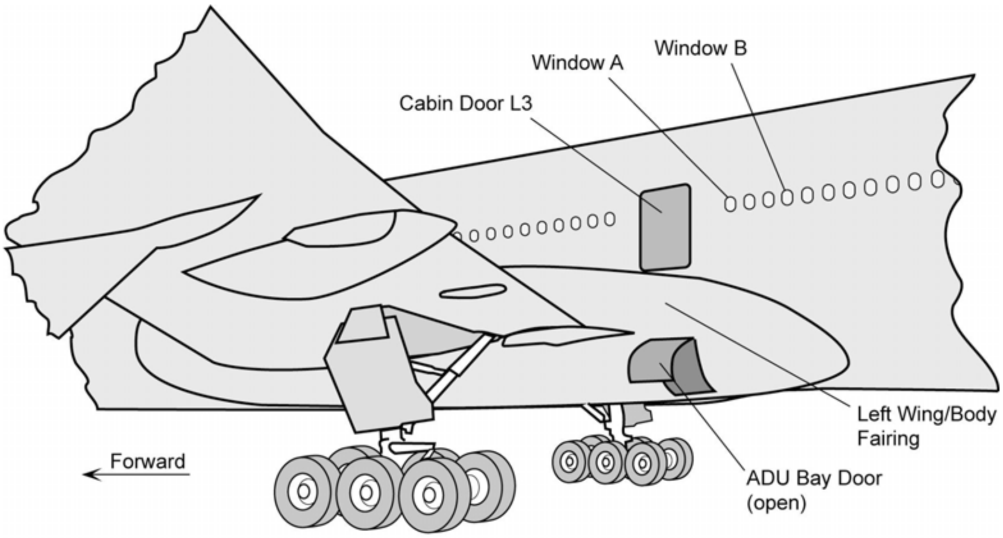
(b) combining access panel opening and re-securing actions during maintenance with the associated maintenance task on a single work card

(c) including on work cards illustrations indicating access panel locations;

(d) additional measures to ensure the re-securing of access panels after maintenance;

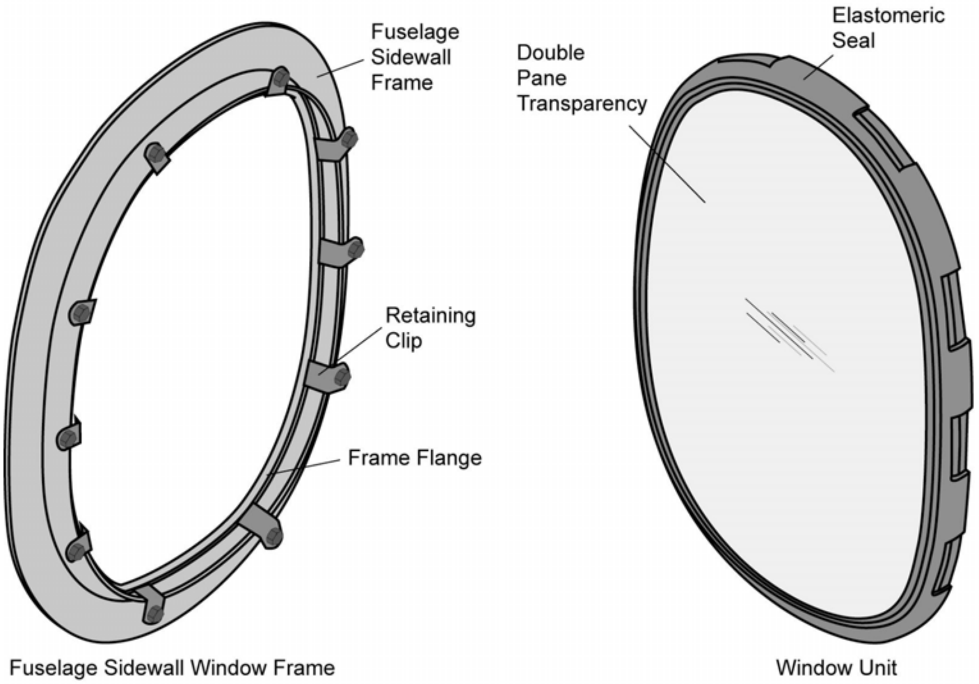
(e) measures aimed at ensuring that access panel latch pads wear is rectified before it becomes excessive and,

(f) examining the possible benefits of varying the walk-round direction for some of the multiple airframe inspections.



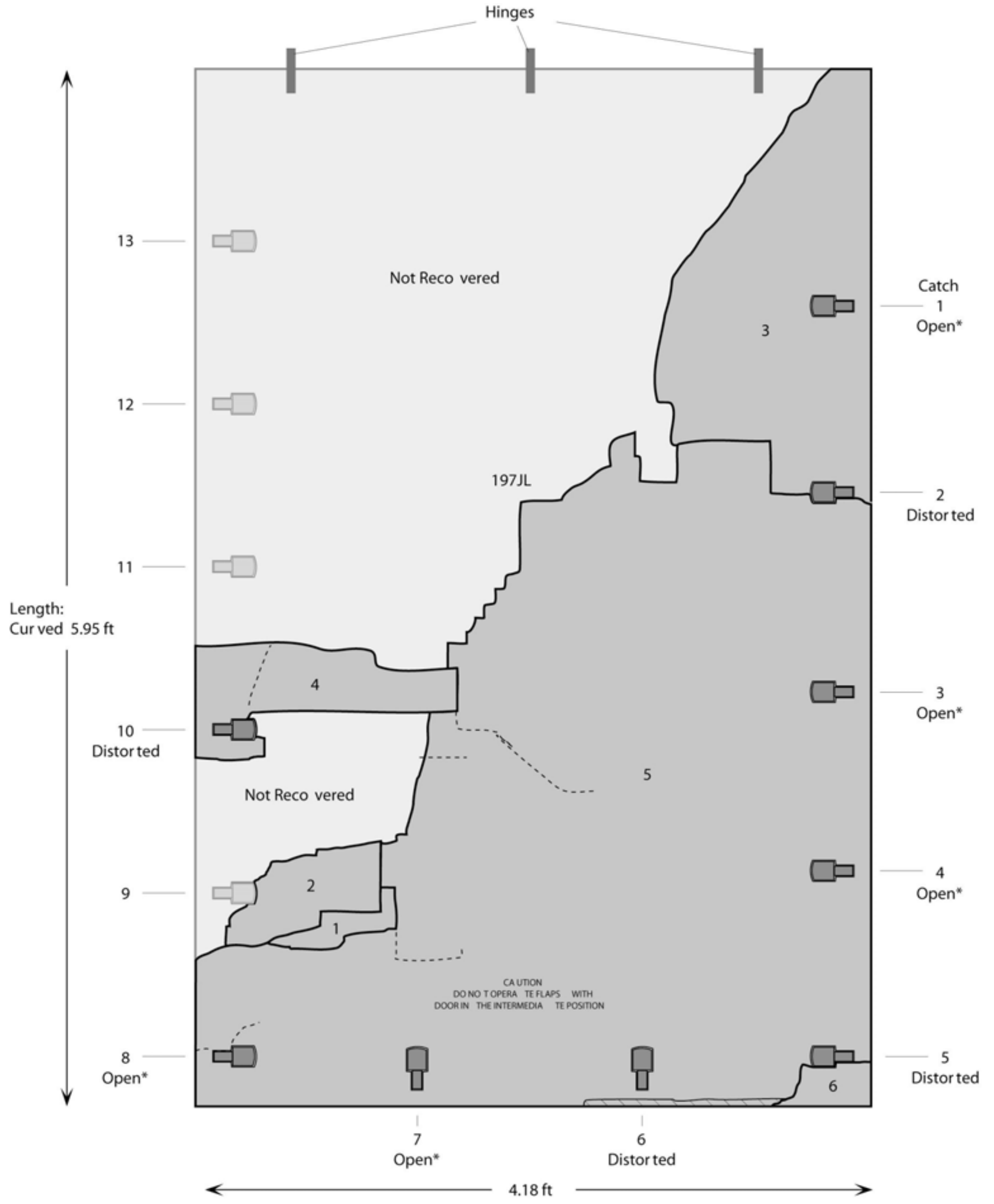
Air driven unit access door location

Figure 1



Cabin window unit

Figure 2

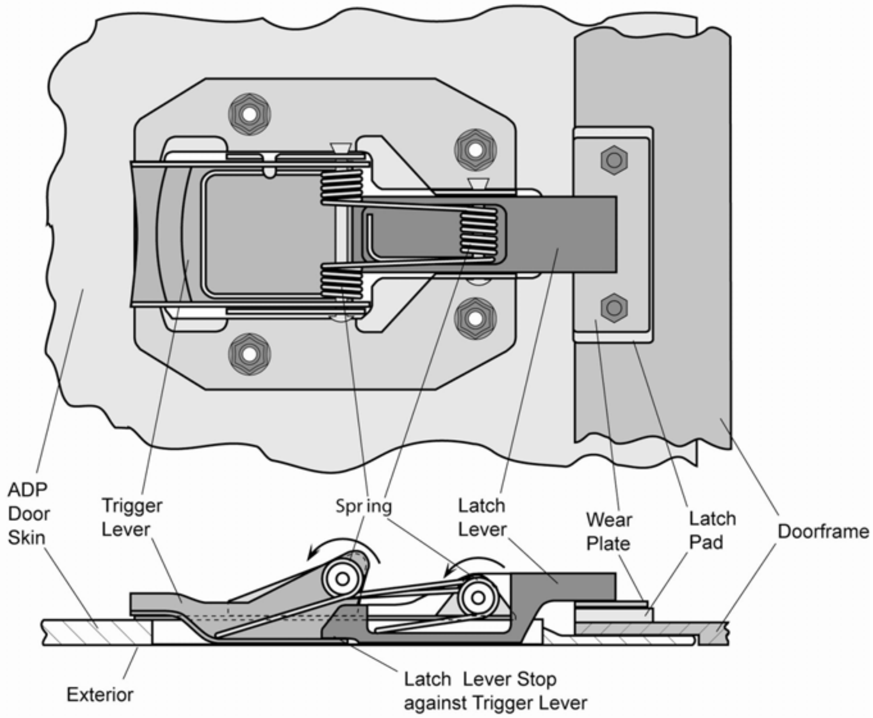


NOTE
1. Door drawn flattened.
2. All recovered items shown except for several small pieces whose location on the door could not be established
3. All recovered items found on ground beneath flight path, except as noted below.
4. Piece 6 found embedded between Seal and fuselage aperture for Window B
5. Piece 8 (approx 2x2 inch, not shown) entered cabin between Seal and fuselage aperture for Window A.

KEY
1. Recovered items in darker shading.
2. * Apparently undamaged.
2. ▨ Paint scraped off.
3. ------ Crack in outer skin.

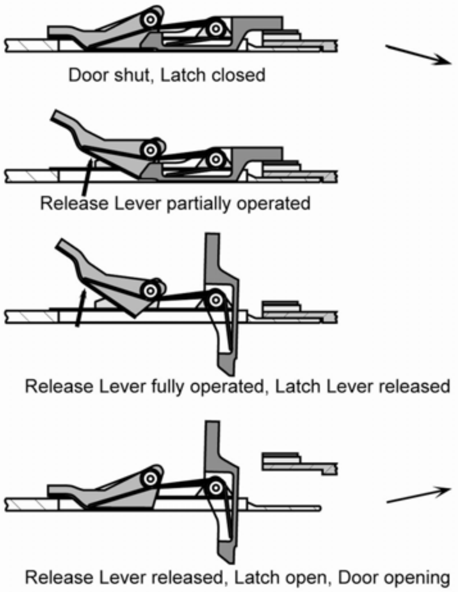
G-VIIA ADU acesss door schematic

Figure 3



ADU bay door latch

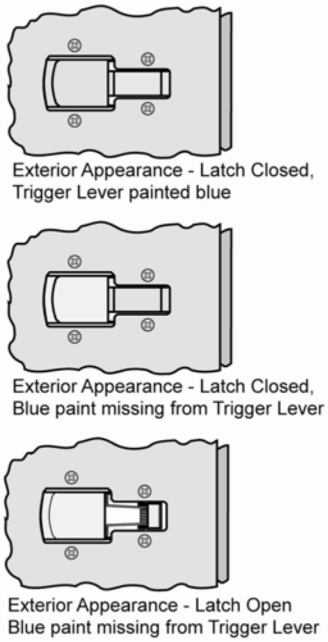
Figure 4


Door shut, Latch closed

Release Lever partially operated

Release Lever fully operated, Latch Lever released

Release Lever released, Latch open, Door opening


Exterior Appearance - Latch Closed, Trigger Lever painted blue

Exterior Appearance - Latch Closed, Blue paint missing from Trigger Lever

Exterior Appearance - Latch Open Blue paint missing from Trigger Lever

ADU bay door latch operation (side view)

Figure 5

ADU bay door latch (Plan view)

Figure 6

Aircraft Type and Registration:	McDonnell Douglas DC-8-63F, 9G-MKO	
No & Type of Engines:	4 Pratt & Whitney JT3D-7 turbofan engines	
Year of Manufacture:	1971	
Date & Time (UTC):	29 April 2003 at 1500 hrs	
Location:	RAF Lyneham, Wiltshire	
Type of Flight:	Public Transport (Cargo)	
Persons on Board:	Crew - 4	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Right main landing gear fractured	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	43 years	
Commander's Flying Experience:	10,200 hours (of which around 3,500 were on type) Last 90 days - 220 hours Last 28 days - 85 hours	
Information Source:	AAIB Field Investigation	

Synopsis

The aircraft's right main landing gear suffered extensive fracturing of its shock-strut piston as the aircraft was making a 180° taxiing turn. Associated disruption to the landing gear scissor linkage allowed the landing gear truck to diverge approximately 45° from the aircraft's heading, but one of the broken parts of the piston remained jammed in the shock-strut cylinder and continued to support the aircraft. Around 90% of the specified overhaul life of the landing gear remained at the time of the accident.

Specialist examination indicated that the piston material was in accordance with the aircraft manufacturer's specification. The fractures had originated from a small pre-existing stress corrosion crack in an area of the surface where cadmium plating was absent. The crack had probably been initiated by abnormally high local stresses associated with a step in a blend radius in the region of the crack origin and with surface scratches in the area. These features should have been apparent during the last overhaul of the landing gear. The pre-existing crack, while small, was probably sufficient to cause the rapid extensive fracturing of the piston under normal operating loads, given the notch sensitivity of the high-strength steel from which it was made.

One safety recommendation, relating to the Federal Aviation Administration's oversight of overhaul organisations has been made.

History of the flight

The aircraft had been prepared for a cargo flight from RAF Lyneham to the Middle East, with a take-off weight of 297,996 lb (135,170 kg). The weather at Lyneham was good, with a surface wind of approximately 200º/15 kt. Runway 24 was in use; this has an asphalt surface that was damp at the time of the accident. The runway is 148 feet (45 metres) wide; a paved protrusion on the right side of the runway at its start provides a turning area 206 feet wide and 200 feet long.

After taxiing to the runway, the aircraft backtracked to the turning area and commenced a 180° right turn to line-up for takeoff. With around 20° of the turn remaining the crew heard a loud noise and the aircraft came to a halt. Engine power was increased but the aircraft did not move; the crew realised that there was a technical problem and requested assistance. Ground engineers found that parts of the right main landing gear (MLG) had fractured and its truck had rotated approximately 45° left relative to the aircraft's heading. The aircraft was then shutdown. It remained on the runway for around 36 hours while the right MLG was replaced.

Aircraft description

The McDonnell Douglas DC-8-63 is a four-engined freight aircraft of conventional layout with a tricycle landing gear. Maximum authorised taxi weight is 358,000 lb (162,388 kg) and maximum authorised take-off weight 353,000 lb (160,120 kg).

