AAIB Bulletin No: 8/94 **Ref: EW/C94/2/2** **Category: 1.1**

Aircraft Type and Registration:	ATR 42-300, G-BUEB
No & Type of Engines:	2 Pratt & Whitney PW-120 turboprop engines
Year of Manufacture:	1992
Date & Time (UTC):	11 February 1994 at 1507 hrs
Location:	Stand 3, London Gatwick Airport
Type of Flight:	Public Transport
Persons on Board:	Crew - 4 Passengers - 37
Injuries:	Crew - None Passengers - 2 Minor
Nature of Damage:	Extensive damage to right propeller and engine; debris impact damage to fuselage
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	59 years
Commander's Flying Experience:	17,576 hours (of which 741 were on type) Last 90 days - 95 hours Last 28 days - 38 hours
Information Source:	AAIB Field Investigation

Flight history

The flight deck crew had reported for duty at 0625 hrs. The left seat was occupied by a new Captain undergoing his first session of line training after a simulator conversion programme. The commander was a senior Training Captain who occupied the right seat. The aircraft was operating a scheduled passenger service from Dublin to Gatwick. It was the crew's fourth and final sector of the day.

The commander was the handling pilot for this sector, but the taxiing of the aircraft was accomplished by the left seat pilot as the nosewheel steering system hand wheel was on the left side of the flight deck. During the taxi out for departure from Dublin, the take-off configuration test was carried out and it was noted that the No 2 DC generator had failed. The crew stopped the aircraft on the taxiway and attempted to reset the generator. They also checked the aircraft's Minimum Equipment List (MEL) in order to ascertain whether it was acceptable to operate the aircraft with one DC generator off-line. In the event, the generator was restored, and the aircraft took off at 1347 hrs. Shortly after departure, the

No 2 DC generator again failed. The appropriate checklist was carried out for the DC Gen 2 Fault, which simply involved the switching off of the affected generator. There were no other actions required in the checklist. Apart from crew consideration of possible expeditious en route diversion airfields in the event of a second generator failure, the flight to Gatwick was uneventful, and the aircraft landed on Runway 08R at 1502 hrs.

The aircraft vacated the runway on No 2 rapid exit turnoff and was cleared to taxi to Stand 3 routing via the Alpha Exit link. The company's normal operating checklist, and that of the manufacturer, called for the No 1 engine to be shut down as part of the after landing drills, once a one minute cooling period had been observed. Nothing in the abnormal checklist for a DC Gen Fault contradicted this procedure. When the left engine is feathered during taxi on this type of aircraft, there is a tendency for the aircraft to initially swing to the right. The left seat pilot therefore suggested that the feathering action be taken as the aircraft approached the natural right turn after passing through the Alpha Exit. This was accomplished, and the left propeller was feathered. In order to enable the engineers to carry out an accurate engine oil contents check during the turnaround, the left engine was kept running with the propeller feathered. The usual procedure prior to this check requires a further period of 20 seconds before engine shutdown. In the event, a period of 35 seconds elapsed prior to engine shutdown. The apron surface was damp. The toe brakes were checked for effectiveness by the left seat pilot, prior to turning onto the stand centreline of Stand 3, and he proceeded under marshalling guidance towards the appropriate stop position. On receiving the stop signal from the ground crew, the left seat pilot applied the toe brakes, but these were ineffective. He notified the other pilot of the problem, and proceeded to apply reverse thrust to the right engine. The commander also applied his toe brakes, to no effect. The commander then reached across and pulled the emergency/parking brake handle, located on the left side of the power lever quadrant, but this action, along with the initiation of reverse thrust, occurred too late to prevent the right propeller from striking the ground power unit (GPU) which had been pre-positioned to the front right side of the normal parking position in order to allow expeditious connection to the aircraft's ground power socket. The collision occurred some 30 seconds after the shutdown of the left engine.

The two ground crew, who were in position to meet the aircraft, observed that a collision was imminent and began to run clear of the area. Debris from the impact struck one of the crew men and narrowly missed the other. Fortunately, neither sustained injuries from the debris.

