AAIB Bulletin No: 1/94 **Ref: EW/C93/3/2** **Category: 1.1**

Aircraft Type and Registration:	Fokker F27 Mark 100 Friendship, G-BLFJ
No & Type of Engines:	2 Rolls-Royce Dart 514-7 turboprop engines
Year of Manufacture:	1959
Date & Time (UTC):	11 March 1993 at 1923 hrs
Location:	Stand 6, Edinburgh Airport
Type of Flight:	Public Transport (Scheduled Passenger)
Persons on Board:	Crew - 4 Passengers - 15
Injuries:	Crew - None Passengers - None Other - 1 Fatal
Nature of Damage:	Right propeller blades and engine mounts severely damaged, right main landing gear damaged
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	32 years
Commander's Flying Experience:	3,475 hours (of which 526 were on type)
Information Source:	AAIB Field Investigation

Accident Events

The aircraft was about to operate a scheduled passenger service to Leeds. All doors were closed, and the first officer called for ATC start clearance at 1920 hrs (slightly ahead of normal schedule, and with no ATC slot time commitment). Both engines were started normally, and the ground crew was signalled to remove the ground power unit (GPU). The ground crew consisted of three men; a signal man, positioned ahead and slightly on the left side of the aircraft, in view of the commander, a tug driver, seated in the push-back tug, and a crew man positioned close in on the right side of the aircraft to remove the ground power cable, and to assist with tow bar removal after push-back. At this time, without liaison with the other ground crew members, a fourth man, the shift leader, appeared at the stand. He mounted the tractor attached to the GPU and attempted to drive the rig away, although its position would not have impeded the push back of the aircraft.

The other ground crew members reported that the rig moved backwards suddenly, colliding with the aircraft tug and jack-knifing, with the tractor narrowly avoiding colliding with the fuselage. The rig remained stationary for a short time, with the tractor engine heard to be at high RPM while the driver

was described as "head down and struggling to select a gear". With the tractor still at high RPM, the combination then moved rapidly forward and through the right-hand propeller disc. Some eyewitnesses reported momentary illumination of the brake lights just before the tractor was struck by the propeller. The tractor cab was cut off, and flew off to the right side of the aircraft, and the driver was struck on the head by the propeller, sustaining fatal injuries, and his body was thrown out to the right side under the wing of the aircraft.

One member of the ground crew went immediately to the telephone located at the head of the stand, in order to summon the emergency services. He found that under the stress of the situation he was unable to immediately recall the correct emergency number (222), and found that no placard was present to indicate the number.

It was dark at the time of the accident, but the normal apron lighting system was serviceable, and was described by the ground crew members as providing an adequate level of illumination on the stand.

Aircraft Evacuation

The first officer observed what had happened, and informed the commander of the nature of the loud impact that had been heard inside the aircraft. Both engines were immediately shut down, ATC was informed, and emergency services requested to attend. The commander then ordered a passenger evacuation, using direct verbal contact with the No 1 cabin staff, instead of the normal method of initiation using the aircraft public address system. This was in turn communicated verbally to the No 2 cabin staff member at the rear who opened the main passenger door. On finding no steps in position, and to confirm what she had heard, the No 2 cabin staff member contacted the commander on the interphone to confirm the request to evacuate. It was confirmed that immediate evacuation should proceed via the rear door only, to avoid the possibility of passengers walking into the left propeller on exit. All passengers were then evacuated, and returned to the terminal building. The fire service was quickly in attendance, but there was no fire.

Communication between the flight deck and the ground crew was by means of hand signals only. Although this had no direct impact on the outcome of this accident, the aircraft operator has now decided that headset communication between flight deck and ground will be used as a standard practice for future push-back operations, wherever possible.

Aircraft Description

The F27 is a high winged aircraft with a turboprop engine mounted on each wing in a nacelle that also incorporates a main landing gear bay. The ground electrical power socket is located on the right side

of the forward fuselage, 3 metres forward of the plane of the propellers. The propellers are four bladed, rotating clockwise when viewed from the front, with a nominal ground idle speed of 560 to 647 RPM. The disc of a rotating propeller is 3.6 metres in diameter, with a ground clearance of approximately 0.85 metres with the aircraft static on its landing gear.

