ACCIDENT

Aircraft Type and Registration:	DHC-8-311 Dash 8, G-BRYW
No & Type of Engines:	2 Pratt & Whitney Canada PW123 turboprop engines
Year of Manufacture:	1997
Date & Time (UTC):	7 October 2005 at 1822 hrs
Location:	Stand 8 at Aberdeen Airport
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 4 Passengers - 50
Injuries:	Crew - None Passengers - None
Nature of Damage:	Aircraft: damage to engine, propeller and fuselage Ground Vehicle: damage to cabin and bodywork
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	31 years
Commander's Flying Experience:	5,600 hours (of which 648 were on type) Last 90 days - 99 hours Last 28 days - 28 hours
Information Source:	AAIB Field Investigation

Synopsis

The DHC-8 aircraft was parked on stand, all the passengers were on board and the engines had been started. Shortly after the Ground Power Unit (GPU) cables had been disconnected from the aircraft, and with nobody in the cab, the GPU moved forward and struck the rotating propeller on the right engine before coming to rest against the fuselage. All the occupants exited the aircraft through the passenger door and no one was injured.

The investigation identified a number of maintenance issues with the GPU. No issues were revealed with either the serviceability or operation of the aircraft, and hence this report is focussed on the GPU.

Three safety recommendations are made; these relate to the regulations for ground vehicles operating near aircraft, maintenance of the ground vehicle and the manufacturer's servicing schedule .

Ground Power Unit information

The GPU was a Houchin C762 and its diesel engine was capable of either supplying aircraft with electrical power via a generator or propelling the vehicle. It was manufactured in May 1997 and delivered to the operator at Aberdeen in June 1997. At the time of the accident 13,471 operating hours had been recorded for the GPU.

The primary motion controls of the vehicle are;

accelerator and brake pedals, a steering wheel, a hand-operated parking brake and a FORWARD-NEUTRAL-REVERSE selector lever. The FORWARD-NEUTRAL-REVERSE selector lever is situated in front of the steering column at the height of the driver's knees. The driver must depress a button on top of the selector lever to move the selector through a mechanical gate; this allows the selector lever to move out of NEUTRAL into either FORWARD or REVERSE.

There is a further switch, located on a panel behind the driver's seat, labelled SERVICE - IDLE. When the operator selects SERVICE mode the drive to the chassis is inhibited and the engine control system increases the speed of the engine so that the unit is ready to supply power to an aircraft. When the switch is moved from SERVICE to IDLE there is a delay in the system of about 10 seconds to allow the engine speed to decrease, the vehicle is then in a safe state and ready to be driven. The vehicle can only be driven away after this 10 seconds delay and if FORWARD or REVERSE has been selected.

The engine speed is regulated by the fuel pump. A governor rod connects the fuel pump to the governor lever and connections at both ends are by ball joints. Changes in engine speed are made via a cable from the accelerator pedal to the governor lever or, when in SERVICE mode, from a mechanical output from the governor to the governor lever.

Description of the accident

The aircraft was parked on Stand 8 at Aberdeen Airport and a three-man ground crew was tasked with dispatching the aircraft.

The first member of the ground crew positioned the GPU facing the right hand engine of the aircraft. He put the FORWARD-NEUTRAL-REVERSE selector to NEUTRAL, applied the parking brake and selected SERVICE mode. He then left the stand to collect the push-back tractor.

The other two members of the ground crew, the headset operator and the GPU operator, then arrived at the aircraft. Whilst the right engine was being started the GPU operator noticed that the noise from the GPU engine was quieter than usual. He checked the meter which read 110 amps, rather than the usual 115 amps; the flight crew noted that the voltage was only 22.5V, rather than the normal 28V. The left hand engine was then successfully started.

With both aircraft engines running the GPU operator selected IDLE and then started to gather the power cables which had been attached to the aircraft. Approximately 10 seconds later, the GPU started to move forwards, over the flat paved surface, towards the rotating right propeller, with nobody in the cab. As the GPU moved into the plane of the propeller it was struck by, and damaged, all four blades. The GPU subsequently struck the fuselage under the right wing, where it came to a halt.

At the time of the impact the flight crew were carrying out their 'After Start' checklist. The first officer looked out of his window, saw that the GPU had struck the fuselage and informed the commander. The commander immediately shut down the engines and, to minimise the risk of any fire, ordered the completion of the 'Engine Fire on Ground' checklist for the right engine; both fire bottles were subsequently discharged. He then contacted ATC and requested attendance of the fire services.