There was a large quantity of smoke apparent from the area around the forward right side of the aircraft, accompanied by a continuous repetitive chime from the centralised crew alerting system (CCAS) and a flashing red master warning light. The commander considered that there was a possibility of a fire, and ordered the cabin crew to carry out an emergency evacuation. In the event, the CCAS warnings occurred because of a low right engine oil pressure indication after the impact. The shutdown actions and Emergency Evacuation checklist were then carried out.

The emergency evacuation of the passengers was quickly carried out by the two cabin staff members, and the passengers were taken to awaiting buses before being taken to the terminal. During the evacuation from the forward left fuselage emergency exit, two passengers were reported to have sustained minor injuries.

Systems description

Aircraft mainwheel disc brakes are powered by aircraft hydraulic system pressure in two alternate modes. Normal braking is powered by Green hydraulic system pressure regulated by pilot and/or co-pilot brake pedal signals transmitted to brake control valves via low pressure manual hydraulic signalling systems (Fig 3). Emergency/Park braking is powered by Blue hydraulic system and controlled by a lever at the left side of the flight deck centre console.

For each aircraft hydraulic system, pressure at a nominal 3,000 psi is generated by an electric motorised pump fed from the aircraft's AC Wild (ie unregulated frequency) system main busbars. The Blue system is also provided with an auxiliary pump, fed from the aircraft's DC electrical system. Each system has a system accumulator and the Blue system incorporates, in addition, an Emergency/Park Brake accumulator which is isolated from the remainder of the system by a non-return valve. Pressurised fluid can be transferred from one system to the other by an electrically motorised crossfeed valve; this remains closed in normal operation but can be manually selected to open provided the hydraulic reservoir fluid level is normal.

The electrical supply to each hydraulic pump motor is fed via a DC pump relay which is controlled by a pump switch on the flight deck overhead hydraulic control panel. Pump relay power supplies are from the DC Main Busbar for the Green system and from the Hot Emergency Battery Busbar for the Blue system. The AC Wild electrical generation system is in two halves, each fed from an engine-driven alternator. The two halves are normally separated but may be connected by a Busbar Tie Breaker (BTB) in the event of a failure of one of the supplies. The DC Main Busbar arrangement is similar, with power generation from a Starter/Generator driven by each engine and with the busbars normally separated but capable of being connected in the event of a failure of one of the supplies. Each half of the DC system also incorporates an aircraft battery; the associated Hot Battery Busbar is normally fed from its respective DC Main Busbar but feeds from the battery in the event of DC Main Busbar de-energisation.

Thus loss of output from one Starter/Generator would not cause de-energisation of any of the busbars associated with the wheelbraking system as the DC Main Busbar associated with the lost generator would be fed from the other generator via the BTB. However, loss of output from both Starter/Generators would de-energise both DC Main Busbars. In this event the Green pump relay would lose its power supplies and open, removing the AC Wild power supplies from the Green hydraulic pump. Green hydraulic system pressure would then decay, at a rate determined by the usage of services supplied by the system and by the system internal leakage rate, unless the crossfeed valve were opened. Blue system would remain pressurised as its pump relay would remain energised from the emergency battery.

Relevant flight deck indications consist of a triple gauge on the flight deck forward panel showing Green and Blue hydraulic system pressure and the Emergency/Park Brake accumulator pressure, together with caption indications on a CCAS Crew Alerting Panel (CAP) on the forward panel, and on the hydraulic system and DC electrical system panels on the overhead panel. Loss of output from both DC generators is immediately apparent by virtue of a master caution light and audio, a CAP ELEC caption illumination, a series of caption illuminations on the DC electrical system panel and by loss of instrument flood lighting and of three of the four cathode ray tube indicator displays. With the aircraft on the ground the associated loss of Green hydraulic system pressure generation is indicated solely by a Green pump switch LO PRESS caption on the hydraulic system overhead panel and will be apparent on the system pressure gauge when system pressure starts to decay. However, the HYD caption on the CAP signifying hydraulic pressure loss is fed from the DC Main Busbar and does not illuminate in these circumstances. It is recommended that the CAA and ATR consider requiring modification to ATR 42 (and ATR 72) aircraft to provide illumination of the hydraulic system caution caption on the centralised crew alerting panel in all reasonably possible circumstances when pressure in either hydraulic system is lost.