Ground Vehicle Description

The tractor unit (Reliance Mercury Type 401), is a four wheel, cabbed vehicle with a nominal weight of 2,610 kg (Fig 1). It stands 1.1 metres high at the bonnet and 1.75 metres high at the cab. The diesel powerplant is rated at a maximum output of 47 bhp, and drives the tractor rear wheels via an automatic gearbox with a torque converter and three forward and one reverse ratios. Nominal performance includes a drawbar pull of 4,000 lb and a top speed of 15 mph. It was not licensed for use on public roads.

The tractor is provided with two seats and has the steering wheel, accelerator pedal and brake pedal on the left side, and a handbrake lever and a transmission selector between the seats. The transmission selector is similar to that conventionally fitted to automatic transmission cars, comprising a lever that can be pivoted fore and aft over a quadrant, with a selector indicator scale adjacent to the left side of the selector lever labelled as in the following box:

(Front)	P	ie	Park
	R		Reverse
	N		Neutral
	D		Drive
(Rear)	1		Forward Ratio 1

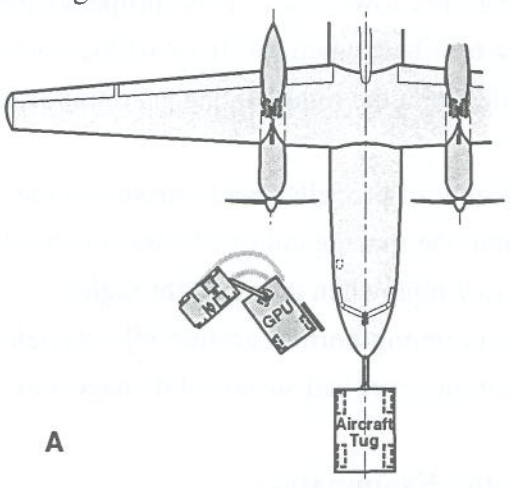
The current selection is indicated by a yellow index line on the selector lever quadrant; the scale is internally illuminated when the vehicle lights are switched on. A lock prevents movement of the selector lever, except between 'D' and '1', until it is disengaged by sliding a spring-loaded lock plunger up the selector lever, naturally operated by lifting with the forefinger and middle finger of the right hand. Selector lever movement is transmitted by a heavy duty Bowden type cable to a lever on the gearbox that operates hydraulic servos actuating two clutches and two epicyclic gear bands, in various combinations. The lever also mechanically operates a pawl lock that prevents transmission rotation when 'P' is selected. A gearbox switch is intended to inhibit energisation of the engine electric starter motor unless the selector is at 'P'.

The GPU being towed (Autodiesel Ltd Type 994/90) is a four wheel truck weighing 2,600 kg. The front wheels are on a short axle carried on a bogie to which is attached a long towbar. A pivot eye at the forward end of the towbar locates on a pin carried on a towing hitch attached to the back of the tractor, placing the front of the GPU 1.5 metres behind the back of the tractor, when GPU and tractor are aligned.

The acceleration performance of a similar tractor/trailer rig was measured after the accident. From a standing start with '1' selected a sudden application of full accelerator pedal produced a maximum steady speed of around 7 mph (3.1 m/s), reached after a 4 to 5 second period of acceleration over a distance of 7 to 9 metres. With 'D' selected the steady speed achieved was 11 mph (5 m/s) after 2 to 3 seconds and 3 to 6 metres travel. Braking performance was also measured; hard brake pedal application when travelling at top speed in 'D' caused the front wheels of the tractor to lock and brought the rig to a halt in an average of 3.7 metres in a time of 1.6 seconds.