Manufacturer's data on ground manoeuvring indicates that the minimum pavement width for a 180° turn is 139 feet, using the maximum nose landing gear steering angle of 67°. Cautions were given in the Aircraft Maintenance Manual and the Operation Manual against using MLG wheel braking to tighten a turn.

Main landing gear description

The MLG leg (Figure 1) consists of a cylinder/piston type oleo shock-strut. The shock-strut cylinder is attached to the wing structure and a four wheeled truck (bogie) is connected to the lower end of the piston by a pivot pin. The vertical load on the piston is supported by a pressurised nitrogen charge within the cylinder and shock absorption is provided by translation of the piston within the cylinder, controlled by regulating the flow of oil between chambers within the oleo. Rotation of the piston relative to the cylinder is prevented by a scissor linkage, consisting of two torsion links, connected together by a horizontal apex pivot joint. The lower torsion link is attached to the piston via a horizontal pivot joint and the upper torsion link is similarly pivoted onto the cylinder.

The piston is approximately 44 inches long and its main part is 9.5 inches in diameter with a 0.63 inch wall thickness. It is closed at its base and carries a number of integral clevis lugs. Two lugs extending below the piston base form a clevis for the truck beam pivot pin and the truck beam fits between these lugs. Two other lugs, formed in an integral boss on the inboard side of the piston near its base, form the clevis for the lower torsion link pivot pin. The bearing faces of these lugs, where they contact the torsion link, are chromium plated.

The piston is manufactured from 4340 steel, a relatively high-strength chromium-nickel-molybdenum steel alloy. It is machined from a forging defined by Douglas Material Specification (DMS) 1555H, and heat-treated to a ultimate tensile strength of 260-280 ksi (thousand pounds per square inch). This is followed by shot peening to reduce residual surface tensile stresses, by cadmium plating for corrosion protection and by hard chromium plating of load bearing regions. The overhaul life specified by the aircraft manufacturer for the shock-strut was 23,000 flight hours; no flight cycle limit was specified. Repair schemes include chromium plating of the plane faces of the cylinder and piston clevis lugs to which the torsion links attached.

Maintenance background

Maintenance records indicated that at the time of the accident 9G-MKO (Serial Number 46147, previously registered as N811CK) had accumulated 48,076 flight hours and 16,533 flight cycles. Its last major check, a 25,000 hour D Check on 28 June 1998, had been 4,944 hours prior to the accident and its last C Check (3,000 hours), on 12 December 1999, had been 2,382 hours before the accident.

The right MLG (Part Number 5759101-5018, Serial Number HA002) had been fitted at the time of the C Check after it had been overhauled in the USA. It had been removed for overhaul from another aircraft and released to service in September 1999 as a zero time unit; documentation did not indicate that the shock-strut piston had been replaced during the overhaul. Subsequent to the C Check, the aircraft had operated for 453 flight hours on the USA register, before being purchased by the operator at the time of the accident, 1,926 flight hours before the accident. Thus at the time of the accident the right MLG had accumulated 2,379 flight hours since its overhaul, around 10% of the specified overhaul life.

Wreckage examination

Initial examination revealed that the piston of the right MLG shock-strut had sustained extensive fracturing that had separated the piston into four main pieces and a number of fragments. A generally axial fracture passed through the base of the two lower torsion link clevis lugs and through the aft limb of the left (inboard) truck beam clevis lug (Figures 2 and 3). From this fracture, two fractures extended up the left side-wall of the piston. Around 9 inches from the base of the piston one of the fractures had become generally circumferential, separating the lower part of the piston into two pieces, detached from the remainder of the piston, with each piece including one of the truck beam clevis lugs.

The right hand piston piece remained jammed into the cylinder and continued to support the aircraft weight. The smaller piston piece, on the left side, remained attached to the lower torsion link. Further fractures extended up the piston (Figures 4 and 5) beyond the circumferential fracture and separated an additional 6 inch length of the piston, which also remained in situ.

The upper torsion link of the scissor linkage remained intact and connected to the cylinder. The lower torsion link had fractured at the apex pin connecting it with the upper torsion link. At its other end, the lower torsion link remained intact, but the unfractured forward limb of the left truck beam clevis lug had twisted around 40°. Deformation and markings indicated that both the torsion link fracture and the lug twisting had resulted from loads transmitted by the scissor linkage as the cylinder had rotated clockwise relative to the truck beam, as viewed from above.

Detailed materials assessment

The shock-strut was disassembled and a detailed specialist assessment of the piston and lower torsion link fractures was made, together with an investigation of the piston material. This found that the majority of the fractures had resulted from sudden catastrophic overload. Directional features on the fracture surfaces indicated that the origin of the failure had been at the edge of the aft lug of the clevis for the lower torsion link, at a blend radius at the edge of the chromed face forming a bearing surface for the torsion link.

Metallographic examination of a sample taken from the region of the suspected origin found that the microstructure consisted of tempered martensite, which is typical of 4340 steel alloy. Energy dispersive X-ray (EDX) analysis of the sample yielded a material spectrum that was also fully consistent with 4340 steel alloy. Hardness testing showed that the average hardness was 539 HV30, equivalent to a tensile strength of 269 ksi and thus within the specified range.

Detailed examination of the suspected region of the fracture origin revealed an area of staining approximately 5 mm (0.197 inches) across and 2 mm (0.078 inches) deep at the edge of the fracture (Figure 6). Examination by scanning electron microscopy showed that the fracture surface outside of the stained region exhibited ductile dimples, characteristic of static overload failure. Within the stained region, crack branching and corrosion product deposits were evident on the surface and the fracture surface had a more intergranular morphology, characteristic of stress corrosion cracking.

The origin area showed signs of three distinct discoloration bands, with evidence that the initial crack had originated at two points (heavily stained areas). The markings indicated that these cracks had combined into a single crack, which had progressed over an area that was less discoloured and then over a further heavily stained area. There was no clear evidence as to the cause of the banding but it may indicate that the crack had been retarded during its growth for a period, possibly due to a temporary reduction in the stress in the component.

It was apparent from the examination that there was a step in the blend radius in the area of the crack origins and mechanical damage locally that was consistent with machining damage in the region (Figure 7). Additionally, EDX mapping showed that, while cadmium plating was generally present on the surface adjacent to the crack origin, it was absent near the edge of the crack (Figure 8). As cadmium is relatively soft and unlikely to spall off as a result of cracking, if correctly applied, it appeared that it had either not been applied in the area of the crack, had not been applied correctly or had been removed during service.

Inspection of the microstructure using nital etching of the surface around the fracture origin and of a polished transverse section through the origin showed no signs of grinding burns. Examination for evidence of shot peening of the surface was inconclusive.

The specialist analysis noted that steels with strength levels greater than a corresponding hardness of around 400 HV are acutely susceptible to stress corrosion cracking, a process where intergranular fracturing of a component under sustained tensile stress in a corrosive atmosphere can occur. A moist air environment would probably be sufficient to constitute such an atmosphere in the case of high-strength steels such as 4340. It was also noted that, while cadmium plating would prevent exposure to the corrosive atmosphere, and thus prevent stress corrosion cracking, in practice it was likely that service use would eventually cause the cadmium plating layer to be compromised in places.

The susceptibility to such cracking would be particularly increased by the presence of a stress raiser, such as a step or nick in the surface. A Boeing article on the Maintenance of High-Strength Alloy Steel Components, published in 2003, also noted the notch sensitivity (sensitivity to stress concentrations) of high-strength alloy steels, defined as steels that generally had been heat-treated above 180 ksi, and emphasised the necessity of proper rework practices. It noted that stress concentrations can lead to initiation of cracking by stress corrosion and other mechanisms, that abrupt changes in sections should be avoided and that finer surface finishes may be needed to eliminate unnecessary stress concentrations, especially in areas of machined radii.

The assessment concluded that 9G-MKO's right MLG piston material was 4340 steel alloy that had been correctly heat-treated. The piston had suffered catastrophic failure due to stress corrosion cracking that originated at a step in a blend radius in the truck beam pin lug where surface scratching damage was also present and cadmium plating was absent. The critical crack length in 4340 steel, ie the depth of crack which could result in rapid extension of the fracture under normal operating stresses, is small, and the catastrophic failure resulting from a stress corrosion crack only 2 mm deep was not considered unusual.

Previous cases

Information on two previous similar cases was found, detailed in McDonnell Douglas All Operator Letters (AOL), as follows:

> AOL 8-1182 (2 June 1994) that noted:
>
> *"One operator recently experienced failure of a right hand main landing gear (MLG) piston assembly while negotiating a 180 degree turn during aircraft positioning for takeoff. The results of the investigation, which was performed by the Civil Aviation Authority of the country in which the event occurred, concluded that the failure was due to overload. The overload was a direct result of a tight 180 degree turn on the runway while using differential braking. The speed at which the turn was made was also a contributing factor. In order to preclude additional failures of this nature, operators are reminded to adhere to the referenced MM and Operations Manual chapters which state:*
>
> *Reference (a):* [Aircraft Maintenance Manual (Chapter 9-2-0, page 1)] *"CAUTION: PIVOTING ABOUT A SET OF BRAKED WHEELS IS PROHIBITED".*
>
> *Reference (b):* [Operation Manual (Chapter 2-143, page 1)] *"CAUTION: DO NOT BRAKE MAIN WHEELS ON INSIDE OF A TURN TO OBTAIN A SMALLER TURN RADIUS THAN IS POSSIBLE BY MAXIMUM NOSEWHEEL STEERING"."*

AOL 8-1218 (12 October 1995) that noted:

> *"A DC-8 operator reported that during takeoff the pilot noticed an abnormal vibration which prompted an aborted takeoff .*
>
> *The aircraft proceeded to turn off the runway onto the taxiway. At that point, the pilot was unable to taxi the aircraft any further. Upon subsequent inspection, it was determined that the right hand main gear piston had fractured near the bogie beam pivot lugs.*
>
> *Analysis of the failed piston revealed that the failure was attributed to stress corrosion cracking. The primary crack origin area of the piston occurred along the inner radius of the torque link [torsion link] attach lug. There were two secondary fractures located along the lower aft surface of the piston. Each of the fracture origins revealed a predominant intergranular mode of rupture most likely due to hydrogen assisted cracking.*
>
> *The contributing factor in cases associated with stress corrosion cracking is an exposed surface exhibiting corrosion due to the loss of surface protection. The exposed surfaces of all landing gear components should be continually monitored for paint erosion or loss of cadmium plating to lessen the potential for additional failures. Maintaining an appropriate surface protection will preclude failures associated with stress corrosion. The chapters noted in referenced OHM* [Overhaul Manual] *provide the necessary information to touch up the primer and paint as well as to brush cadmium plate small areas of damage on landing gear components."*

Discussion

It was clear that, as the aircraft was making a 180° taxiing turn, the piston of the right MLG shock-strut had suffered extensive fracturing into a number of pieces from an origin in the region of the attachment lugs on the piston for the scissor linkage. The manoeuvre was likely to have increased the stresses in the fracture origin area, as indicated by one of the previous cases of MLG shock-strut piston fracture, but no evidence was available to indicate whether the design stress had been exceeded. However, there was clear evidence that the piston had a pre-existing crack that, while small, was probably deep enough to result in rapid catastrophic fracturing under normal operating stresses, given the notch sensitivity of the high-strength steel from which the piston was made.

The evidence indicated that the initial crack had resulted from a stress corrosion process, caused by the effects of a sustained tensile stress in the area in a damp environment. The step in the blending radius and the surface scratches in the region of the crack origin would have acted as local stress raisers that probably led to the initiation of the stress corrosion cracking and the local absence of cadmium plating would have assisted the process.

There were no signs that the step and the scratches could have been formed in service and it appeared likely that they had resulted from machining operations during overhaul of the piston, possibly when the chromium plating on the associated lug had been replaced. The reason for the local absence of cadmium plating could not be established but did not appear to have been due to wear in service. No evidence was available to determine when the features had been formed, but they should have been apparent during the last overhaul of the landing gear.

Detection of the pre-existing crack was unlikely to have been possible, given its location and size, without disassembly of the MLG. Only around 10% of the MLG life had been used since its last overhaul, and there was no maintenance requirement for the area to be subjected to detailed inspection in this period.

Previous safety recommendation

In December 2002 the nose landing gear outer cylinder of a Boeing 747-367 fractured as it taxied for takeoff from London's Heathrow Airport. The nose landing gear outer cylinder suffered a circumferential fracture as a result of fatigue cracking initiating from a groove at the upper edge of the internal diameter seal band. The groove had been inadvertently machined into 70% of the internal circumference during overhaul in the USA. The AAIB made two safety recommendations directed at the FAA as a result of the accident investigation. One recommendation concerned the retention of maintenance/overhaul records and the other (Recommendation 2004-70 made on 28 October 2004) was as follows:

> *Safety Recommendation 2004-70*
>
> *It is recommended that the Federal Aviation Administration (FAA) adopt a programme for performing targeted surveillance and increased oversight of overhaul practices at '14 Code of Federal Regulations Part 145' Repair Stations that are conducting repair, overhaul and rework of aircraft landing gears, to ensure that the manufacturer's overhaul manuals and instructions are followed and that appropriate quality assurance procedures are in place for the continued airworthiness of these components.*

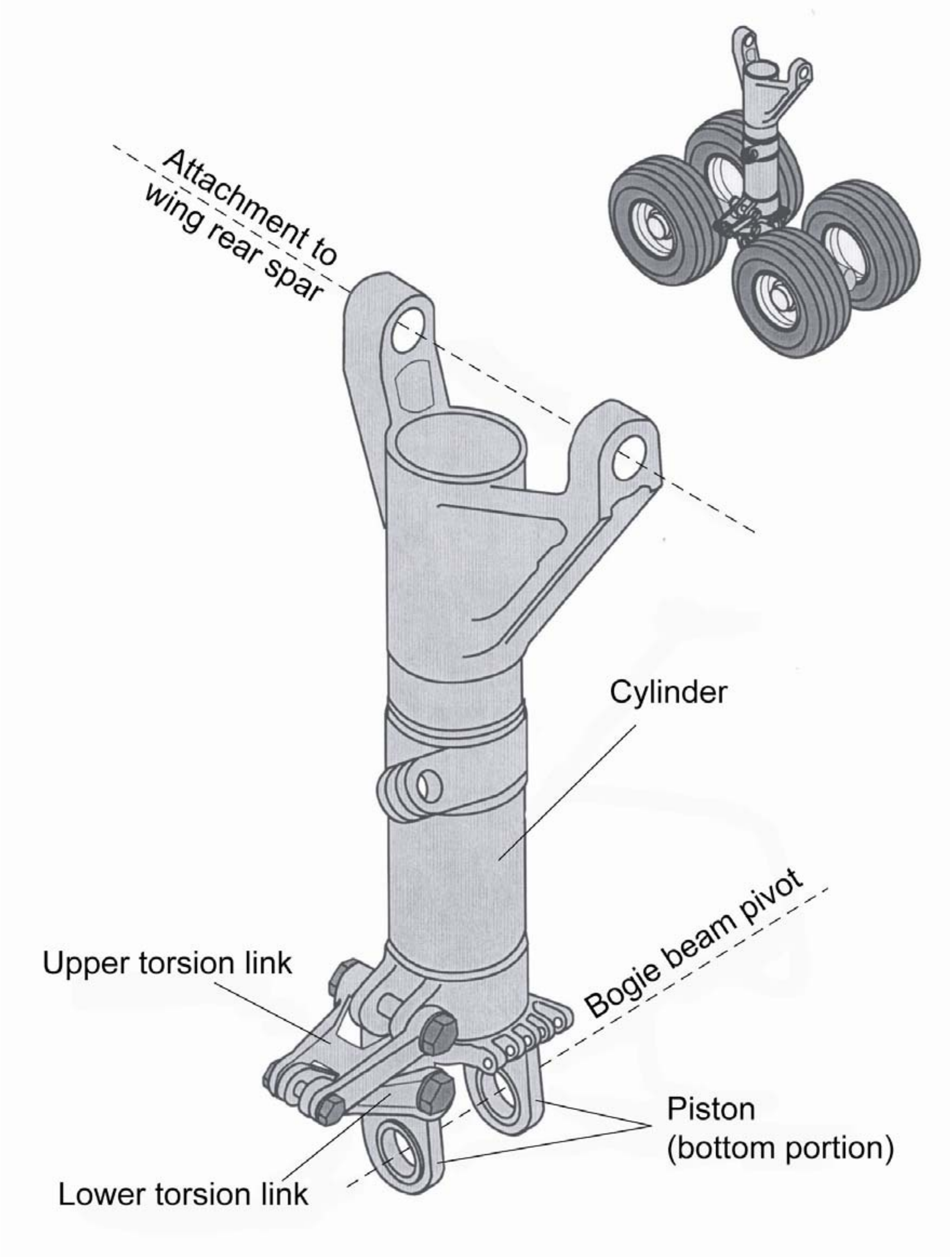
To date no response has been received from the FAA addressing either recommendation.