Accident site

Examination of the accident site showed that the GPU rig was positioned almost laterally across the stand (Fig 2), facing away from the centreline and with the back of the GPU approximately 3.8 metres right of the centreline and just forward of the extended line on which the aircraft nose wheels would normally stop, the crossbar marked '146 100'. The aircraft had come to rest approximately 8 metres beyond its normal stop position on a heading 2° right of the stand centreline and with the nose landing gear 0.74 metre right of the centreline. The evidence indicated that none of the main landing gear wheels had skidded during the stop. With the aircraft in this position, the left propeller was situated within 7 cm (3 inches) of portions of the fixed airbridge. The right propeller was forward of the GPU and the right propeller blades had sustained multiple strikes on the upper rear portion of the GPU. The aft portion of the GPU cover had been severely damaged. It exhibited a number of propeller blade slashes, but these were unevenly spaced, apparently because of propeller distortion on striking the heavyweight GPU structure, and estimation of aircraft ground speed was not possible. Fragments of the blades were scattered over a wide area of the apron, concentrated on the left side of the aircraft, up to 60 metres from the No 2 propeller axis.

Aircraft damage

All four blades of the No 2 propeller had sustained gross damage, with the outer one third of the span exhibiting complete disintegration of the composite parts and severe distortion of the spar. The blade pitch change mechanism within the hub had failed and blade cuff damage had allowed oil release. The engine mounting structure escaped damage, but the engine casing at the forward end of the compressor module had sustained 360° fracture and there were signs that the two parts of the engine had undergone considerable relative displacement.

The region of the fuselage forward of the plane of the propellers was found coated with oil, consistent with the effects of oil release from the No 2 propeller hub while the propeller was delivering reverse thrust. The right side of the fuselage had been peppered with debris between Frames 18 to 25, with the damage particularly concentrated between Frames 20 to 23, and the right wing inboard leading edge and the fuselage/wing fairing had also sustained a number of debris strikes. The damage generally consisted of scratching and localised denting of the fuselage skin and scratching and gouging of cabin windows. However, in one instance the ice protection panel and the underlying fuselage had been penetrated by the cover stop bar from the right aft corner of the GPU that had been torn off by a propeller blade. The bar had penetrated the fuselage between Frames 20 to 21 at cabin floor level (Stringer 14). The evidence indicated that contact with the edge of the fuselage crease beam (the sidewall floor bracket) had fortuitously deflected the bar below, rather than above, the floor. It had then struck and distorted four 6 mm diameter hydraulic pipes, forming part of the co-pilot's left and right wheelbrake low pressure signalling control lines and nose landing gear retract and extend pressure lines, respectively. The pipes had crippled in places, resulting in a small rupture in the case of the nose landing gear down pressure line. In addition, the bar had damaged a composite air conditioning duct and deformed and cracked a stringer near the fuselage bottom (Stringer 17) before coming to rest in the under floor area. No debris entered the passenger cabin above floor level, although the sidewall trim in the cabin had been locally dented and holed.

Aircraft systems examination

Examination of the aircraft revealed no evidence of unserviceability prior to contacting the GPU, with the exception of the No 2 DC Starter/Generator. The results of a component manufacturer's assessment of the cause of the generator output loss is awaited; internal short circuiting as a result of a build-up of carbon dust from the brushes has been a problem in the past.

Ground functional tests of the aircraft following replacement of the No 2 engine and propeller and the damaged hydraulic pipes and temporary repair of the structure also indicated that there had been no additional faults present before the collision. In addition, the electrical and hydraulic generation and distribution systems and the CAP system behaved as described previously in normal and simulated fault conditions. Functional tests on G-BUEB and on another similar aircraft showed that Green hydraulic system pressure decayed fairly rapidly following de-energisation of the Green system pump, and would be effectively depleted by two foot brake applications. The Emergency/Park brake accumulator provided around six full brake applications before effective depletion. It is recommended that the CAA and ATR consider requiring modification to ATR 42 (and ATR 72) aircraft in order to maintain hydraulic supplies to the Normal Wheelbrake System in the event of de-energisation of both DC starter/generators.

Previous cases

The aircraft manufacturer knew of one previous incident, to an ATR 72, which has similar systems to the ATR 42. With the aircraft aligned towards a marshaller the No 1 engine was shut down. This caused disconnection of the No 2 DC Starter/Generator from its DC Busbar because of a faulty generator control unit connection and on application of the normal brakes the hydraulic pressure bled away. The crew used the emergency brake to halt the aircraft.