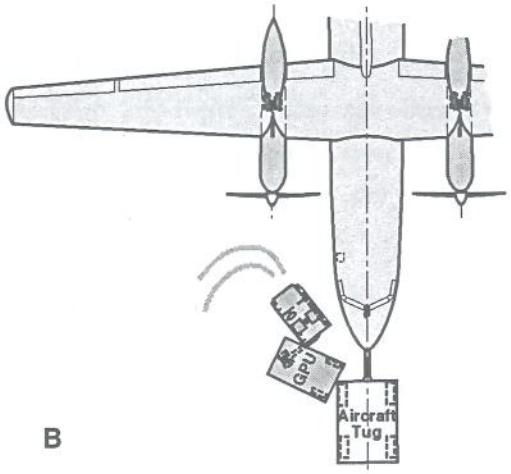
Wreckage Examination

The rig came to rest with the tractor beneath G-BLFJ's right engine and the front of the tractor in contact with the right main landing gear drag strut. Inspection showed that contact of the rotating propeller with the tractor had caused detachment of the tractor's bonnet, cab structure and steering wheel. Components in the upper part of the engine compartment, the instrument panel and the seats had also been damaged. Damage to the aircraft had been confined to the right powerplant and associated airframe structure and the right landing gear drag strut. Each of the four propeller blades had bent and twisted, and the outer 6 to 7 inches had broken off. The engine mounts and local mounting structure had distorted and/or cracked in a number of areas and the lower strap holding the engine fuel collector tank had fractured. The drag strut for the right landing gear sustained localised impact distortion. Wreckage was thrown over a wide area of the concrete apron to the right side of the aircraft.



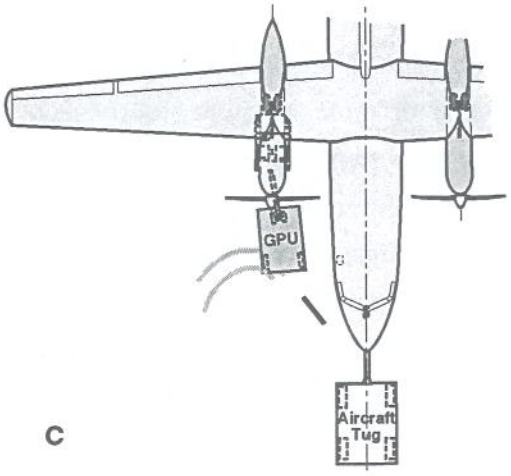
Detailed examination revealed wheel tracks and a rubber deposit on the concrete forward of G-BLFJ's right engine and contact markings on the tractor, the tractor towbar, the GPU and the aircraft tug (Fig 2). These indicated that with the rig in its initial position the tractor had probably been pointing away from the aircraft approximately as at A.

The tractor then reversed and turned left, causing the back of the GPU to collide with the left forward corner of the tug while the rig jack-knifed until locked with the towbar across the GPU and the left rear corner of the tractor in contact with the right side of the GPU (B). The rubber deposit on the concrete suggested that the right rear wheel of the tractor had spun while continuing to drive rearwards with the GPU hard against the tug; this was in agreement with eyewitness evidence. In this position the tractor was approximately 1 to 2 metres from the right side of the forward fuselage. Its front was 4 metres forward of the right propeller disc.



B

The final orientation of the vehicles and the characteristics of the propeller markings were consistent with the tractor having then travelled forwards, causing the rig to straighten out, before heading nearly parallel with the fuselage axis and passing almost centrally through the lower part of the propeller disc. The rig came to a halt when the front of the damaged tractor collided with the right landing gear drag strut (C).



C

A number of propeller blade strikes on the tractor were evident; the spacing indicated a tractor speed in the order of 6 to 7 mph when it passed through the disc, assuming normal ground idle propeller speed. The tractor transmission selector was found at '1', but the lever had sustained damage and could have been moved from 'D' during the impact.

Tractor Examination

In spite of the extensive damage to the tractor it was found possible to start the engine from an external electrical source and to operate the vehicle over short distances with various transmission selections. This showed that the tractor drove in the appropriate direction when 'D', '1' and 'R' were selected; with the engine idling the motion was a creep that could be readily stopped with the footbrake, but the more rapid tractor motion produced by application of significant amounts of accelerator pedal could not be stopped with the footbrake. However, with 'N' selected the tractor also tended to travel forward, at a creep at idle engine RPM and faster as RPM was increased, but in all cases the motion could be

stopped with determined footbrake application. This tendency to drive forward in neutral reduced with time of running, consistent with the effects of increasing transmission oil temperature. However, with 'P' selected the tractor behaved in the same way as when 'R' was selected, including being unstoppable by footbrake application at higher engine speeds.