Recommendation

The evidence, gathered in the investigation into 9G-MKO's MLG failure, indicated that a poor profile and surface finish on part of the MLG shock-strut piston had probably been responsible for the initiation of a stress corrosion crack that would most likely have been undetectable in service but had led to extensive fracturing of the piston. These detrimental features should have been apparent during the last overhaul of the landing gear and the previous investigation highlighted similar areas for concern with the quality control at another overhaul agency. Even though the investigations highlighted problems in the quality control present within organisations involved with the overhaul of aircraft landing gear the problem of less than adequate quality control may be more widespread generally amongst FAA approved aircraft component overhaul organisations. The following recommendation is therefore made:

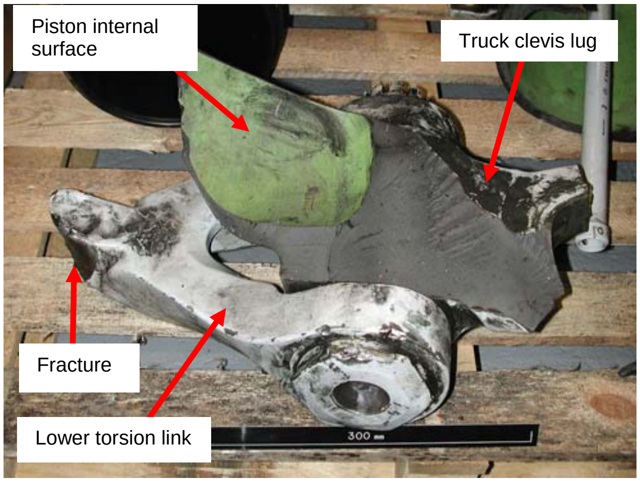
Safety Recommendation 2005-04

It is recommended that the Federal Aviation Administration (FAA) take measures aimed at ensuring that overhaul organisations approved by them have in place adequate standards of quality control.



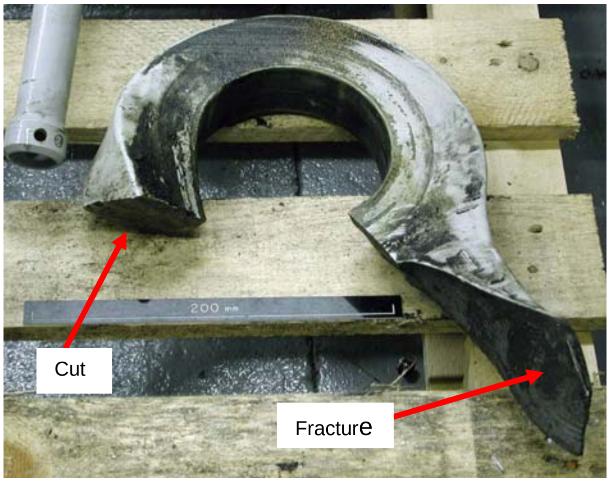
Main Landing Gear
Figure 1

Main landing gear piston



Part of piston and lower torsion link

Figure 2



Truck clevis left lug

Figure 3

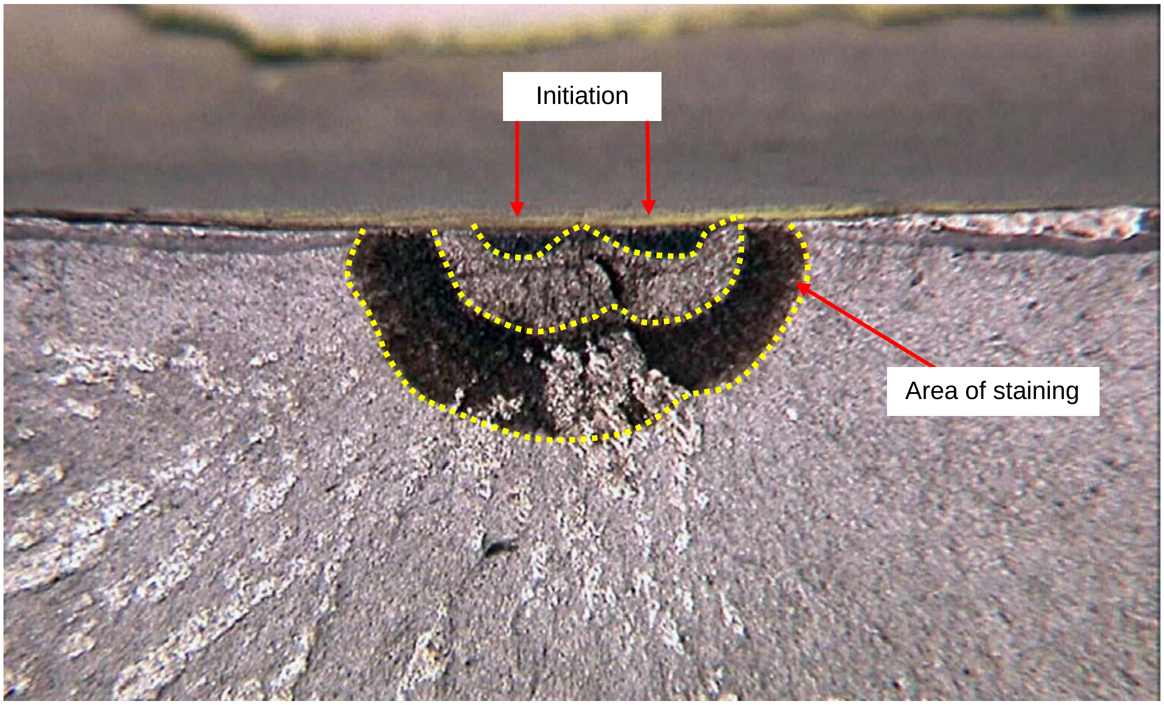
Piston upper part

Figure 4

Separated portion of piston

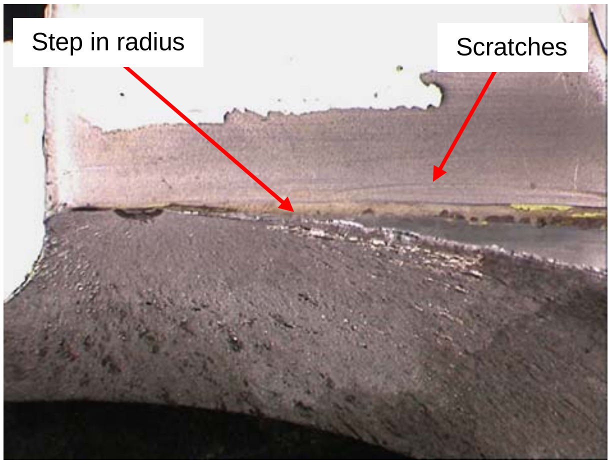
Figure 5

Piston pre-existing crack



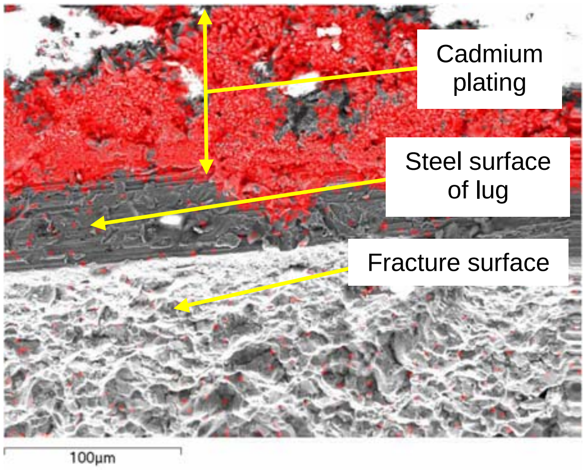
Initial crack

Figure 6



Lug radius showing step and poor machining

Figure 7



Surface at fracture origin showing cadmium distribution (red)

Figure 8

AAIB Bulletin No: 3/2005 **Ref: EW/G2004/10/15** **Category: 1.1**

INCIDENT

Aircraft Type and Registration:	Boeing 767-304, G-OBYH	
No & Type of Engines:	2 General Electric CF6-80C2B7F turbofan engines	
Year of Manufacture:	1999	
Date & Time (UTC):	21 October 2004 at 0642 hrs	
Location:	Edinburgh Airport, Scotland	
Type of Flight:	Public Transport	
Persons on Board:	Crew - 11	Passengers - 313
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Embedded glass fragments in, and scuffing of No 1 mainwheel	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	54 years	
Commander's Flying Experience:	13,450 hours (of which 6,886 were on type) Last 90 days - 228 hours Last 28 days - 78 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot and report by the company	

Following a normal landing at Amsterdam Airport, scuffing of the tyre and embedded fragments of glass were found during a visual inspection. Subsequent inquiries revealed that four runway lights were damaged near the threshold of Runway 24 at Edinburgh. The two previous sectors for G-OBYH involved a landing on Runway 06 at Edinburgh and a subsequent takeoff on Runway 24. Both these sectors had required a clockwise turn at the threshold of Runway 24. The landing had been in the dark on a wet runway and the exterior inspection carried out prior to the next flight had revealed no indication of any tyre damage. The subsequent takeoff was at dawn and on a dry runway.

The commander considered that the damage to the tyre had probably occurred at Edinburgh. He considered that he had made an error of judgement concerning the lateral displacement of the left gear from the edge of the runway during a 180° turn. Contributing factors may have been incorrect seat positioning and/or head movement.

AAIB Bulletin No: 3/2005 Ref: EW/G2004/11/10 Category: 1.1

INCIDENT

Aircraft Type and Registration:	Cessna 550 Citation, G-FCDB
No & Type of Engines:	2 Pratt & Whitney Canada PW530A turbofans
Year of Manufacture:	2001
Date & Time (UTC):	25 November 2004 at 0700 hrs
Location:	Teesside Airport, Darlington, Co Durham
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 2 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	None.
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	52 years
Commander's Flying Experience:	7,500 hours (of which 4,000 were on type) Last 90 days - 102 hours Last 28 days - 32 hours
Information Source:	Air Accident Report Form submitted by the pilot, flight data recorder and reports from the airport operator and aircraft engineering facility

History of the flight

The aircraft taxied with a crew of two and one passenger for a flight to Copenhagen. The crew was instructed by ATC to taxi via taxiway Alpha for Runway 23 and was subsequently cleared for takeoff prior to reaching holding point Alpha One. The commander, who was the handling pilot, reported that he carried out a rolling takeoff after following the taxiway centreline onto the runway. Take-off power was set and all engine indications were seen to be normal. As the aircraft was accelerating through an estimated airspeed of 70 kt, the commander felt a bump, then felt the aircraft yaw to the right. The co-pilot later reported that he had seen a hare or rabbit run towards the aircraft from the right hand side and associated the bump with this animal, though he did not have time to call this to the commander at the time.

The commander instinctively applied opposite rudder to correct the yaw, which had an immediate effect. The maximum heading deviation achieved, though initially thought by the commander to be much higher, was later reported as 10°; the co-pilot assessed the deviation as 30° to 40°. The commander initially thought that the bump and yaw may have been due to a tyre failure, though he had only previously experienced this in the simulator. Using rudder but no braking, the commander was able to bring the aircraft back onto the runway heading by the time the aircraft had reached the end of the concrete dispersal area (Figure 1), but the aircraft was now on the edge of the marked runway. The aircraft then partly left the paved surface and crossed a grass area between the dispersal concrete and the disused section of Runway 01/19. After crossing Runway 01/19, the aircraft was still at the main runway edge and the commander was aware that the right wheel had entered the soft grass which was causing the aircraft to yaw to the right. As it did so the nose wheel also left the paved surface and the commander, attempting to regain the runway as soon as possible, applied differential braking and increased power on the right engine. He was aware that the nose wheel was on the grass and was tracking down the edge of the runway surface for a time before the aircraft finally re-entered the runway. The commander then taxied the aircraft back to the apron and shut down.

The commander was unable to account for the bump or sudden yaw and was unsure if it could have been caused by hitting an animal. He was confident that it was not due to an inadvertent brake application by himself, and the co-pilot's feet were not on the rudder pedals at the time. He further commented that the lead in area to the runway was poorly lit and that there were no runway centreline lights.

Aerodrome Information

The main runway at Teesside Airport is orientated 23/05 and is 2,291 metres (7,515 feet) in length, 46 metres (150 feet) wide and has a magnetic heading of 232º. The main runway is crossed by Runway 01/19, though only that part to the south of the main runway is useable. The airport was originally a military base, and is equipped with two concrete dispersal areas at each runway end to the north side. The runway edge is marked across the dispersal areas by an unbroken white line which extends to each threshold.

The runway is equipped with high intensity bi-directional edge lights at 60 metre spacing with a low intensity omni-directional component. The edge lights are set 2.5 metres outside of the runway edge marking. There are high intensity runway centre line lights at 30 metre spacing. Taxiway Alpha is marked by a yellow line as it joins the runway and is equipped with green centreline lights, supplemented by green reflectors. As the taxiway crosses the edge of the dispersal area, the taxiway edge is marked by blue reflectors. The white runway edge line is supplemented by red reflectors one metre outside the line for that part of it which crosses the dispersal area. Apart from the white runway edge line, there are no ground markings on the Runway 23 dispersal area. The associated dispersal area for Runway 05 is marked by white crosses to indicate that it is not to be used for take off. Figure 2 shows the view along Runway 23 from a point adjacent to taxiway Alpha as it enters the runway.

The United Kingdom AIP entry for Teesside airport includes the following statement:

> *At both ends of Runway 05/23, its width is twice that of the associated edge lights due to extra pavement at the northwest side. Pilots should ensure that they are correctly lined up, especially if take-off is at night, when the runway is contaminated or in low visibility. The yellow taxiway centre-line marking supplemented with green reflective studs must be followed until alignment with the runway centre-line lights is achieved.*

Meteorological information

At 0620 hrs Teesside Airport reported a surface wind from 200º(M) at 8 kt, a visibility of 6,000 metres and a temperature and dew point of 8ºC. Sunrise was at 0752 hrs.

Flight data recorder

The indicated airspeed (IAS) readout commenced at 34·3 kt, which was achieved just as the aircraft stabilised on runway heading. Eight seconds later there was a heading deviation of 2° to the right for about two seconds before a larger deviation to the left, to about 7° left of the runway heading. The heading then deviated right once again, about 3° right of the runway heading, before once again deviating left of the runway heading by a maximum of 15°; this was the point at which the aircraft re-entered the runway. The recorded engine RPMs initially reached a maximum of 79·1%, which was reached just as the first heading deviation to the right occurred and about one second before the point at which the maximum recorded IAS of 72·5 kt. During the second deviation to the right, the RPM for the number 2 engine was seen to increase from idle to a maximum of 81·7%, and then reduce as the aircraft re-entered the runway. Accelerations were consistent with passage across an unprepared surface and there were no indication of an 'initiating event'.

Examination of site

An examination of the site was conducted by the airport operator. The results of the examination are shown diagrammatically at Figure 1. The diagram also shows the centreline of Taxiway Alpha entering the runway, and a notional point A indicating the start of take-off roll for an aircraft following this yellow line.