Subsequent to the accident to G-BUEB, the operator was informed of two other occasions when its crews had experienced similar loss of toe brake pressure whilst taxiing. These had not previously been reported by the crews involved. Had they done so, the accident to G-BUEB may well have been prevented.

Action taken

Immediately after the accident to G-BUEB, the aircraft operator issued an instruction to crews that in future, taxiing was only permitted on two engines. In the event of a single engine landing, once vacated from the active runway the aircraft should be shut down and towed onto stand.

The aircraft manufacturer pointed out that timely use of the emergency brake system in this case would have prevented the collision. However, the manufacturer has now revised the ATR 42 checklist, for use after failures, to include the note that after a DC Gen Fault, DC Bus 2 Off, ACW Gen Fault, or ACW Bus 2 Off, the aircraft should taxi on two engines. The manufacturer's Flight Crew Operating Manuals have been amended accordingly. It is recommended that the CAA conduct a review of UK registered public transport aircraft types, and UK operator practices, with regard to taxiing with engines shut down. Such a review should consider the effect of possible further single systems failures on the operation of the wheelbraking and steering systems. The potential hazards which may exist should be evaluated. The effectiveness of flight deck indications related to these systems should be assessed, especially with regard to the simultaneous presentation of other (non-relevant) warning indications. Where such hazards are identified, adequate advice to crews should be promulgated, or the aircraft be required to be taxied with all relevant systems/engines operative.

Crew experience and training

The pilot in the left seat had undertaken a conversion course at the manufacturer's facility in Toulouse earlier in that same week. He had already flown 580 hours on type in the right seat. Pilots in the right seat do not have the opportunity to taxi the aircraft because of the location of the nosewheel steering handle, and do not operate the aircraft's emergency/parking brake lever, located to the left side of the power lever quadrant.

The conversion course in the left seat comprised two simulator details, each of 1.5 hours duration, during which handling exercises were practised which called for landing in abnormal configurations, using the emergency braking system to stop the aircraft. Additionally, during each parking sequence and taxi out, the emergency/parking brake lever is operated, both to apply the brakes and to check system serviceability.

Emergency evacuation

Several passengers who had evacuated through the forward left emergency exit subsequently commented adversely to the AAIB on the height of the exit sill above ground level, noting that while a younger, physically fit passenger would have little problem leaving through this exit, any older or less agile person would have some difficulty negotiating the drop without assistance. The sill height above ground is 1.63 metres.

The maximum permitted drop without additional devices for an emergency exit is defined in the Air Navigation Order (ANO) as 1.82 metres from the sill to the ground.

Minimum equipment list (MEL)

The manufacturer's Master Minimum Equipment List (MMEL) did allow an aircraft to be despatched with one DC Generator Inoperative under certain stringent operating conditions. This was not acceptable to the CAA for operation of a UK registered aircraft, and the CAA MMEL deleted this condition, and replaced it with the following wording:

30-1 DC Generator Channels (Generator and related GCU)		
Number fitted	-	(blank)
Number Required	-	(blank)
Remarks or Exceptions	-	NOT USED

The phrase 'NOT USED' only occurred in two locations in the entire list. The operator's MEL for this aircraft reflected this wording. As a result of this investigation, it was considered that this form of wording was ambiguous, and the entry in the operator's MEL has been amended to indicate:

30-1 DC Generator Channels (generator and related GCU)

Number Fitted	-	2
Number Required	-	2
Remarks or Exceptions	-	Both must be operative

Flight recorders

The Cockpit Voice Recorder, a Fairchild A100, was removed and a satisfactory replay obtained. Recording began during approach, and stopped after the collision when the aircraft was shut down.

The Flight Data Recorder, a Fairchild model F800 was replayed using AAIB facilities. The data extracted showed the shutdown of No 1 Engine during the taxi, as the aircraft turned onto the stand. The recorder continued to operate with battery power, as the No 2 Engine Electrical Generator had developed a fault earlier, until the aircraft was shut down completely. The power interruption when the No 1 Engine was shut down caused the FDR to change track erroneously, and the subsequent data was recorded elsewhere. The model F800 has 25 hours of data recorded onto 6 tracks, each containing just over 4 hours of data, and the data should be recorded sequentially, with the most recent data overwriting the data recorded 25 hours ago.