The cabin crew confirmed that there were no signs of smoke or fire in the cabin but that there were signs of fuel leaking from the right engine. The commander therefore made an announcement to the passengers

telling them that they should disembark quickly, using the main door, and that they should leave their baggage behind. The disembarkation was uneventful and, since there were no ground staff present, the commander instructed the first officer to supervise the passengers during their transit to the terminal.

The fire service and the police arrived promptly to manage the accident site. A photograph taken shortly after the accident is presented at Figure 1.

Figure 1

Post impact photograph showing GPU and aircraft

Operating Procedures – Position of GPU for Ground Servicing

Diagrams in the Operator's Ground Operations Manual showed a GPU positioned facing away from the aircraft that it was servicing. However, it had become local practice to position the GPU facing the aircraft in order to keep the GPU exhaust fumes away from designated passenger walkways and so that the headset operator could be seen from the GPU cab. There was no documented evidence of a formal risk assessment of this local practice.

The operator raised a 'Ground Damage Alert Notice' within 48 hours of the accident. This notice referred to the Operator's Ground Operations Manual and reinforced the importance of the use of brakes or chocks, and that vehicles should be parked in such a way that should there be any movement of the vehicle it would not collide with the aircraft.

Personnel information

Ground Crew

All three members of the ground crew had been appropriately trained and were familiar with the working environment and equipment. They were in compliance with the company's Working Hours Limitations and there were no issues with staffing levels that might exert undue pressure on the crew.

Ground Vehicle Maintainer

The GPU was maintained by an engineer who was responsible for the maintenance of 15 items of ground equipment. He had over 25 years experience in the maintenance of aircraft and vehicles and operated alone, hence his work was neither signed off nor checked.

Damage to the aircraft

After the incident the aircraft was towed to a hangar where it was inspected. There were three main areas of damage to the aircraft as follows:

a) The right propeller had suffered significant damage to all four blades and to its hub.

b) The right engine had come to an abrupt halt and, as a result, the engine required a complete overhaul.

c) There was a dent in the fuselage with associated local damage to the fuselage structure.

Inspection of the GPU

Initial Inspection

There was extensive damage to the GPU cabin and the engine cover. The windscreen and the windows to the left and right doors had shattered, there were dents consistent with propeller blade strikes to the cabin, and the internal structural members of the cab around the left door were severely disrupted. Part of the leading edge of one of the propeller blades, a strip of metal about 50 cm long, had become detached and was found on the driver's seat in the cab of the GPU.

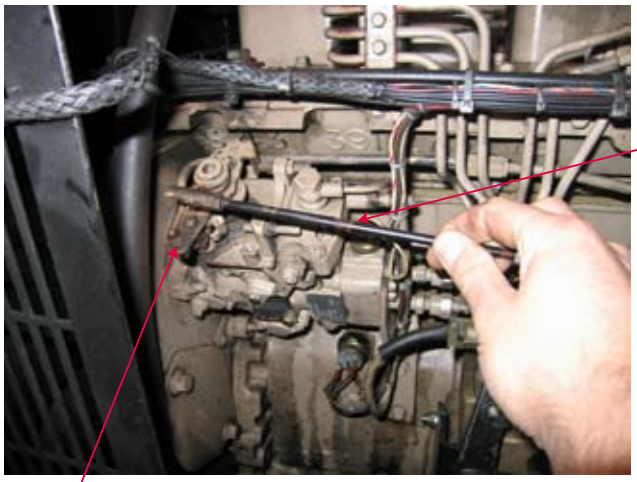

Figure 2

Photograph showing detached governor rod and worn ball joint

After the accident the GPU was taken to a vehicle maintenance facility on the airport where an inspection revealed the following:

a) Governor rod and fuel pump spring

On opening the engine cover the governor rod was found to be disconnected from the fuel pump. Further inspection revealed that the ball joint on the fuel pump lever was worn, hence the governor rod could become detached from the fuel pump lever with little effort. Figure 2 shows the detached governor rod and the worn ball joint. The spring on the fuel pump was also worn so that when the governor rod became detached from the fuel pump, the engine ran at a moderate speed and not at idle.

b) FORWARD-NEUTRAL-REVERSE selector

The FORWARD-NEUTRAL-REVERSE selector has a central button and under normal operation this must be depressed to allow the selector lever to move out of NEUTRAL. The mechanical gate mechanism was found to be worn, it was therefore not necessary to press the button prior to moving the lever. Figures 3 and 4 show, respectively, the location of the selector and the worn mechanical gate.