Tyre marks were seen entering the grassed area at point B, which measured 140 metres from point A. The point where the tyre marks entered the grass was 26·2 metres from the runway centreline, and continued for 23·3 meters, approximately parallel with the runway, until the track entered the crossing runway at point C. A further tyre mark started on the crossing runway at point D, 28 metres from point C, and continued for a further 37·2 metres to the edge of the disused runway at point E. As the tyre mark crossed the disused runway, it was deviating to the right slightly. As the tyre mark entered the grass at point E, a further tyre mark is seen entering the grass, but closer to the runway. Both tracks then deviate to the left and the tyre track closer to the runway re-enters it 10 metres further along. The main tyre track then parallels the runway edge before deviating to the right once again at which point the second track re-appears. Both tracks then show a gradual turn to the left and re-enter the runway at F, a distance of 134 metres from point E where the tracks entered the grass for the second time.

An extensive search for the reported hare or rabbit was conducted immediately after the incident but no remains were found.

Aircraft examination

The aircraft was examined by the company's engineering personnel the day after the incident. No fault was found which could account for the yaw described by the crew. The aircraft was subsequently returned to service and has experienced no reoccurrence at the time of writing.

Analysis

Although both crew members reported a significant yaw which resulted in the aircraft leaving the paved surface, this was not evident from the recorded data. The commander recalled that the yaw event was corrected and the aircraft returned to a track parallel to the runway by or about the time that it encountered the first grass area. For a 10° heading change to develop, as reported by the commander, and cause the aircraft to reach the grass at point B, it would have had to commence almost as soon as the aircraft had begun its take-off roll. In this case the aircraft would have been bought under control long before the edge of the runway was encountered.

If the assumption is made that the aircraft followed the taxiway lead-in line, it would have been lined up at about point A, a distance of 140 metres from the beginning of the grass area and, since IAS first registers as the aircraft aligns with the runway, the airspeed at this point can be assumed to be 34·3 kt. Using recorded IAS data it is possible to determine the approximate distances of significant flight events from point A. The maximum airspeed was recorded 9 seconds, or approximately 237 metres after point A, which is about the time the aircraft enters the grass for the second time. The slight yaw to the right takes place when the aircraft has travelled between 167 and 237 metres from point A; this coincides with the crossing of the disused runway. The first deviation to the left is calculated to occur after 273 metres, which matches closely the observed ground marks.

The possibility that the initial set of tyre marks between B and C were not made by the aircraft involved in this incident was considered, together with the possibility that a higher, though momentary, deviation to the right had occurred which had not been recorded on the data recorder which sampled heading at a rate of once per second. However, considering that there was no heading deviation until about 167 metres from point A, the yaw rate and amount that would have been necessary to cause the aircraft to leave the paved surface at point E would have been beyond the capabilities of the aircraft without it sustaining major damage and is not supported by lateral acceleration data which has a higher sampling rate.

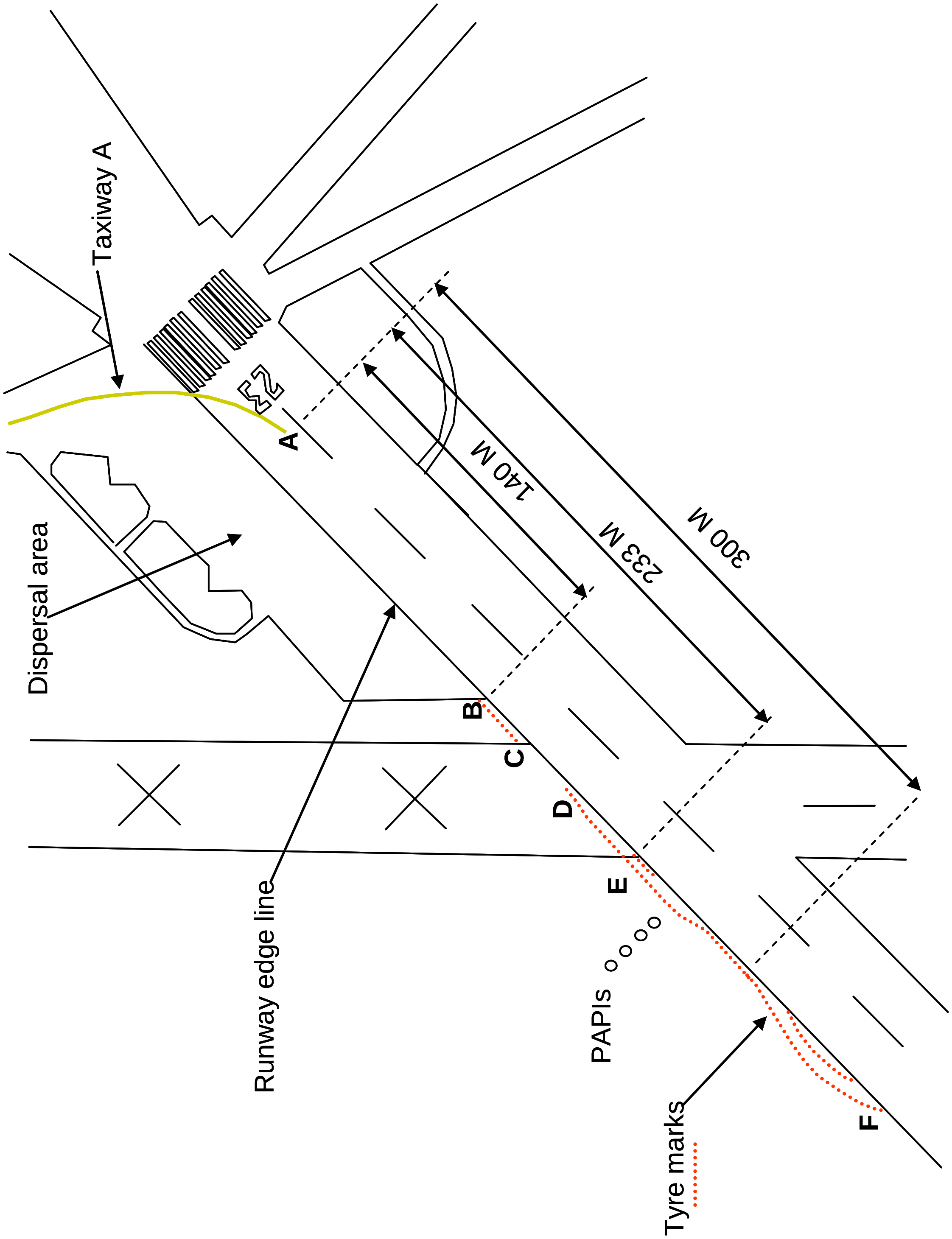
The available flight data and ground witness marks indicate that the aircraft was lined up for takeoff on the runway edge line instead of the runway centre-line. The commander's report that the runway did not have centre-line lighting, when if fact it does, also supports this conclusion. The investigation therefore looked at how the crew may have made this error and what may have caused both pilots to interpret the subsequent events in the way they did.

The initial heading deviation to the right was probably caused by the drag of the right main wheel as it encountered the grass. This would have been exacerbated if the wheel had contacted a drain cover and the edge of the disused runway, which would also account for the bump felt by both pilots. By this stage it would have been obvious to both pilots that they were not on the runway centreline, which would not have agreed with their "mental model". As there would have been some sensation of a yaw to the right, it is likely that both pilots remembered the yaw as more severe than it was in an unconscious attempt to make sense of what had happened. Both pilots report that the commander instinctively applied rudder to correct the swing, but instead of correcting track to parallel the runway as they believed, this was actually yawing the aircraft back towards the runway, as is evident from the flight data and ground marks. Once beyond this point, the crew's recollection matches the other available evidence.

Measures had been taken by the airport operator to reduce the likelihood of a crew lining up on the edge line. These included the requirement stated in the UK AIP that crews follow the taxiway marking and lights until established on the centre-line lights, the provision of blue taxiway edge reflectors when approaching the runway and the red reflectors placed about one metre outside the edge line as it crosses the dispersal area. However, unlike Runway 05, there were no ground markings to indicate that the dispersal area was not part of the runway. The view had been taken that the position of the PAPI lights was such as to alert a crew of an incorrect line up. However, this visual cue may not be available in poor visibilities when the error may be likely to occur. Nor did this prevent the crew of the aircraft involved in this incident from lining up incorrectly. The flight deck of this aircraft is also much lower than larger types and this may have reduced the effectiveness of the visual alert provided by the PAPI lights.

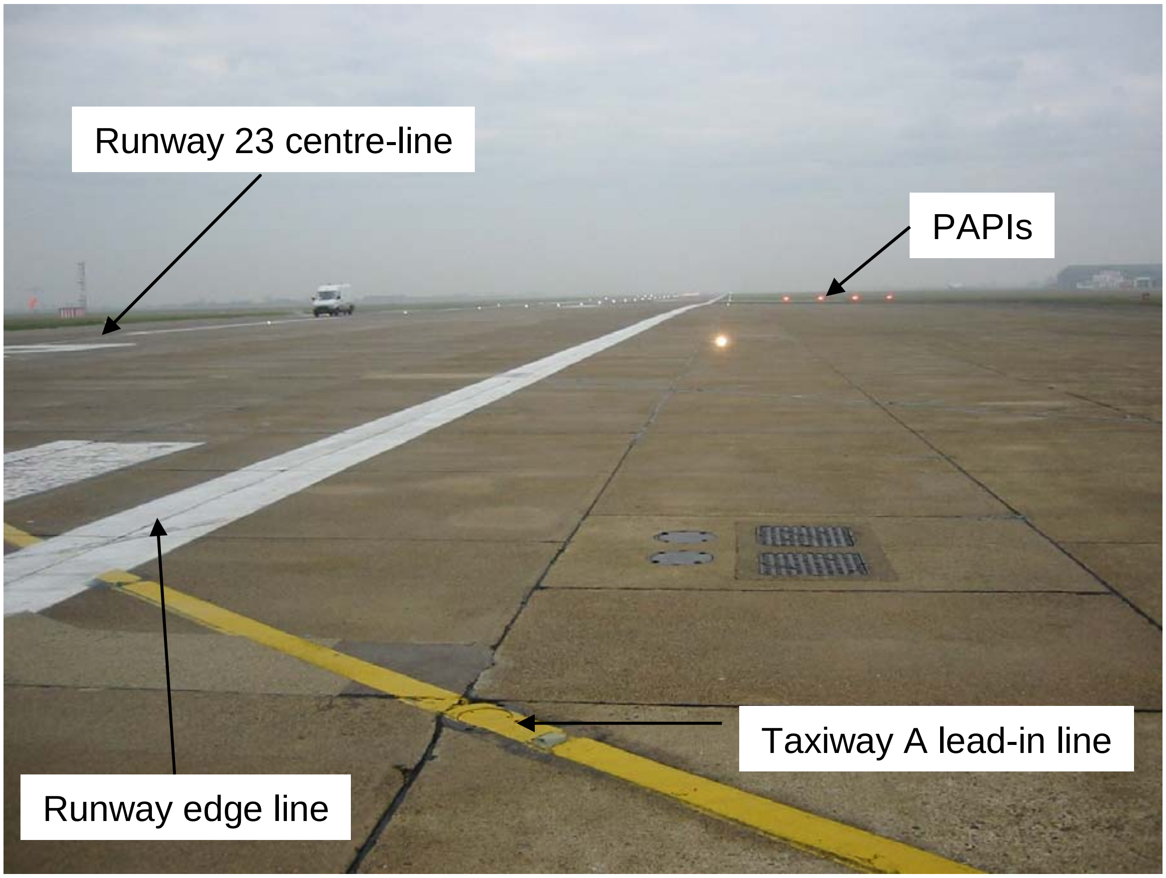
Safety action by the airport operator

The ground markings at Teesside Airport are the subject of a current refurbishment programme. In the light of this incident and as part of that process, the airport operator has scheduled a review of the ground markings for Runway 23 which will take place early in 2005. Additionally, an upgrade to the airfield ground lighting system is scheduled for mid-2005.



Taxiway A
Dispersal area
Runway edge line
A
B
C
D
E
F
140 M
233 M
300 M
PAPIs
Tyre marks

Figure 1



Runway 23 threshold area

Figure 2

INCIDENT

Aircraft Type and Registration:	Cessna 550 Citation 11, G-VUEA
No & Type of Engines:	2 Pratt & Whitney JT15D-4 turbofan engines
Year of Manufacture:	1991
Date & Time (UTC):	21 April 2003 at 2025 hrs
Location:	On approach to Runway 24 Right at Manchester Airport, Manchester
Type of Flight:	Positioning
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Cockpit defog fan overheated and failed. Considerable smoke in cabin
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	46 years
Commander's Flying Experience:	2,750 hours (of which 250 were on type) Last 90 days - 70 hours Last 28 days - 30 hours
Information Source:	Aircraft Accident Report Form submitted by the commander and follow-up activity by the AAIB.

History of the flight

The aircraft was engaged on a positioning flight between Edinburgh and Manchester, with only the two flight deck crew on board. Whilst being vectored by ATC for an approach to Runway 24 Right at Manchester, and as the aircraft was descending through about FL80, the crew became aware of a strong smell of burning electrical insulation. The passenger cabin was seen to be completely filled by smoke which obscured its rearmost part. There was no smoke in the cockpit at this stage, despite there being only an open curtain separating the two areas.

The commander instructed the co-pilot, who was handling the aircraft through the autopilot system, to don his oxygen mask. As the co-pilot was so doing, the commander made a MAYDAY call to ATC though this was hindered by thick smoke which by this time was entering the cockpit area and causing the commander breathing difficulties. Immediately after the MAYDAY transmission, the commander donned his oxygen mask; as he did so, the smoke was beginning to obscure the instrument panel and forward vision from the cockpit.

With no malfunctions apparent in the cockpit, the commander initiated the SMOKE REMOVAL emergency drill from memory. His action was to open the dump valve to depressurise the aircraft, which caused a partial clearance of the smoke. The commander made the decision not to carry out any further emergency drills as the crew were becoming engaged in preparation for the approach and landing, which he considered to be his priority. Manchester ATC provided the crew with an expeditious routing towards the localiser for Runway 24 Right, though communications with ATC were difficult due to a high noise level in the cockpit, which was attributed mainly to noise from the oxygen masks. The weather at Manchester Airport was reported as CAVOK with light surface winds.

Whilst on a visual final approach, the smoke concentration began to increase again, which the commander thought may have been due to reduced airflow into the cabin from the throttled back engines. However, the smoke concentration was not sufficient to restrict forward vision. The aircraft landed normally and the crew bought it to a stop on the runway before shutting down both engines and removing all electrical power. The pilots evacuated the aircraft without difficulty through the main door and as they did so the Airport Fire Service arrived at the aircraft. Inspection by the fire crew revealed no signs of fire, though smoke continued to emerge from the open door for a further 20 minutes.

The only injuries sustained were a sore throat and chest which the commander experienced as a result of inhaling smoke whilst making the initial distress call.

Aircraft examination

It was established by the operator that the circuit-breaker protecting the motor of the cabin defog fan blower had tripped, apparently as a result of a fault within the motor. The motor was found to be defective and was passed to the AAIB for further examination.

Component examination

Examination of the cabin defog fan revealed no evident damage to the fan unit but considerable resistance to rotation of the shaft. Contamination of the gauze type filters on the external vent holes of the motor with a black sticky residue was evident. Strip examination confirmed that the interior of the motor had grossly overheated, melting and degrading much of the insulation therein. There was, however, no evidence of any point of concentration of burning or local overheat. The commutator was severely worn but the brushes remained in good condition. Black staining and a deposit of sticky residue were present in two of the airflow paths from the motor into the fan case. One motor bearing was confirmed to be very stiff in operation, indicating that seizure had occurred at some stage.