Examination of the complete FDR information showed that the unit had been switching tracks at start-up throughout the 25 hours of information. There have been a number of cases of erroneous track changes on this type of recorder, and the manufacturer issued a Field Service Bulletin No DFR 027, dated 9 November 1993. The Field Service Bulletin isolated the fault to the premature failure of a component on the CPU printed wiring assembly. Replacement of the non-volatile track retention electrically erasable programmable read only memory (EEPROM) along with the Software Program Memory EEPROM on the CPU printed wiring assembly eliminates the premature failure and includes fault detection for this problem. All newly manufactured model F800 FDRs from December 1993 incorporate this modification.

This Field Service Bulletin was not made mandatory in the UK, and was categorised as discretionary. The Flight Recorder does not function properly with this fault, and can result in the recorder overwriting data that is only just over 4 hours old, and this could happen in flight with a power interruption, such as at engine shutdown. The loss of previous information could be significant in an accident investigation.

Since this accident the manufacturer has sent out a revision to the Field Service Bulletin which changes the modification from 'required' to 'mandatory' incorporation at the next shop visit.

Safety recommendations

94-23 It is recommended that the CAA in conjunction with DGAC and the aircraft manufacturer consider requiring modification to ATR 42 (and ATR 72) aircraft to provide illumination of the hydraulic system caution caption on the centralised crew alerting panel in circumstances when pressure in either hydraulic system is lost while the aircraft is in operation.

94-24 It is recommended that the CAA in conjunction with DGAC and the aircraft manufacturer consider requiring modification to ATR 42 (and ATR 72) aircraft in order to maintain hydraulic supplies to the Normal Wheelbrake System in the event of de-energisation of both DC starter/generators.