c) Electrical safety system for traction

A series of checks were conducted on the GPU to check the electrical safety system for traction. No defect could be identified that would allow the vehicle to move without the FORWARD-NEUTRAL-REVERSE selector being in either FORWARD or REVERSE. The 10 seconds delay, before the vehicle can move after switching from SERVICE to IDLE, worked satisfactorily.

d) Parking brake

The handbrake system was tested and it was shown that with a normal application of the lever (about four notches of the ratchet out of a maximum of six) the parking brake would hold the GPU on

Button - in normal use this must be pressed to allow FORWARD or REVERSE to be selected

Figure 3 (left)

Photograph showing location of FORWARD-NEUTRAL-REVERSE selector in front of the steering column

Worn gate

Figure 4 (right)

Photograph showing worn gate in the FORWARD-NEUTRAL-REVERSE selector (NB rubber gaiter removed)

level ground with the engine at normal idle or low speed settings and with FORWARD mode selected. The parking brake would not hold the GPU with the engine at moderate or higher engine speeds with the same mode selected.

e) Other defects

The near-side front tyre had exposed chords in the tread area, there was corrosion and pitting on several areas of the front brake pipes and the pins and bushes on all the road springs were worn.

Detailed Inspection

The GPU was transported to the manufacturer's facility for inspection. The inspection confirmed the findings made at Aberdeen; however, the following additional findings were made:

a) The printed circuit board that controls the electrical safety system for traction was bench tested using the manufacturer's dedicated test procedure and no fault was found.

b) It was concluded that the only way the vehicle could move forward was with the FORWARD mode selected; attempts were therefore made to assess how the selector unit might have moved to the FORWARD position. It was concluded that human intervention, or possibly a jolt as the cabin door closed, were the only realistic causes.

c) Tests found that the speed of the engine after the governor rod became detached was likely to be 1,500-1,600 rpm. This is significantly higher that the normal idle of around 1,100 rpm, but less than the maximum of 2,400 rpm.

GPU Maintenance

The GPU had been maintained at a facility at Aberdeen Airport since it was delivered as a new vehicle in June 1997. There were 24 entries in the log book for *'service'* or *'3 month service'* over the 8 year operational life of the GPU until the accident; an average of 3 services per annum. Corrective maintenance actions were also logged.

The maintainer worked alone and he had found that the level of unscheduled maintenance made it difficult for him to keep to a plan for scheduled maintenance. A defect reporting system was in place; however, there was evidence that not all defects were being reported. There was also evidence that the gate on the FORWARD-NEUTRAL-REVERSE selector had been unserviceable for at least two years.

Manufacturer's Recommended Maintenance

The Technical Manual for the Houchin C762 contains recommended servicing actions at defined intervals ranging form daily to every 12 months.

A review of the recommended servicing actions concluded that there are no specified checks that would have detected the worn ball joint, the worn spring on the fuel pump or the worn gate on the FORWARD-NEUTRAL-REVERSE selector.

Annual inspection by the Airport Authority

The GPU had completed its annual safety inspection on 28 January 2005. This is a 29-point check list, which is effectively a direct copy of the CAA recommended checks provided in CAP 642[1] with the exception that box 30 (Trailer Connections) had been deleted. All 29 boxes were ticked, indicating that the items were 'serviceable'.

Safety management of airside vehicles

Airside Safety Management - CAP 642

CAP 642 provides guidance to aircraft and airport operators, as well as to necessary third parties, on safe operating practices for airside activities; the guidance provided in this document is not mandatory. It was first issued in March 1995 on the recommendation of a working group drawn from representatives from the CAA, the Health and Safety Executive, the aircraft operators and the airport agencies. Issue 2 followed in February 2003 after a review by the working group, and incorporated revisions to reflect changes to legislation and advances in safety management practice. There was a subsequent revision in 2005 as a result of recommendations made by the AAIB concerning airbridge and aircraft towing operations.

CAP 642 provides guidance on standards for airside vehicles, and includes at Appendix C *'Model Proformae that may be suitable for use by an Aerodrome Authority dealing with Airside Vehicle Inspection Requirements'*.

Footnote

[1] Airside Safety Management Appendix C, Annex B Safety and Serviceability Inspection Forms for Ground Power Unit/Airstart Unit.

There are several proformae including at Annex B a 30-point checklist for '*Ground Power Unit/Airstart Unit'*.

Airside Vehicles – applicability of road vehicle standards

Airside vehicles have a number of different characteristics to those of road vehicles. They are designed to support the operation of aircraft; for example, towing aircraft or assisting in the loading and unloading of baggage. Therefore, the direct application of road vehicle regulation for the design and maintenance of airside vehicles is not necessarily appropriate. In addition, airside vehicles are often produced in low numbers which creates additional financial pressures on any design and maintenance regulation.