The cabin defog fan had a life of 3,500 airframe hours between overhaul or replacement with a service exchange unit and the failed unit had been installed for 2,090 airframe hours since new. The part number of this component has been superseded and the type is no longer supplied as a replacement item. There is no indication, however, that the unit type which failed on this occasion was not permitted to operate up to its quoted overhaul life. A continuing component reliability analysis programme carried out by the aircraft manufacturer does not produce conclusive statistical evidence of the reliability of the failed unit type.

Arrangement of the air conditioning system

The cabin defog fan is included in the air conditioning system to provide conditioned air to the cockpit foot warmers and windshield and side-window defog outlets. It also influences airflow into the passenger cabin area. A 28V DC electric motor drives a centrifugal fan which receives conditioned air from the engine bleeds via the refrigeration unit and delivers it into the cabin duct system. The unit, which is situated below the floor towards the rear of the cabin, can be selected by the crew and has a high and low speed setting.

A small volume flow rate of air for motor cooling is also drawn into the fan housing from the interior of the motor via four vent holes at the fan end of the motor casing. This cooling air enters the motor casing from the under-floor area, via a further four vent holes with gauze filters. These are positioned in the exposed end cap of the motor. A reduced flow of conditioned bleed air passes from the refrigeration unit into the cabin via the defog fan even when the latter is not operating.

A further fan, the Overhead Blower, supplies conditioned, re-circulated or fresh air to the cabin, depending on temperature conditions. A manual emergency dump valve is provided as part of the pressurisation control system; its purpose is to dump all cabin pressure by commanding both outflow valves to open fully.

Operational procedures

There are three emergency procedures relevant to this incident. These are contained in the Company operations manual which is issued to each pilot and also in an emergency checklist format available in the cockpit. The crew would normally be expected to carry out either the ELECTRICAL FIRE OR SMOKE drill or the ENVIRONMENTAL SMOKE OR ODOUR drill depending on the perceived source of the smoke. Then, if required, the crew would apply the third procedure, SMOKE REMOVAL.

The ENVIRONMENTAL SMOKE OR ODOUR procedure is not intended to be completed from memory. However, it is a relatively straightforward checklist which directs the crew to don oxygen masks and smoke goggles, establish inter-crew communications and then to turn off both the cabin (overhead blower) fan and defog fan. The drill then directs the crew to attempt to isolate the source of contaminated air by selecting either engine bleed air source in turn whilst checking for improvement between selections.

The ELECTRICAL FIRE OR SMOKE procedure is a more complex reference procedure, but does begin with the following memory items:

OXYGEN MASKS	*SELECT 100%, DON*...
MIC SWITCHES	*MIC OXY MASK*
SMOKE GOGGLES	*DON*

If the source of the fire or smoke has been identified, the procedure directs the crew to isolate power from it by pulling the associated circuit breaker (CB). If, as in this case, the source is not identified, the procedure involves removing power to a large part of the electrical system by selecting the battery to an emergency mode, switching off the engine generators and pulling several CBs associated with the DC electrical system. This essentially provides remaining battery power for only those services essential to safe flight. The pilots' instrument displays for G-VUEA were configured with conventional instruments for the co-pilot and EFIS displays for the commander. In the ELECTRICAL FIRE OR SMOKE configuration, the only flight instruments available would be the co-pilot's conventional displays.

The procedure goes on to direct the crew to declare a MAYDAY and to *"LAND AS SOON AS POSSIBLE"*. It then advises the crew to carry out the SMOKE REMOVAL drill if this is warranted. Prior to landing the crew must re-instate the left generator before lowering the landing gear and flaps. Landing distance is increased due to the anti-skid system being inoperative in this configuration.

The SMOKE REMOVAL procedure is also intended to be completed by reference to the checklist. However, some discrepancies were noted between that version in the operations manual and the checklist on the aircraft. Essentially, the drill directs the crew to don oxygen masks and smoke goggles, establish inter-crew communications, deploy the passenger oxygen system and to operate the pressurisation dump valve. The version available on the aircraft did not include a reference to smoke goggles but did include an additional requirement to set a higher cabin altitude on the cabin altitude selector prior to operating the dump valve.

The Company's operations manual, under the heading *"Authority, duties and responsibilities of the commander"* states:

> *'The pilot-in-command shall, in an emergency situation that requires immediate decision and action, take any action he considers necessary under the circumstances. In such cases he may deviate from rules, operational procedures, and methods in the interest of safety.'*

Analysis

It was clear from the internal condition of the defog fan motor and the visible contamination of the passages of the cooling air between the motor and the fan case, that considerable smoke was being drawn from the motor into the cabin air-flow path. The motor appears to have continued to operate at progressively reducing RPM with consequently reduced cooling flow once seizure of the bearing had begun. This appears to have been the cause of the overheating.

It is presumed that the fan's circuit breaker tripped some time after the motor began to produce smoke, although the precise time in the flight when this occurred is not known. The high temperature already reached by the unit, together with its mass, and the fact that air from the engine bleeds and the refrigeration unit continued to flow through the fan would have resulted in a period between the circuit breaker tripping and the time at which the unit cooled sufficiently to cease supplying smoke to the cabin. The lengthy time during which the hot, non operating motor is capable of generating smoke is confirmed by the period over which smoke issued from the cabin after the aircraft had landed and all systems had been shut down.

Unusually in this case, and because of the role of the defog fan, either the electrical smoke or the environmental smoke procedures would have isolated power to the fan, though the crew had no way of knowing that the fan was the source of the smoke at the time. In this case, the commander identified the smoke as being electrical in origin and although he recognised the serious threat the situation presented, decided that his immediate priority should be to execute an approach and landing as soon as practicable. The commander's decision took into account the limited time available to complete the complex ELECTRICAL FIRE OR SMOKE procedure, and the possible greater hazard of accomplishing an expeditious approach with minimum systems and flight instruments available. The commander did order the donning of oxygen masks as required by the procedure. However, neither crewmember afforded himself the extra protection of smoke goggles, which was one of the memory items, though neither reported any ill-effects or difficulties as a result.

The commander initiated the SMOKE REMOVAL DRILL from memory, operating the manual dump valve to depressurise the cabin. Had he referred to the cockpit checklist, he would have been directed to enter a higher altitude on the pressurisation system's cabin altitude selector. However, this would be a redundant action as the dump valve depressurises the aircraft fully and much quicker than would be achieved by use of the cabin altitude selector. Reference to the cabin altitude selector in the context of this drill was deleted in the company's operations manual. The remaining items on the SMOKE REMOVAL procedure, which mainly concerned the activation of passenger oxygen, were not carried out due to the imminent landing. Operating the dump valve would not have had any effect on the continuing operation of the smoke source but would have reduced the intensity of the smoke in the cockpit. The commander thought that increased smoke concentration when on the approach was due to the engines being throttled back. This was more probably due to a reduced inflow of fresh air via the spring-loaded ram air valve as the aircraft slowed on approach, as the bleed supply from the engines is largely constant at a wide range of power settings.

Aircraft electrical equipment and wiring in general has fuse or circuit breaker protection. These protection items, for a variety of reasons, are generally rated at well above the maximum current normally drawn by the component they protect. There are thus component failure modes in which a unit may continue for a significant period to draw current well in excess of its maximum rated value, yet below the rated value of its protection. Under these circumstances, the failed component rapidly overheats and materials therein begin to degrade and emit smoke. This problem will apply to certain types of failures in a range of electrical components. When they occur in the very small cabin volume of small pressurised business type aircraft, rapid deterioration of cabin visibility and breathable air quality must be expected, particularly if the failure occurs in equipment associated with cabin air distribution. Failures in a component such as a fan motor, representing a large heat sink, can result in a significant quantity of heat becoming present therein. In particular, a fan motor which seizes progressively will draw a high current and generate increasing heat whilst the cooling flow reduces as a result of the drop in fan speed. Even when the power is isolated, after its supply is switched off manually or the circuit breaker trips, such a unit cools only slowly and the resulting flow of smoke can be expected to continue for a lengthy period. It is thus highly desirable to isolate such a failing component at the earliest possible opportunity, ideally before a large temperature rise occurs.

Identifying and isolating the affected equipment, even if successfully carried out, may not always lead to a rapid reduction in the smoke being generated. In this instance, the crew had no way of knowing which component was causing the problem; implementation of either the electrical or environmental emergency procedure, had it been carried out before the CB tripped, may not immediately have affected the amount of smoke entering the cockpit, since engine bleed air continued to flow into the cabin via the fan unit, even when the latter was not operating. However, had the CB not been tripped by this stage, completion of the check list would have removed power from the defective fan at the earliest possible time and ensured that smoke circulation and concentration were minimised.

The commander's decision not to complete the relevant emergency procedures was influenced by the time available and the need to concentrate on the approach and landing. In effect, the commander chose to action what he considered to be the most important part of the procedure, the statement *"Land as soon as possible"*.

Aircraft Type and Registration:	Cozy, G-BXDO	
No & Type of Engines:	1 Lycoming O-235-C2C piston engine	
Year of Manufacture:	1998	
Date & Time (UTC):	10 July 2004 at 1500 hrs	
Location:	1 mile south of Junction 12 of the M5 motorway, Gloucestershire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Minor damage to the underside of nose during landing followed by damage to the propeller during the subsequent flight, followed by severe damage, during the ensuing forced landing, to the right wing, right foreplane and left wing tip fin	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	64 years	
Commander's Flying Experience:	979 hours (of which 44 were on type) Last 90 days - 6 hours Last 28 days - 2 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot plus telephone enquiries and photographs	

Introduction

The aircraft is an all-composite 'home-built' design featuring a retractable nose-wheel, fixed main undercarriage, a rear-mounted wing, canards and a pusher-propeller; it is similar in appearance to a Long-EZ. G-BXDO was constructed by a previous owner and granted a Permit to Fly. The aircraft type is usually parked with its nose wheel retracted and the nose of the aircraft resting on the ground; consequently the underside of the nose is reinforced to withstand parking loads and surface abrasion.

History of the flight

At the conclusion of the previous flight, the aircraft landed at Kemble with the nose landing gear retracted (inadvertently). Damage to the underside of the nose was considered minor and the aircraft departed for Shobdon Airfield. During this flight, the inspection hatch for the retractable nose wheel system separated from the upper surface of the nose and passed through the propeller at the rear of the fuselage. The resulting damage to the propeller caused severe vibrations, which necessitated the gradual reduction of engine power. The enforced power reduction culminated in a loss of height from 1,200 feet over a period of about three minutes and a forced landing. Before the landing the pilot turned off all the aircraft's systems.

The aircraft landed at a microlight field near Morton Valence which is located approximately one mile south of Junction 12 of the M5 motorway. The surface wind was from 300° at 15 kt and, being unable to discern a runway, the pilot elected to land to the south of the field, in a direction aligned with its length.

After touchdown, the aircraft's nosewheel sank into soft ground and the nose landing gear collapsed. The aircraft yawed and then pitched onto its back, causing substantial damage to the airframe including destruction of the right wing and canard, and the left wingtip-mounted fin. The aircraft was quickly righted by several people who were at the scene and the pilot then exited normally from the relatively undamaged cockpit, once the canopy, which opens upwards on a forward hinge, was free to open.

Discussion on survivability

Because of the configuration of the aircraft's canopy, the pilot would have been unable to evacuate the inverted aircraft unaided after the accident without breaking the canopy. He reported that, in the silence after the landing, he was "listening for the sound of dripping petrol," very aware of the danger that a fire might start. He had planned to use his radio to summon help, had help not been imminent.

AAIB Bulletin 8/2003 contains details of an accident to a Tri-Kis light aircraft, G-BXJI, which turned over during an attempted go-around. As in this case, the pilot and passenger of the Tri-Kis were unable to evacuate the aircraft until help arrived because of the design of the canopy. In both these and other similar cases, the safety of those on board would have been severely compromised by their inability to escape rapidly from the aircraft and without external assistance should a fire have broken out.

Although in the case of the accident to G-BXDO, the availability of immediate assistance and the absence of fire prevented a serious threat to the pilot's safety, it illustrates again that '*The provision of an implement [hand held] in the cockpit, fit for the purpose of breaking out through the cockpit transparencies, could be crucial.*'

As a result of the accident to G-BXJI, Safety Recommendation 2003-70 was made by the AAIB to the Joint Airworthiness Authorities (JAA) which recommended that *'The CAA should take forward to the JAA a proposal to review the requirements for the design of exits and the provision of safety equipment, in aircraft of the Very Light Aeroplanes category, to enable rapid escape from such aircraft in any normal and crash attitude including turnover.'*

Further safety action

The CAA accepted Safety Recommendation 2003-70 and undertook to forward to the JAA, by 27 September 2003, a proposal to review the requirements for the design of exits and the provision of safety equipment in aircraft of the Very Light Aeroplanes category. Since this recommendation was made, responsibility for the certification specifications for aircraft of this category has been transferred to the European Aviation Safety Agency (EASA) but no response has been forthcoming from either the JAA or the EASA. Therefore, Recommendation 2003-70 was reiterated as Recommendation 2004-107 and directed to EASA.

Safety Recommendation 2004-107

The European Aviation Safety Agency (EASA) should review the requirements for the design of exits and the provision of safety equipment within the Certification Specifications for Very Light Aeroplanes (CS-VLA), to enable rapid escape from such aircraft in any normal or crash attitude including turnover.

Safety action pending

Although no reply to AAIB Safety Recommendation 2004-107 was received direct from the EASA, action is expected this year. According to the CAA, the EASA, working in concert with the JAA, has responded positively and the EASA Rulemaking Directorate has included a review of the design of exits on Very Light Aeroplanes in its forward rulemaking programme. The particular item, VLA.004, plans for a working group to be formed in the second quarter of 2005, and requests a Notice of Proposed Amendment to the Certification Specifications CS-VLA to be delivered in the second quarter of 2006. The EASA programme for CS-VLA rulemaking is available online at http://www.easa.eu.int/doc/Rulemaking/rule_advace_plan_2006_08.pdf and the relevant entry may be found on page 17 of the downloaded file.

AAIB Bulletin No: 3/2005 Ref: EW/G2004/07/24 Category: 1.3

Aircraft Type and Registration:	DH82A Tiger Moth, G-APAO	
No & Type of Engines:	1 Gipsy Major 1C piston engine	
Year of Manufacture:	1940	
Date & Time (UTC):	29 July 2004 at 1132 hrs	
Location:	Duxford Aerodrome, Cambridgeshire	
Type of Flight:	Training	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Damage to right main landing gear, wing tip, elevator, and aileron control arm	
Commander's Licence:	Commercial Pilot's Licence with Instructor rating	
Commander's Age:	35 years	
Commander's Flying Experience:	2,327 hours (of which 115 were on type) Last 90 days - 220 hours Last 28 days - 67 hours	
Information Source:	AAIB Field Investigation	

Synopsis

During a baulked landing on a temporary grass runway, the right main landing gear of the aircraft struck a proprietary 'Tribox' marker, being used to mark the runway's left edge. This caused the aircraft to decelerate, caused damage to the landing gear and gave the pilot cause to abandon his attempt to go-around. The investigation identified that the marker did not satisfy Civil Aviation Authority (CAA) requirements in terms of size, weight, or frangibility.

History of the flight

The Tiger Moth was part of a small fleet of 'classic' aircraft providing pleasure flights and flying instruction at Duxford and other locations.

A week prior to the accident, the instructor had been on duty at Duxford, and had been made aware that the usual grass runway was closed. He was briefed verbally about a temporary grass runway, informed of its dimensions, and told that it was only available to his company. He discussed the restricted width of the temporary runway with a colleague, and agreed that while operating from it they would work to a maximum crosswind limit of 10 kt instead of the normal company Operations Manual crosswind limit of 15 kt.