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ACCIDENT SITE

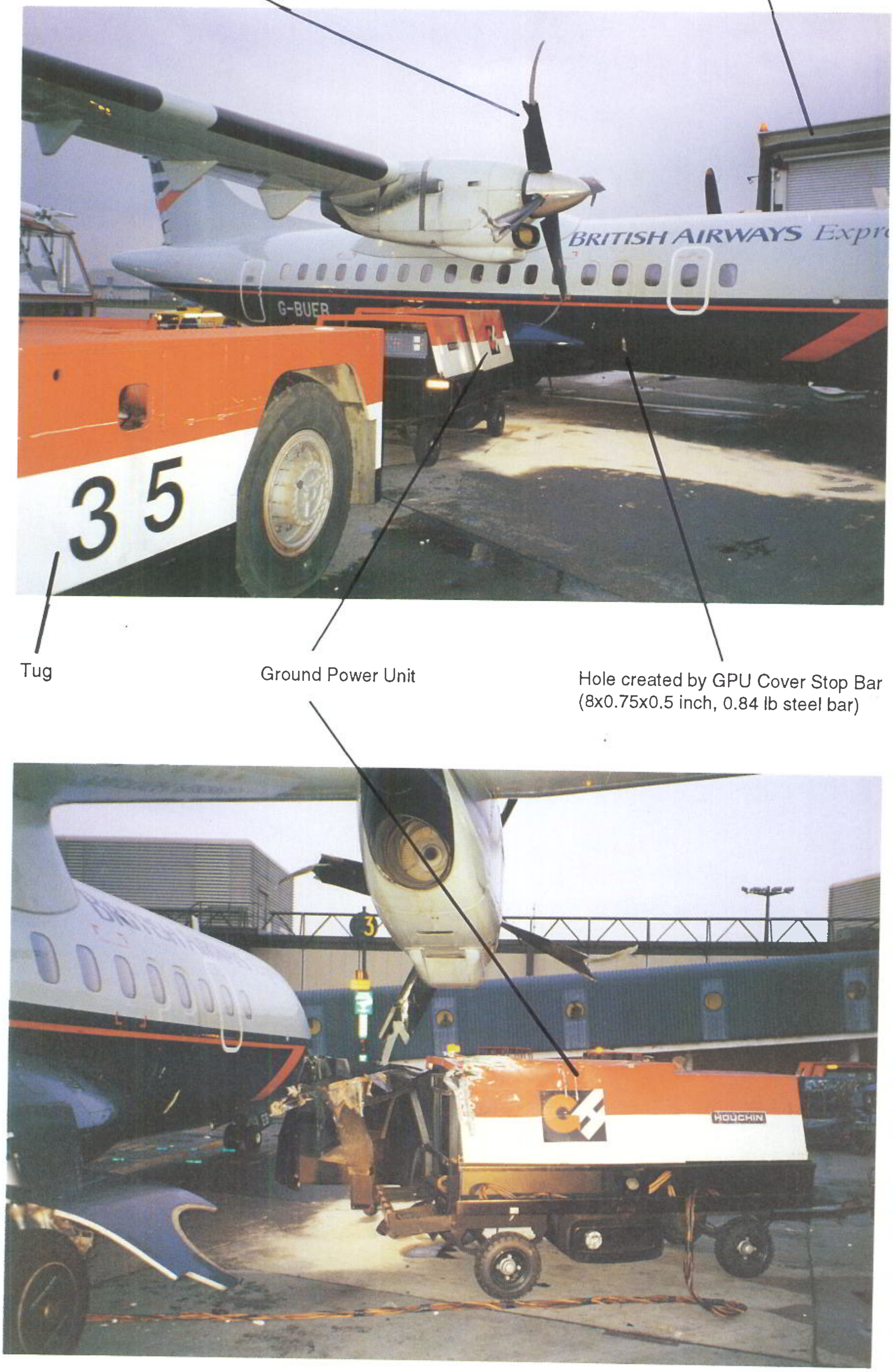


FIG 1

ACCIDENT SITE PLAN