There is however a large area of commonality between airside and road vehicles and CAP 642 (section 3.5.5.) states that:

> *'all vehicles should normally be required to meet the requirements appropriate for the grant of Department for Transport test certificate'.*

Accordingly, the Vehicle and Operator Services Agency (VOSA) were contacted to assess whether the GPU would have passed a standard 'MOT' test.

The MOT for vehicles not exceeding 3.5 tonnes includes tests for *'Driving Controls'*. The procedure for this part of the MOT is to check the operation of the driving controls *'from the driver's seat'* and several reasons for failure are listed. It was concluded that the FORWARD-NEUTRAL-REVERSE selector would have failed an MOT since it was *'obviously not functioning correctly'* due to the gate not working. The worn ball joint and the worn spring on the fuel pump would probably not have been inspected as part of an MOT test since the test for driving controls is made from the driver's seat; hence these would not have resulted in an MOT failure. The corroded brake pipes and the exposed chords on the tyre were items that would have resulted in a failure of an MOT, as well as the Airport's Roadside Check (as per CAP 642).

Analysis

Three factors associated with the GPU and its operation contributed to cause this accident.

The engine speed was significantly higher than the normal idle setting, such that the vehicle could override the parking brake. This is attributed to excessive wear on the ball joint, which allowed the engine governor rod to become detached, and to the worn spring on the fuel pump, which did not subsequently set the engine to idle. Whilst the airport authority used the check list recommended in CAP 642, this does not include a check on engine controls. The worn ball joint and the worn spring were not identified or rectified by the operator's maintenance system and there was no dedicated check in the manufacturer's recommended maintenance scheme.

The GPU drive system would only allow the vehicle to move forward if it was in FORWARD mode. It was not possible to determine how the GPU drive system went into the FORWARD mode; human intervention would seem the most likely cause, unless it had been disturbed by a jolt as the cabin door was closed. The gate on the FORWARD-NEUTRAL-REVERSE selector, a safety feature, was found to be ineffective due to wear, thus allowing the FORWARD mode to more easily be selected. As with the worn ball joint and worn spring the annual check recommended in CAP 642 does not include a check on such controls. The operator's defect reporting system did not detect this failure, and there was no appropriate check in the manufacturer's recommended

servicing to inspect for a worn gate in the FORWARD-NEUTRAL-REVERSE selector.

The GPU was, as had become routine, positioned facing the aircraft although this was not in accordance with the company's operating procedures. At airports such as Aberdeen, there are many activities placing demands on the available ramp space and, had this GPU been facing away from the aircraft, in accordance with the company's operating procedures, it might have struck the aircraft parked on the next ramp. The failure to adhere to the company's Standard Operating Procedure is not considered a primary causal factor since it would seem more appropriate to minimise the risk of occurrence rather than to minimise any subsequent risks.

Conclusions

The incident occurred because the GPU was being operated with a worn ball joint on the governor rod, a worn fuel pump spring and a worn gate in the FORWARD-NEUTRAL-REVERSE selector.

These three mechanical defects are attributed to:

a) Inadequacies in the operator's maintenance system, including defect reporting.

b) The lack of appropriate checks in the manufacturer's recommended servicing schedule.

Safety Recommendations

The following safety recommendations have been made:

Safety Recommendation 2006-092

It is recommended that British Airways review their operations at Aberdeen Airport to ensure that airside vehicles are maintained in accordance with the appropriate manufacturer's recommended servicing schedule and to ensure that their defect reporting system for ground vehicles operates effectively.

Safety Recommendation 2006-093

It is recommended that Houchin Aerospace update their recommended servicing schedule to include checks for governor rods, fuel pump springs and forward-neutral-reverse selectors at appropriate intervals. These changes should be promulgated to all operators of relevant equipment world-wide.

Safety Recommendation 2006-094

It is recommended that Houchin Aerospace review the design of their engine control systems for self-propelled ground equipment to ensure that safety is not compromised if there is a system failure.

Previous recommendations

Following an incident at Prestwick Airport[2], where a baggage vehicle ran into the fuselage of a stationary Boeing 737 aircraft, the following safety recommendation was made. The recommendation is equally relevant to this accident.

AAIB Safety Recommendation 2006-060

It is recommended that the Civil Aviation Authority should remind airport operators that their Safety Management Systems should ensure that safe standards of maintenance and use are applied to all vehicles and mobile ground equipment used in the proximity of aircraft.

Footnote

[2] Aircraft registration EI-DAP; report was published in AAIB Bulletin 9/2006