On the day of the accident the instructor arrived for duty and consulted the Terminal Aerodrome Forecast (TAF) for nearby London Stansted Airport which forecast good visibility and light and variable wind increasing to 160º/10 kt by 1400 hrs. He then undertook a training detail with a student and returned to the airfield for a landing on temporary grass Runway 06, handling the aircraft himself. The approach was normal, but as the aircraft touched down a gust of wind caused it to drift to the left. The instructor applied power to go-around and, mindful of the presence of the 'Tribox' runway edge markers, maintained a three-point attitude in an attempt to gain height as rapidly as possible. Very early in the go-around however, with the aircraft still drifting left, the right main landing gear struck a 'Tribox' marker on the left edge of the temporary runway. The collision damaged the aircraft and caused it to decelerate forcing the instructor to abandon the go-around. The aircraft ground-looped and came to a halt a short distance further on, resting on the right wing tip, left landing gear and tail. Both occupants vacated the aircraft without injury.

After the accident, the instructor noted that the hollow 'Tribox' markers each contained water to a level approximately half way up from the base.

Airfield details

Duxford Aerodrome has two parallel Runways, 06/24; one tarmac and the other, grass. The permanent grass runway is 890 metres long by 53 metres wide. The aerodrome operator had planned an open-air concert that required a large stage to be erected on an area between the grass runway and the aerodrome buildings. This stage infringed the protected area around the existing grass runway. Accordingly the aerodrome operator, in agreement with the CAA's Aerodrome Standards Department, marked out a temporary grass runway similar in length to the permanent one but 28 metres narrower (25 metres wide). This was positioned between the permanent grass and tarmac runways. It was agreed that the temporary runway should be marked in accordance with Civil Aviation Publication (CAP) 168 titled '*Licensing of Aerodromes*'.

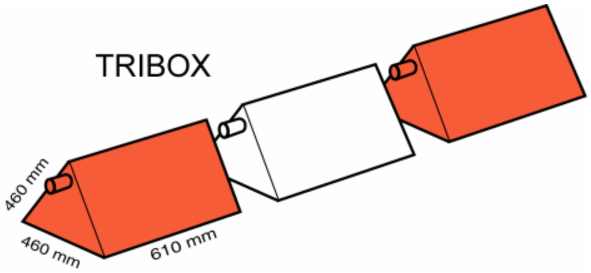
The Aerodrome Standards Department does not give specific guidance to aerodrome operators on issues such as the method of marking temporary runways or equipment to be used. The Department does however, inspect aerodromes regularly to ensure that relevant legislation, standards and recommended practices, are being complied with.

Proprietary 'Tribox' markers were purchased and used to mark the temporary runway and were laid at each runway end and along the sides. Once the markers had been placed, it was recognised that they might be disturbed by propwash, jet-blast, or helicopter rotor-wash, and instructions were given to the Aerodrome Fire Service to partially fill each hollow 'Tribox' with water. No specific instruction was given regarding the amount of water to be used, but the aerodrome operator reported that the 'Triboxes' could be moved 'fairly easily' by one man, even with water in them.

A Notice to Airmen (NOTAM) was published, stating that the permanent grass runway was closed and local arrangements were made for the Tiger Moth operator to have use of the temporary runway, though no formal written briefing was provided. The operator was made aware of the runway dimensions and markings.

The Tribox

Each triangular 'Tribox', constructed of strong medium-density polythene, is 610 mm long, with sides measuring 460 mm in length and standing 398 mm high. Individual boxes may be locked together by means of spigots that locate into holes in an adjoining box.



The manufacturer's website describes the 'Tribox' system as a system of *'Bad ground markers'*, and states that *'Tribox is virtually indestructible being moulded by the Rotational Casting process'*. It also advises that *'the Tribox can be partially filled with water to create extra stability when Jetblast or adverse weather conditions are a problem'.........'Where appropriate, each product meets ICAO, FAA and individual country CAA recommendations'*.

The 'Tribox' itself is relatively light-weight. By calculation however, a Tribox containing water to half its height would weigh some 40 kg more that its empty weight.

Protection of runways

CAP 168 gives guidance and instructions to aerodrome operators on a variety of topics. In the main it is derived from International Civil Aviation Organisation (ICAO) Annex 14 titled '*Aerodrome Design and Operations*'.

CAP 168 contains the following relevant definitions:

(a) 'Runway Strip'

'An area of specified dimensions enclosing a runway intended to reduce the risk of damage to an aircraft running off the runway and to protect aircraft flying over it when taking-off or landing'.

One purpose of a Runway Strip is: *'to protect aeroplanes flying over it during landing, balked landing or take-off by providing an area which is cleared of obstacles except permitted aids to air navigation'.*

(b) 'Cleared and Graded Area'

'That part of the Runway Strip cleared of all obstacles except for minor specified items and graded, intended to reduce the risk of damage to an aircraft running off the runway'.

The following instructions are also given:

(a) 'The Siting of Aids to Navigation within Runway Strips'.

'Any aids to air navigation to be sited within a runway strip should be made as light and as frangible as design and function will permit'.

(b) 'Markings on unpaved runways'.

'Where aircraft performance considerations necessitate the notification of field lengths for a grass aerodrome, the boundaries of unpaved runways and stopways should be delineated by runway edge markers visible from an aircraft on the approach at a range of at least 2 km. Delineation should be effected by either of the following methods: a) white, flat, rectangular markers flush with the surface, 3 metres long, 1 metres wide and spaced at intervals not exceeding 90 metres, or b) frangible markers single-coloured to contrast with their background and firmly secured to the surface spaced at intervals not exceeding 90 metres; the height of the markers should not exceed 36 cm.'

Frangibility

CAP 168 defines frangibility as:

> *'The ability of an object to retain its structural integrity and stiffness up to a specified maximum load but when subject to a load greater than specified or struck by an aircraft will break, distort or yield in such a manner as to present minimum hazard to an aircraft.'*

CAP 168 does not provide any guidance or instruction as to the value of the *'specified maximum load'* nor what constitutes '*minimum hazard'*, and it does not propose any tests for frangibility.

ICAO Annex 14 lays down Standards and Recommended Practices for Aerodromes, with Volume 1 covering Aerodrome Design and Operations. It defines a 'Frangible object' as:

> *'An object of low mass designed to break, distort or yield on impact so as to present the minimum hazard to aircraft',*

The document also contains a note stating:

> *'Guidance on design for frangibility is contained in the Aerodrome Design Manual Part 6 (in preparation)'.*
>
> (The Aerodrome Design Manual Part 6 has been in preparation since approximately 1980, and ICAO hope to publish it in 2005).

In the absence of this publication, ICAO issued 'Interim Guidance' by means of an 'Attachment' to a State letter in October 1991. This Interim Guidance proposes tests for frangibility, requiring two cases to be considered, both using a notional 3,000 kg aircraft as the test example:

> *(1) Collision with the aircraft wing in flight at 75 kt, and*
>
> *(2) Collision with the nose landing gear moving on the ground at 27 kt.*

For these tests, the frangibility requirement is that the structure shall *'break, distort or yield readily'*. The document illustrates equipment to be used in this testing and gives guidance as to how testing should be carried out. It states that:

> *'The object is considered "frangible" if it breaks, deforms, or yields readily upon impact and it is judged that the resulting damage to the impactor is such that no hazardous condition exists'.*

The United Kingdom Civil Aviation Authority received the attachment to the State letter.

Landing gear design

The standards for the design of aircraft landing gear are laid down in British Civil Airworthiness Requirements (BCARs), Joint Aviation Requirements (JARs), Federal Aviation Regulations (FARs), European Aviation Safety Agency Certification Specifications (EASA CS) and other codes. These standards require landing gear to be capable of withstanding loads and stresses encountered during normal ground operations, takeoff and landing. There is no specific requirement to withstand collision with ground objects.

Discussion

ICAO's Standards and Recommended Practices correctly recognise the hazard posed to aircraft by collision with objects on the ground and make it clear that the runway and the cleared and graded area around it should be free of obstacles that might hazard the safe flight of an aircraft taking off, landing and in baulked landing cases.

It is inevitable that there will be occasions when temporary runways must be marked out. In establishing such markings the precise boundaries of the runway must be apparent to avoid confusion with existing markings for nearby permanent runways; although these should be obscured where necessary. The flat markers proposed by CAP 168 would seem to have many advantages and only one shortcoming; that they might be difficult to see in certain light conditions when markers with a vertical element might be more easily perceived.

The aerodrome operator chose the 'Tribox' as a means to mark the temporary runway without taking note of the maximum height stipulated in CAP 168 or assessing the frangibility of the 'Tribox' structure. The decision to partially fill the 'Triboxes' with water is at variance to the CAP 168 requirement for such markers to be lightweight.

The 'Triboxes' used were of a design intended for use on airfields. Their design however, does not satisfy the CAP 168 criteria for use as runway markers within the cleared and graded area as they stand more than 360 mm high. Furthermore, although no testing was carried out, it is clear by inspection that the combination of the structurally-strong triangular-sectioned design, the thickness of the walls and the dense plastic material makes them unlikely to distort or yield when struck. Indeed, the manufacturer describes them as *'virtually indestructible'*.

The manufacturer's statement that they are designed to be used to mark bad ground illustrates one purpose for which they may be suitable. However, the ICAO or CAP 168 specification for 'Bad Ground' markers differs from that for temporary runway markers and this may not be immediately apparent to a potential purchaser.

The manufacturer states that 'Triboxes' may be partially filled with water but does not specify how much water should be used and it is possible that, had the Tribox in this case contained significantly less water, the consequences of the collision may have been less severe.

The delay in the publication of the Aerodrome Design Manual Part 6 (Guidance on design for Frangibility), is significant. Given this delay, the decision by ICAO to issue interim guidance material was sound but the Guidance however, does not constitute a Standard or Recommended Practice and the CAA, in receipt of the Guidance, appears not to have taken action to communicate it to aerodrome operators. This Guidance could have been incorporated into CAP 168 and would have addressed the fact that CAP 168 does not provide any definitive guidance on assessment of frangibility. Had this been carried out, aerodrome operators would have been able to carry out accurate testing to determine frangibility and this might have set in action a process by which the 'Tribox' could have been identified as unsuitable for use as a temporary runway marker within the cleared and graded area.

The ICAO tests take a 3,000 kg aircraft as the 'baseline' model and it would appear that they consider the Piper PA-31 Navajo as a typical example. The PA-31 is a twin piston light aircraft typically seating a pilot and five passengers. Frangibility requirements derived from tests, which consider a comparatively large light aircraft, are however, unlikely to be appropriate for aerodromes where most traffic is substantially lighter and slower. In particular, it will offer little safeguard to aircraft such as the Tiger Moth or many other light training and touring aircraft, microlights, or gliders.

It is also apparent, that whilst the ICAO Guidance provides means of testing for frangibility, this does not take any relevant standard for landing gear design as its baseline; indeed no such standard exists.

Conclusions

The aircraft struck a runway marker during a baulked landing that damaged the aircraft and prevented the execution of a successful go-around. The runway marker did not meet criteria regarding height and frangibility specified in CAP 168 and was made significantly heavier than its empty weight by being filled with a quantity of water.

Safety Recommendation 2004-106

It is recommended that the United Kingdom Civil Aviation Authority Aerodrome Standards Department publish advice to aerodrome operators to ensure that obstacles placed within a runway's Cleared and Graded Area are genuinely lightweight and frangible taking into account the types of aircraft that commonly use the runway.

Safety action

The manufacturer of the Tribox informed the AAIB that:

> *'We intend advising new buyers of TRIBOX in future that whilst a small volume of water can usefully be used to weight TRIBOX to prevent it from 'blowing away' one must always consider the frangibility of this or any other product in relation to moving aircraft in Cleared and Graded areas'.*

Similar advice has also been published on the manufacturer's website.

Aircraft Type and Registration:	Europa AL Europa, PH-ZZZ	
No & Type of Engines:	1 NSI Subaru EA81 piston engine	
Year of Manufacture:	1998	
Date & Time (UTC):	9 December 2004 at 1137 hrs	
Location:	RAF Linton-on-Ouse, Yorkshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - 1 (Minor)	Passengers - 1 (Minor)
Nature of Damage:	Extensive damage, aircraft written off	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	53 years	
Commander's Flying Experience:	4,010 hours (of which 50 were on type) Last 90 days - 61 hours Last 28 days - 9 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

The pilot took off from Wombleton Airfield near Pickering in Yorkshire, for a flight to Manston Airport in Kent. About 15 minutes into the flight a loud bang was heard from the engine compartment and the engine began to run very roughly, accompanied by a considerable decrease in power and a smell of fuel in the cockpit. The pilot was unable to restore full power, and that which remained was only just sufficient for level flight. The aircraft was turned towards RAF Linton-on-Ouse which was about 10 minutes flying time away. The pilot established communications with ATC at Linton-on-Ouse and was given radar vectors to assist navigation. The longest runway available was Runway 22, but the pilot chose to make an approach to Runway 28, which allowed for a more expeditious approach and required less manoeuvring. The surface wind at RAF Linton-on-Ouse was from 150º(M) at 5 kt, with 6,000 metres visibility in smoke haze and with scattered cloud cover at 1,500 feet.

The pilot identified the airfield at relatively close range and commenced approach to Runway 28, remaining high to assure a landing on the runway if the engine should fail completely. Once he was confident of reaching the runway, the pilot reduced power to idle and lowered flaps to the landing setting. The aircraft approached the runway at a higher than normal approach speed and appeared reluctant to decelerate for landing. The pilot later estimated that the aircraft's airspeed approaching the flare may have been as high as 80 kt. He also had the impression that a physical throttle restriction may have prevented him selecting the idle setting.

It became clear to the pilot that the runway was much shorter than expected and that a landing on the remaining runway would not be possible without risking an over-run. He initiated a go-around and the engine appeared to produce some power initially, but the power then reduced rapidly. The pilot selected a field ahead and to the right for a forced landing, but soon realised that an impact with a hedge immediately before the field was likely. Rather than risk stalling the aircraft in an attempt to clear the hedge, he flew the aircraft into the hedge, actually touching down briefly in the field just before it. The aircraft passed through the hedge into the field beyond and then travelled for about 20 metres before pitching nose down and inverting. The 'gull wing' doors and front windscreen separated from the aircraft as it inverted but the pilot and his passenger became trapped in the wreckage.

The pilot turned off the master switches and both occupants were able to confirm that they had not sustained major injury. Neither was able to move though, and with fuel dripping over them, both were concerned about the obvious fire risk. After a few minutes the RAF fire and medical crews, which had been placed on stand-by, arrived at the crash site and were able to lift the wreckage with airbags. The occupants were then airlifted to York hospital where they were found to have suffered only minor injuries.

Runway 28 at RAF Linton on Ouse is 1,339 metres long. For a normal powered approach, the aircraft owner's manual quotes an approach speed of 60 kts, with a touchdown speed of 45 to 50 kt, depending on weight. The landing ground roll at maximum weight is 160 metres on a hard, dry surface with normal wheel braking applied in calm conditions. The recommended glide speed (engine off) is 75 kt.

The cause of the engine's rough running has not yet been determined. The aircraft owner, who lives abroad, is to arrange a detailed inspection of the engine in due course; the results of that investigation will be issued as an addendum to this report in a future bulletin.

Aircraft Type and Registration:	Piper PA-25-235 Pawnee, G-BDWL	
No & Type of Engines:	1 Lycoming O-540-B2C5 piston engine	
Year of Manufacture:	1965	
Date & Time (UTC):	1 February 2004 at 1354 hrs	
Location:	Crowland Airfield, Lincolnshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - 1 (Fatal)	Passengers - N/A
Nature of Damage:	Aircraft destroyed	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	81 years	
Commander's Flying Experience:	2,160 hours (of which 685 were on type) Last 90 days - 5 hours Last 28 days - 4 hours	
Information Source:	AAIB Field Investigation	

Synopsis

The Pawnee carried out a normal takeoff towing a glider. At approximately 500 feet it inexplicably turned to the right and entered a descent. The glider released from the tow and was able to land normally back on the airfield. The aircraft however, continued its descent striking the ground banked 35º to the right in a 45º nose down attitude. It is probable that the pilot became medically incapacitated in flight before being fatally injured in the impact. One medical related safety recommendation has been made.