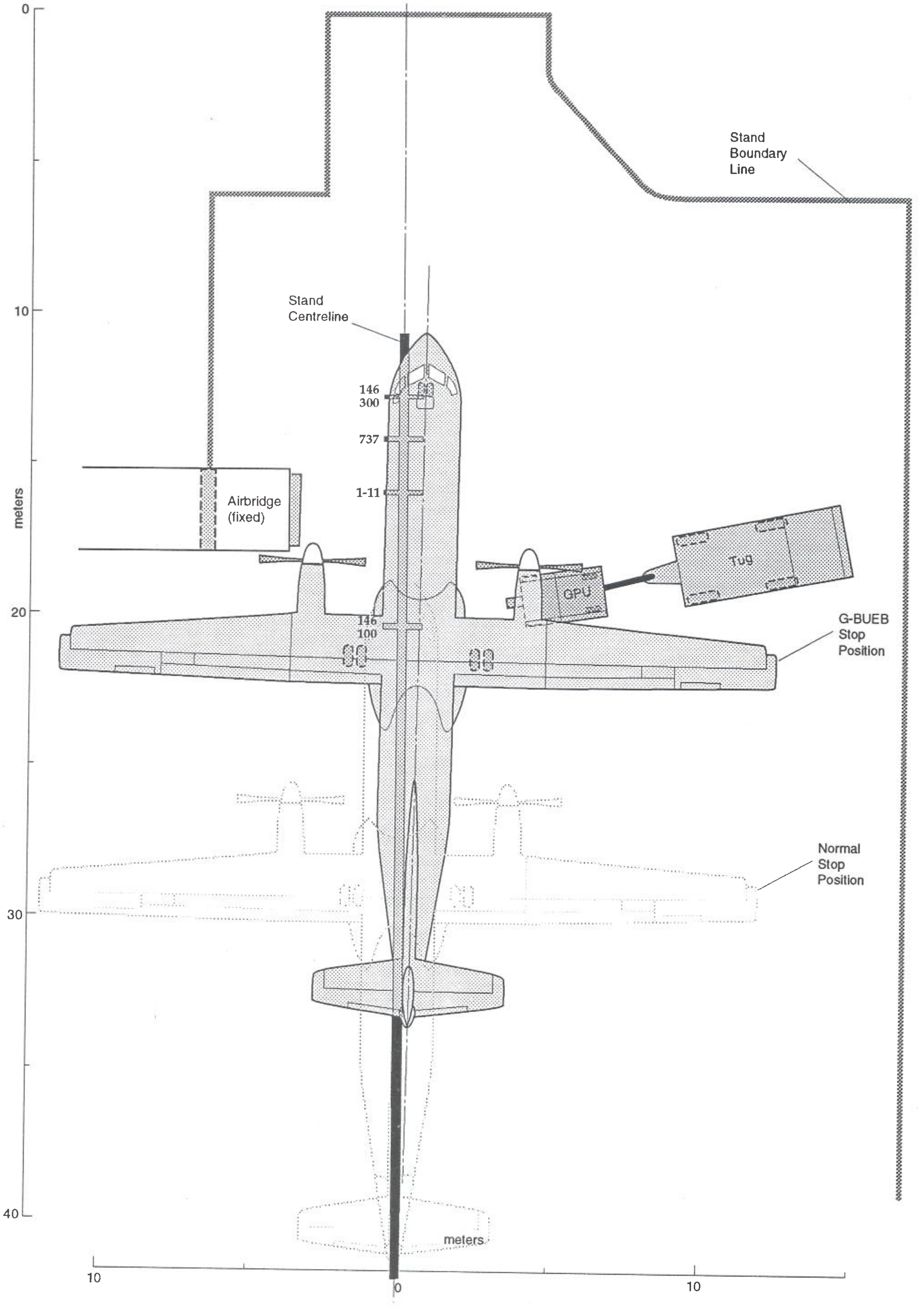
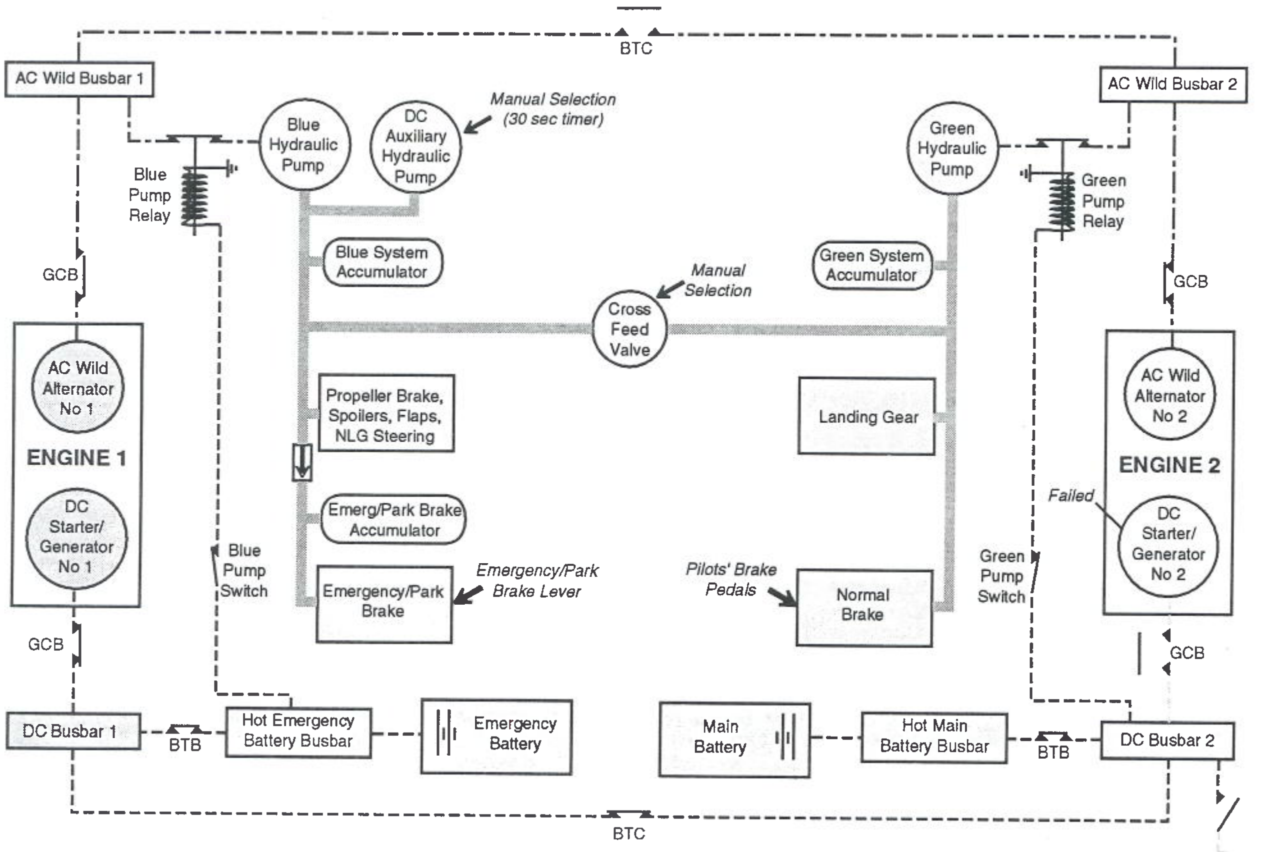
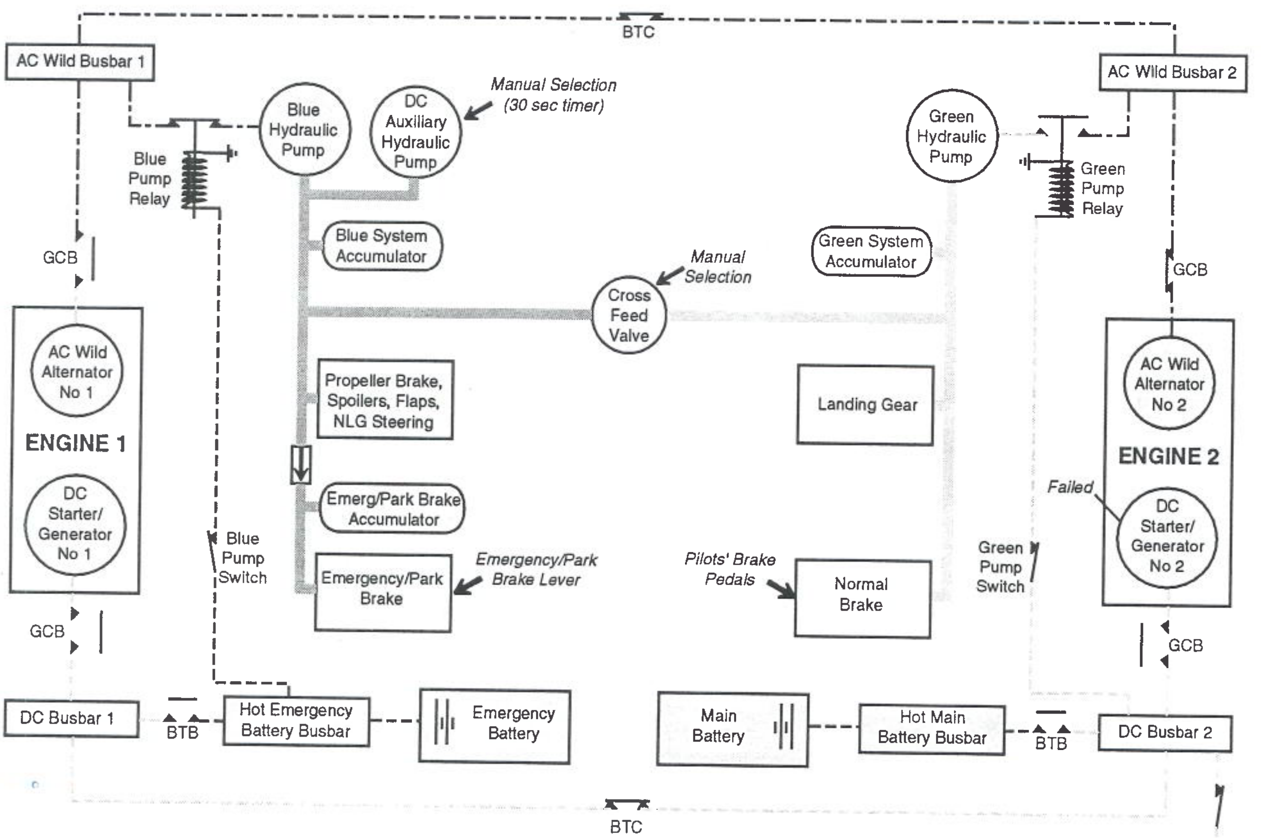


FIG 2

WHEELBRAKE SYSTEM SCHEMATIC



Before Engine No. 1 Shutdown



GCB - Generator Contact Breaker
BTC - Busbar Tie Contactor
CAP - Crew Alerting Panel

After Engine No. 1 Shutdown

Fig 3