History of the Flight

The pilot and his wife, both qualified glider pilots, flew together earlier in the day, successfully completing a twenty-minute glider flight from an aero-tow release height of 3,000 feet. An hour after landing the pilot relieved the 'duty pilot' on the tug aircraft, G-BDWL, to carry out the final aero-tow of the day. Although the weather at the time was satisfactory there were signs that deteriorating conditions were approaching from the west. The surface wind was estimated to be

210°/15-18 kt with moderate turbulence; the visibility was good; there were a few clouds at 3,000 feet and the temperature was 11°C.

As he strapped himself into the Pawnee, the pilot was described as being 'his normal self, chatting and joking' with the 'duty pilot' who was checking that the aircraft canopy was clean. Meanwhile, a student and gliding instructor were strapping themselves into the glider. The two aircraft were then connected by the tow rope in preparation for takeoff.

It was normal practice for the gliding club to use radios, which were fitted in both the towing aircraft and the glider, to enable communication between the ground crew and the tug pilot. This particularly applied while the slack was being taken up on the towing cable and to confirm that all was ready for the two aircraft to takeoff. This flight was no exception, and the glider pilots heard the tug pilot respond correctly to the radio calls made by the ground crew.

The takeoff from Runway 21 proceeded normally and the aircraft and glider combination climbed ahead, at approximately 60 kt on the runway heading, until they reached a height of about 500 feet. The Pawnee then started a gentle turn to the right. The glider followed as the Pawnee's angle of bank gradually increased and its rate of climb reduced. There was no change in the Pawnee's engine power and no apparent pilot induced deflection of the Pawnee's control surfaces that could have given rise to the manoeuvre. The tug and glider combination then began to descend and accelerate. When the angle of bank reached approximately 20° the glider instructor realised that something was wrong. He took control of the glider and called "release" while pulling on the yellow release toggle. The student also pulled his release toggle and the glider separated from the tug at an estimated height of between 300 to 400 feet agl and at a speed of about 70 kt. The glider continued the turn into a right hand circuit and landed safely back on Runway 21. Meanwhile, the Pawnee was seen to continue to turn to the right, with a gradually increasing angle of bank, and to descend at an ever steepening angle, still without any apparent control inputs being made by the pilot. The aircraft struck the ground pitched nose down by 45° and banked 35º to the right. Witnesses on the ground remarked that the engine sounded as if it had remained at take-off power throughout.

Members of the gliding club rendered assistance to the pilot of the Pawnee, which, despite being severely damaged, had not caught fire. On arrival at the aircraft however, it was evident that he had not survived the accident.

Pilot Information

Flying experience

The pilot had been flying Single Engine Piston (SEP) aeroplanes and gliders for 50 years He was issued his Private Pilot's Licence in 1953 and had accrued a total of 2,160 hours in SEP aeroplanes and 2,400 hours in gliders, in which he was also qualified to instruct. He flew on a regular basis and had carried out three aero-tows as the pilot of the tug aircraft the day before the accident. There was no evidence that the accident was the result of any handling problems.

Medical examinations

The pilot had a current Joint Aviation Authorities (JAA) Class 2 medical certificate. This certificate had to be renewed annually because he was over the age of 50. An annual electrocardiogram (ECG) examination also formed part of the medical certificate requirements. (Note: Class 2 medical certificates held by pilots below the age of 50 are valid for 2 years as is the requirement for an ECG examination.)

During his routine flight crew medical examination conducted in 2001 his ECG had been queried and he had been subjected to a cardiological review in September of that year. This review included an exercise ECG and the UK Civil Aviation Authority (CAA) considered that the results were compatible with a JAA Class 2 medical certificate. In 2002 the pilot's ECG again caused him to be referred to a cardiologist. After a review in July 2002 and a 24-hour ECG later in the year, which showed no abnormalities, the pilot was declared fit to fly but with a requirement for an annual cardiology review. As a consequence, the pilot saw a cardiologist again in November 2003 and, once more, he was assessed as being fit to hold a JAA Class 2 medical certificate, with no further cardiology review required over and above the normal requirements. However, the pilot's blood pressure was noted to be high and he commenced a course of treatment in the same month, with further medication being prescribed in January 2004. Although the pilot had been advised that he should inform the CAA of any additional medication prescribed, he appears not to have done so.

Pathology

The report of the post mortem examination stated:

> *In summary, this man died due to the effects of injuries sustained during the crash and it is likely that the crash was caused by medical incapacitation due to haemorrhage into an atheromatous plaque of a coronary artery. Appropriate medical screening had been performed and he had been reviewed by a cardiologist; given that his coronary artery*

> *atheroma was not severe and that haemorrhage of this sort into a plaque is a random and unpredictable event, it is unlikely that any other more intensive medical screening would have prevented this occurrence. His age clearly represents a risk factor not only for cardiac events but other potentially incapacitating medical conditions, and the Civil Aviation Authority may wish, once more, to review the medical requirements for pilots in this age group.*

The report considered it likely that the haemorrhage would have triggered a spasm of the coronary artery, leading to a cardiac arrhythmia, or irregular heartbeat, and loss of consciousness. It also stated that there was no reason to assume that the blood pressure medication, which the pilot had recently been prescribed, contributed to the accident.

Glider towing operations

Although the aircraft and the glider were both fitted with a radio, it was also possible for the pilots to use a system of pre-arranged signals between the glider and tug aircraft to cater for abnormal situations if there was a radio failure. In the event of a tug problem the pilot would rock the wings, signalling the glider to release at once. If the tug pilot saw a problem with the glider, such as its airbrakes being open, he would move the rudder from side to side. In an emergency it was also possible for the tug pilot to release the tow cable from its attachment at the rear of the tug aircraft using a release handle in the cockpit. Neither of the visual signals nor activation of the tow cable release by the tug pilot were observed on the accident flight.

It was the usual practice at this club for an aircraft/glider combination, after becoming airborne, to climb straight ahead at 60 kt to 2,000 feet agl before releasing.

The previous tug pilot estimated that the aircraft contained between nine and ten gallons of fuel when he handed it over for its final flight. He stated that the aircraft had operated normally on its previous flight, which was also an aero-tow, and that he was planning to operate the next aero-tow himself when the accident pilot asked if he might take over the towing duties.

Accident site details

The aircraft crashed into cultivated ground adjacent to the left hand edge of Runway 27. The initial impact mark had been made by the right wing tip; immediately beyond this were marks made by the main landing gears and nose of the aircraft. The disposition of the marks indicated that the aircraft had struck the ground on a track of around 300° magnetic, banked approximately 35° to the right and in a steep nose-down attitude, probably in excess of 45°. The aircraft had then performed a cartwheel manoeuvre along a track of approximately 330° onto the grassed surface of the runway, with the main wreckage coming to rest erect and with the nose pointing back along the impact path approximately 25 metres from the initial impact point. The aft fuselage had suffered an inertial failure during the impact such that it was lying parallel to the right wing.

The glider tow rope had detached from the aircraft and was found lying on the ground a few metres back along track from the initial impact point. It was found that the release mechanism on the aircraft had operated, most probably due to movement of the release lever in the cockpit during the initial impact. The glass-fibre fuel tank had burst open at impact but this had not resulted in a fire. The absence of a refuelling log meant that the contents at the time of the accident could not be quantified.

Examination of the wreckage

The cable operated flying control system was examined and it was established that there had been no pre-impact failure or disconnect. It was also established that the flaps were in the retracted position at impact.

The engine had been torn off its mountings during the impact but had remained attached to the airframe by various control and instrumentation cables. The two-bladed metal propeller did not display the usual evidence of power applied at impact, ie chord-wise scoring and damaged leading edges. However the witness evidence was consistent in that the engine was heard to be operating at high power throughout. It is probable that the absence of significant propeller blade damage was the result of the steep impact attitude causing the propeller to be brought to an immediate halt. Also, the heavy, clay-based soil contained few obstructions, such as stones, that could have damaged the blades.

During the course of the examination some corrosion was found in the right elevator. The elevators on this type of aircraft are constructed from a steel frame with a fabric covering. The forward structural member consists of a ⅞ inch diameter torque tube which is attached to the rear of the horizontal stabiliser. A curved trailing edge tube, of approximately ⅜ inch diameter is welded to the inboard end of the torque tube, close to the fin.

The trailing edge tube was found to have corroded through almost its entire thickness close to its welded joint with the torque tube. The outboard section of the tube however, was in good condition. Whilst it was not clear if the tube had failed prior to impact, it is considered that even if it had, this would have resulted in some loss of span-wise torsional rigidity, perhaps leading to a degree of warping. Thus, there may have been a reduced down-force on the right elevator when aft stick (up elevator) was applied. It is considered that this did not have any bearing on the cause of the accident. The corrosion may have had its origins in the aircraft's crop-spraying days, but is not visible under the fabric covering. The equivalent component on the left elevator displayed no corrosion. The Civil Aviation Authority's (CAA) attention has been drawn to this matter.

Survivability

Despite the severity of the impact, the tubular space-frame construction of the fuselage had prevented a collapse of the cockpit area. The seat had broken from its mountings although the harness had remained intact. The shoulder straps were attached via a steel cable to a lockable reel located in the aft fuselage. The reel was mounted on a plate that had been welded to one of the structural tubes. The reel could be locked by means of a lever in the cockpit connected to the lock mechanism on the reel itself. This was found in the unlocked position, and while it is possible that it could have been moved post accident, the reel had broken away from its mount due to severe distortion of the strut on to which it had been welded. The distortion was associated with the structural disruption that had occurred in the cartwheel manoeuvre; thus the reel did not break away as a result of any loads applied via the shoulder harness cable.

In view of the steep attitude and the likely speed at impact, it is considered that the accident was non-survivable.

Additional information

A very similar accident, reported in AAIB Bulletin 9/2004, occurred on 29 February 2004. That investigation concluded that the pilot of a Pawnee (G-ASKV), aged 71 years with a JAA Class 2 medical certificate, probably died in flight as a result of heart failure. It was considered that an abnormality in the pilot's heart had developed in the five month period since his previous medical examination. He, likewise, gave no indication that he felt unwell and had already completed several aero-tows immediately before the accident flight.

Analysis

The aero-tow flight proceeded normally until, at approximately 500 feet agl, the tug aircraft inexplicably rolled to the right and descended. Realising that something was wrong, the glider released from the tow to carry out a normal landing on the airfield. After release the tug aircraft continued to roll and descend into the ground. The pilot appeared to have no influence on the aircraft's progress once the unexpected deviation from the normal flight path occurred.

The engineering examination, although discovering some corrosion in the right elevator, did not reveal any technical fault that could have caused the accident.

The pilot was experienced in glider towing operations, familiar with the aircraft and held a current JAA Class 2 medical certificate. Although he appeared to be fit and well, the post mortem report stated that it was likely that the accident occurred as a result of him becoming medically incapacitated in flight. He had received a number of cardiological reviews in the previous three years and had been assessed as fit to hold a JAA Class 2 medical certificate on each occasion. It was considered unlikely that any more intensive medical screening would have prevented his incapacitation as the underlying cause was regarded as a random and unpredictable event.

The post mortem report stated that *'the pilot's age clearly represents a risk factor not only for cardiac events but other potentially incapacitating medical conditions, and the Civil Aviation Authority may wish, once more, to review the medical requirements for pilots in this age group.*

The accident on 29 February 2004, in which a 71-year-old pilot, operating another glider towing Pawnee, probably died of heart failure in flight, appears to add weight to the argument for such a review.

The aviation medical authorities require an increased level of medical scrutiny for flight crew over the age of 50 years because of the statistical increase in health risks attributable to increasing age. The periodicity of medical and ECG examinations for pilots significantly over the age of 50 however, remains unchanged. At one time there was a requirement for pilots over the age of 65 to have an aviation medical examination every six months. This requirement however, was changed to 12 months by the JAR. ICAO Annex 1 paragraph 1.2.5.2 details a 'Standard' of 24 months periodicity for private pilots. ICAO Annex 1 also details a (non-mandatory) 'Recommendation' (paragraph 1.2.5.2.2) that this should be reduced to 12 months in those over 40 years. The JAR is therefore in accord with the ICAO 'Recommendation', but is more stringent than that demanded by the relevant 'Standard'.

Notwithstanding the comments above, this accident, and the one on the 29 February 2004, involved elderly pilots suffering from a rapidly deteriorating medical condition whilst airborne. The onset of one condition appears to be 'random and unpredictable' whilst the other appears to have developed between medical examinations.

Safety Recommendation 2004-101

It is therefore recommended that the Joint Airworthiness Authority (Licensing Sectorial Team) consider supporting a study of the continuing medical fitness of elderly pilots in order to ascertain whether a review of the medical requirements and periodicity for a Joint Airworthiness Authorities (JAA) Class II medical is required or, regardless of medical examination requirements, whether there should be an upper age limit placed on persons wishing to operate aircraft certificated for single pilot operations.

AAIB Bulletin No: 3/2005 **Ref: EW/G2002/08/05** **Category: 1.3**

Aircraft Type and Registration:	Piper PA-28-140 Cherokee, G-AYWE
No & Type of Engines:	1 Lycoming O-320-E2A piston engine
Year of Manufacture:	1970
Date & Time (UTC):	7 August 2002 at 1515 hrs
Location:	Approach to Denham Airfield, Middlesex
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Severe damage to aircraft
Commander's Licence:	Airline Transport Pilot's Licence with Flying Instructor Rating
Commander's Age:	32 years
Commander's Flying Experience:	6,500 hours (of which 1,500 were on type) Last 90 days - 180 hours Last 28 days - 70 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

History of flight

The purpose of the flight was to conduct a PPL skill test. During the flight, regular carburettor ice checks were carried out and, reportedly, no evidence of ice was apparent. After some two hours airborne the aircraft was flown back to Denham where the student completed a normal circuit for a touch-and-go on Runway 24. During this circuit, carburettor heat was applied on the downwind leg and on final approach and the engine responded normally throughout. Cold air was selected for the subsequent climb back to the circuit height of 750 feet agl. For the next circuit, the student had been briefed for a glide approach and, when on the downwind leg, the pre-landing checks were completed including the selection of full carburettor heat for several seconds. On base leg, the student again selected full carburettor heat and, after a few seconds, closed the throttle and commenced the descent from 750 feet agl. During the subsequent descent, the engine speed indication was showing between 1,100 and 1,200 RPM. Initially, the descent profile was good with an aiming point about ⅓ distance along the runway. Then, following the selection of 25° flap, a slight undershoot of the aiming point began to develop. As the aircraft approached the normal APAPI descent profile of 4.5°, at about 200 feet agl, the instructor called for the application of power. The student reacted immediately but there was no apparent response from the engine. The instructor called "Go-around" and the student promptly applied full throttle. With no response from the engine, the carburettor heat was selected to 'cold' but with no effect on engine response. The aircraft struck trees in the undershoot area and then impacted the ground; it came to rest on a heading of 040°, some 100 metres short of the runway threshold. Both occupants were able to evacuate unaided from the aircraft. The instructor reported that the AFS arrived promptly on the scene but that there was no fire.

The instructor subsequently commented that he was aware that the weather conditions were conducive to the formation of carburettor icing. The actual conditions at the time of the accident were as follows: surface wind 270°/7 kt; visibility greater than 10 km; isolated showers; temperature of 25°C and dew point of 13°C. Information contained within General Aviation Safety Sense Leaflet 14A: *Piston Engine Icing*, indicate that, in these conditions, serious icing could occur with descent power. Subsequent to the engineering investigation as reported below, the Meteorological Office at Bracknell was contacted for more detailed information on the possibility of carburettor icing in the Denham area, particularly on the day of the accident. This indicated that there were frequent heavy showers in the Denham area around the time of the accident; this activity would have increased the humidity and the possibility of carburettor icing.

Engineering investigation

The aircraft and its engine were examined by the AAIB at Denham Airfield. The aircraft had been severely damaged by impact with trees and the ground. The left wing was severed at the root and all three landing gears had been torn off. The fuselage had sustained damage to the nose section and was also badly buckled behind the cabin area, but the cabin itself was intact. Although a significant amount of fuel was released from the aircraft after impact, no fire had occurred.

Damage to the tips of the propeller blades (chordwise scraping and blade tip deformation) indicated that the engine was running at the time of impact, although it was evident that the engine had not been developing high power. Impact damage to the crankshaft and the carburettor precluded any possibility of functionally testing the engine but it was examined in-situ, as detailed below.

The cold and hot air induction paths were inspected and found to be free from blockage. The throttle cable and mixture controls operated satisfactorily but the carburettor heat control was jammed due to the carburettor heat flap housing having been crushed in the impact. When the cable was cut at its connection to the heat flap operating lever, the carburettor heat control cable could be moved freely. There was no evidence of pre-impact damage to the heat flap mechanism, which was judged to have been open (cold air position) at the time of impact, which could have prevented it from operating correctly prior to impact.

The spark plugs were inspected and found to be in good condition, with the exception of the lower plug on the front right cylinder, which was heavily wetted with oil. This probably occurred after impact, as there was no evidence that the oil had been burnt. Continuity of the crankshaft, pistons, valve gear and accessory drives was confirmed by turning the engine by hand.

The carburettor was returned to the AAIB at Farnborough and disassembled for inspection. The inlet filter was found free of significant debris, there was no blockage of the main jet and the accelerator pump mechanism operated correctly. The electric fuel pump was tested, and also operated satisfactorily, and a sample of fuel obtained from this pump was confirmed to be the correct colour for AVGAS and did not contain any visible water.

In summary, no evidence was found of any mechanical defect to explain the failure of the engine to respond to throttle application.

Discussion

In the existing weather conditions, and with no obvious mechanical defect, the most probable reason for the engine failing to respond would be carburettor icing. However, both the instructor and student considered that they had fully complied with the advice contained within the aircraft, and the relevant CAA publications, to minimise the chances of such icing. The AAIB are studying all recent occurrences of suspected carburettor icing, together with historical data, with a view to making a collective submission on the subject to the CAA.

Aircraft Type and Registration:	Reims Cessna FA152, G-BGLN	
No & Type of Engines:	1 Lycoming O-235-L2C piston engine	
Year of Manufacture:	1979	
Date & Time (UTC):	27 July 2004 at 1545 hrs	
Location:	Ingleby Cross, Northallerton, Yorkshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Substantial damage	
Commander's Licence:	Private Pilot's License	
Commander's Age:	28 years	
Commander's Flying Experience:	152 hours (of which 116 were on type) Last 90 days - 27 hours Last 28 days - 12 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

The aircraft was being flown on a navigation exercise from Bournemouth to Teesside Airport and had been refuelled with 86 litres of fuel, which would give an endurance of approximately 3.9 hrs. The wind was variable at 5 kt with 15 to 20 km visibility and a cloud base at 2,500 feet.

After approximately 2.7 hrs, and 16 miles SSE of Teesside, the engine started to run roughly. The pilot selected CARB HEAT and initially the engine ran smoothly before it again ran roughly with a loss of power. As the pilot was experiencing difficulty in maintaining height he made a PAN call to Teesside Approach Radar who responded by giving the QDM and miles to run to the airfield. Approximately five minutes after the initial loss of power the engine stopped and the pilot declared a Mayday. Despite selecting full flap and making a number of S turns, the aircraft touched down half way into the selected field at 70 kt before running through a hedge at its far end at approximately 40 kt. The nose wheel collapsed and the aircraft came to rest 10 metres beyond the hedge in a nose down attitude. The pilot and passenger, who were secured by four point harnesses, were uninjured and made a successful egress through the cabin doors.

The Head of Training from the pilot's flying club visited the crash site the following day when he operated the engine fuel drain and observed a steady stream of Avgas. The pilot believes that the engine failed due to carburettor icing. A radiosonde ascent to the west of the crash site showed the airmass at the time of the accident to be reasonably moist at 6,000 ft and the temperature dew point recorded at Teesside at 15.50 hrs was 22°C/12°C. Reference to a carburettor icing chart showed that these conditions are conducive to moderate icing at cruise power.

AAIB Bulletin No: 3/2005 **Ref: EW/G2004/11/09** **Category: 1.3**

INCIDENT

Aircraft Type and Registration:	Cessna 172C, G-ARYK	
No & Type of Engines:	1 Continental O-300-C piston engine	
Year of Manufacture:	1962	
Date & Time (UTC):	4 November 2004 at 1654 hrs	
Location:	Lydd, Kent	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Dent in right horizontal stabiliser leading edge	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	75 years	
Commander's Flying Experience:	308 hours (of which 102 were on type) Last 90 days - 0 hours Last 28 days - 0 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Following a local flight, the pilot prepared, about 1654 hrs, for an approach to Runway 03 at Lydd Airport. Official sunset was 1630 hrs which, together with a reported cloud cover estimated to be about 3 oktas, resulted in degraded visual conditions for the landing.

On the day of the accident, work was being carried out at the start of Runway 03. This displaced the threshold of the runway by 500 metres and the area of work in progress (WIP) was indicated by a series of red blocks, followed by a line of black cones (with reflective strips), across the runway. In addition, the runway lighting had been reduced, with illuminated edge lights commencing some distance beyond the line of black cones. The WIP had been communicated in a NOTAM, which stated:

' A)EGMD B)0410270800 C)0411231700 EST
E)RWY 03/21 TEMPO DECLARED DIST DUE WIP ON SW 500M:
RWY 03 TORA/ASDA 945M TODA 1675M LDA 805M
RWY 21 TODA/ASDA 945M TORA 805M LDA 910M
DISPLACED THR 03 IDENTIFIED WITH TEMPO MARKINGS AND WINGBARS. RWY 03
PAPI AND ALS NOT AVBL, RWY EDGE LGT LIMITED. APRON/TWY EGDE LGT U/S.
WHEN RWY 03 IN USE SOLO TRAINING FLT NOT PERMITTED. OUT OF HR PERMITS
CNL UFN. HEL SHALL CONFORM TO FIXED WING PATTERNS AND MUST AVOID
OVERFLYING WIP. DETAILS CONTACT 01797 320881 OR
WWW.LYDD-AIRPORT.CO.UK)'

As the pilot approached the runway he became away of the line of red blocks but, due to the reduced visibility of dusk and a partially cloudy sky, he did not see the line of black cones until he was close to touchdown. As he landed, the right main wheel contacted one of the cones, causing the cone to be flung upward and rearward, which then struck and dented the leading edge of the right horizontal stabiliser. The aircraft did not sustain any further damage and no injuries were suffered by the pilot or passenger.

The pilot's most recent flight was at Lydd in May 2004.

AAIB Bulletin No: 3/2005 **Ref: EW/G2004/10/13** **Category: 1.3**

INCIDENT

Aircraft Type and Registration:	Yak-52, G-YOTS	
No & Type of Engines:	1 Ivchenko Vedeneyev M-14P piston engine	
Year of Manufacture:	1990	
Date & Time (UTC):	31 October 2004 at 1300 hrs	
Location:	Southend Airport, Essex	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Nose wheel tyre and propeller damaged	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	62 years	
Commander's Flying Experience:	789 hours (of which 116 were on type) Last 90 days - 30 hours Last 28 days - 10 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot and further AAIB enquiries	

History of the flight

The pilot, who was also the aircraft owner, took off from Southend Airport intending to practise aerobatics before landing at North Weald Airfield for re-fuelling and refreshments. The pilot flew a stall turn at 3,500 feet, which ended with the aircraft in a 70º dive. At this point the pilot became aware of a control restriction and checked that his passenger, who was qualified on type, was not applying pressure to the controls. The pilot closed the throttle and assessed that there was just sufficient control authority in the nose up sense to recover from the dive normally, albeit with considerable loss of height. The aircraft recovered to climbing flight below 1,000 feet agl and the pilot then applied power to gain height. He declared an emergency on Southend Tower frequency, stating that he had a control restriction and requesting an immediate landing at Southend. Runway 06 was in use with a light easterly surface wind but, as the aircraft was positioned 3 nm north east of the airport and considering the nature of the emergency, the pilot chose to make an approach to Runway 24. A light aircraft which had been on finals for Runway 06 was instructed to go-around and, once it had commenced an early left turn, the YAK-52 pilot was cleared to land.

The pilot flew a steeper than normal approach but could not arrest the descent rate prior to landing. The aircraft touched down very heavily and bounced, though the subsequent touchdown seemed to observers to be much more controlled. The pilot reported that he re-gained control of the aircraft after the initial bounce. The aircraft suffered damage to the nose wheel and propeller tips, which left 4 two inch deep strike marks on the runway surface. Both occupants were wearing 5 point harnesses and were uninjured. The airport fire service, which had been alerted after the initial emergency call, accompanied the aircraft as it vacated the runway under its own power. The pilot was of the opinion that, had the aircraft impacted an unprepared surface, the crash may not have been survivable.

Aircraft examination

The aircraft was examined by a company specialising in the import, overhaul and repair of this type. A mobile telephone was found loose in the rear most section of the fuselage. The telephone exhibited considerable damage, which was consistent with it becoming trapped in the rear elevator quadrant. A ceconite barrier, fitted in the fuselage as a mandatory modification and designed to prevent the migration of loose articles rearwards, was found to be detached from approximately 60% of the frame to which it was bonded. The pilot later reported that he had been aware of the defective barrier for some time, but stated that the disbonded area was limited to a corner of the barrier which resulted in a small flap of approximately 1 inch square.

The loose article

The mobile telephone had been introduced into the aircraft two weeks before the flight described in this incident. The aircraft owner had taken a passenger for a flight but as the flight did not include aerobatics, the owner had not taken specific measures to ensure that no potential loose articles were taken into the cockpit. The owner of the telephone, who was not a pilot, had not realised that it had been lost inside the aircraft. The aircraft flew approximately 6 hours after that flight and before the flight during which the incident occurred; aerobatics were flown during this period, but not the type of manoeuvre which preceded the control restriction.

Previous occurrence

There have been a number of cases of a loose article causing a jam in the elevator control assembly of this type of aircraft. In a fatal accident involving Yak-52 G-YAKW (AAIB Bulletin October 2003), a screwdriver was found to have jammed the aft elevator quadrant, preventing the elevator from being moved beyond neutral in the up direction. In the accident to G-YAKW, the elevator also became jammed during a stall turn manoeuvre, denying the pilot the necessary control to recover from the ensuing vertical dive. The construction of the aircraft was found to have contributed to the accident. Being originally designed for military purposes, the YAK-52 is stripped of most of the trim and bulkheads normally associated with civilian aircraft, exposing the flying controls to loose articles in both the cockpit and rear fuselage. Additionally the rearmost vertical fuselage frame, which is just to the rear of the elevator control quadrant, was found to be capable of receiving loose articles during vertical flight in such a manner as to 'offer them up' to the elevator quadrant as the elevator was moved. As a result of the accident investigation, the AAIB made Safety Recommendation 2003-71. This called for the Yak-52, and aircraft of a similar design, to be fitted with a method of preventing loose articles migrating to a position where they could jam or otherwise interfere with the operation of the flying controls.

Airworthiness action

In response to Safety Recommendation 2003-71 the CAA issued Mandatory Permit Directive (MPD) 2004-006. The MPD called for a barrier to be installed in the rear fuselage to close off the aft elevator quadrant from the cockpit area in order to prevent loose articles finding their way to the rear of the aeroplane and jamming the elevator control.

Although he was aware of some limited damage to the barrier fitted to G-YOTS, the pilot thought that a second barrier was also fitted further aft and so did not appreciate the significance or implication of the damage. The damage was first noted before the telephone was introduced into the aircraft and was visible through a clear view panel in the fuselage side designed for this purpose. His pre-flight check for loose articles in the aircraft rear was to slap the fuselage and listen and feel for vibrations which would indicate a loose article present within the fuselage. This is a common check taught to pilots of this aircraft type. A limited visual inspection of the rear fuselage interior towards the installed barrier is possible from the cockpit area, but is hindered by an electronics rack aft of the rear seat. The area behind the barrier is only accessible after removing an access panel which would not be practical for a pre-flight inspection and is instead incorporated into the maintenance schedule.

The investigation into the accident to G-YAKW identified a good awareness among YAK-52 operators of the loose article hazard on this type, but also highlighted the limitation of slapping the rear fuselage to identify loose articles. It was found that this method was only capable of detecting articles in the mid section of fuselage, as a handle prevented slapping the fuselage in the rearmost section adjacent to the elevator quadrant.

Analysis

The barrier in G-YOTS had been fitted by an approved agency which also conducts the required annual inspection and renewal of the barrier. To date, about 60 aircraft fitted with this barrier have been inspected by the agency, none of which have exhibited a similar defect. Enquiries were made of another maintenance company, which also reported no similar incidents. It was not possible to determine when the barrier became detached or what caused it, but the defect was present before the mobile telephone entered the aircraft. Nor was it possible to account for the discrepancy between the limited damage that existed before the flight as reported by the pilot and the more extensive damage found by the repair agency afterwards. The damage cannot be attributed to the phone striking the barrier, though if this happened repeatedly it may have aggravated any existing damage. With the barrier partially detached the telephone was able to migrate aft, though it is not known exactly when this happened. Once the telephone was behind the barrier, it would then be possible for it to become lodged in the elevator quadrant. The most likely scenario is that it fell onto the last bulkhead during the final vertical climb and was "scooped up" by the quadrant as the elevator was moved during the manoeuvre or recovery. The telephone then remained jammed between the quadrant and the aircraft structure until it was jarred free during the very hard initial touchdown and bounce, enabling the pilot to regain control for the subsequent landing.

Although the modification mandated by MPD 2004-006 had been carried out on G-YOTS, the barrier had become partially detached and this was known to the pilot. With the barrier in its damaged state the aircraft no longer fully complied with the MPD and should not therefore have been flown until the defect was rectified even if, as the pilot believed, the extent of the damage was negligible and that a second barrier was fitted.

This incident highlights the need for the utmost vigilance with regard to foreign objects, particularly in aircraft used for aerobatics and with control systems vulnerable to loose articles. The similarities between this incident and the fatal accident to G-YAKW serve to remind that a tragic outcome was narrowly avoided.

Conclusion

The incident was caused by a loose article, a mobile telephone, penetrating a defective barrier and jamming the elevator control system. The barrier was a mandatory airworthiness requirement and was intended to prevent such an occurrence.

Aircraft Type and Registration:	Enstrom 480, N480DS	
No & Type of Engines:	1 Allison C20 turboshaft engine	
Year of Manufacture:	2001	
Date & Time (UTC):	12 November 2004 at 1418 hrs	
Location:	Near The Heliport, Droitwich, Worcestershire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - 1 (Minor)	Passengers - 1 (Minor)
Nature of Damage:	Major damage	
Commander's Licence:	FAA Private Pilot Certificate	
Commander's Age:	65 years	
Commander's Flying Experience:	500 hours (of which 418 were on type) Last 90 days - 50 hours Last 28 days - 20 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot and enquiries by the AAIB	

At the end of a five minute flight from a private site, the pilot made his approach to The Heliport from the north east. Prior to his departure, he had assessed the surface wind as about 220°/10 to 15 kt. However, on arrival at Droitwich he noted from the wind sock that the wind direction appeared to be very variable and he assessed it as generally varying between 270° and 300° with a strength of 15 to 18 kt. Initially, he considered that his approach was good until approaching the landing area when he experienced an apparent wind shear, which resulted in N480DS moving forward towards a nearby hedge. He immediately applied collective control but was unable to avoid striking the hedge with the tail section of the helicopter. The helicopter started rotating in a clockwise direction and the pilot was then aware of it touching down briefly on the skids before toppling onto its right side.

An aftercast from The Meteorological Office indicated that the surface wind was 340°/15 kt gusting 25 kt. This would have resulted in a tailwind component during the approach and would have made precise control of the helicopter more difficult.