Examination showed that neither the gearbox nor the selector cable had been damaged in the collision and that the selector lever damage sustained had not affected the rigging between it and the gearbox lever. Drive system manipulation made it apparent that the park lock pawl was failing to engage with 'P' selected. It was confirmed by an overhaul agency for this type of gearbox that, while the pawl can fairly readily be broken by selecting 'P' while the transmission is turning, the gearbox should not transmit drive in either direction with either 'P' or 'N' selected. Internal examination of the gearbox was not possible and it could not be ascertained whether the defective performance with 'P' selected was likely to have been identical before the accident, or had been aggravated by damage to the park pawl possibly caused during the manoeuvring immediately leading up to the collision. The evidence indicated that the torque transmission that occurred with 'P' and 'N' selected could have been due to misrigging of the cable between the selector lever and the gearbox lever.

The engine starter inhibit switch on the gearbox had reportedly broken some time before the accident and was found to have been by-passed by a non-standard electrical cable; in this condition the starter could be energised with the gearbox selector lever in any position.

Braking performance assessment on a brake roller tester failed to provide a quantitative measure as the tractor was too heavy for the tester but, in conjunction with road testing during the transmission functional testing, indicated that the footbrake was reasonably effective but that full handbrake application had no noticeable effect.

Aircraft Ground Handling Practice

The tractor and GPU were owned by an aircraft ground handling agency company with an outstation at Edinburgh. They were operated by the outstation personnel of the engineering subsidiary company of the airline to which G-BLFJ belonged, for use with their own and other airlines' aircraft, under a local standing subcontract agreement with the ground handling agency. The ground equipment used during general ramp handling operations was a mixed fleet of vehicles, tractors, tugs, GPUs *etc*, some owned by the ground handling agency and some by the airline's engineering company. All items of equipment in use at the time of the accident were owned by the ground handling agency.

Personnel Details

The shift period for the deceased, who was the shift leader, had commenced at 1400 hrs on the day of the accident. He was an avionics engineer with the airline engineering company, and had been

employed since 1988. He had been appointed as a shift leader on introduction of a 3 shift working pattern in November 1992. There was no record of his having completed the airline engineering company's 'Receipt and Despatch of Aircraft' ground handling training course, and no specific training was given in connection with his role as shift leader. The other ground crew members commented that it was common practice to organise themselves in the allocation of duties for aircraft handling during turnarounds.

The shift leader held an Edinburgh Airport Ltd (EAL) Airside Driving Permit, indicating that he had completed the required EAL Airside Driving Course (classroom based), and passed the appropriate written test. There was no practical driving training or specific driving test required for airside operations. He had a company disciplinary warning letter on file regarding an incident where an aircraft push-back towbar was bent on 8 February 1993, while driving an automatic transmission push tug in a jerky manner. He normally drove a car equipped with manual gearbox.

The shift leader was wearing spectacles at the time of the accident, but the airline engineering company did not require regular medical checks for ground personnel, or any checks on eyesight and hearing standards. The personal medical records of the deceased did not reveal any significant contributory factors.

Human Factors

Evidence from a psychology specialist indicates that in the event of a machine reacting in an unexpected way to a command that the operator believes he has made, the result is likely to be a considerable level of confusion in the mind of the operator. It is reasonable to suppose that the driver may have accelerated the tractor's engine in order to sense that it was running above the noise of the aircraft's engines, before driving off, believing the transmission to be in 'Park'. If the tractor in fact responded unexpectedly by reversing, it is plausible that the level of surprise may have been sufficient to cause the driver to react by keeping the accelerator pedal depressed, and to then mishandle the controls in panic when the collision with the push-back tug occurred with the tractor close to the aircraft's fuselage.

Ground Vehicle Maintenance

A local agreement was in effect for the operators, *ie* the airline engineering company personnel, to carry out day to day servicing of the ground vehicles such as replenishment of fuel, oil and water. Other maintenance of the vehicles was conducted by Glasgow based motor mechanics employed by the ground handling agency. Vehicles were not given a special annual MOT type inspection; the agency intended that satisfactory vehicle standards would be maintained by inspection by their mechanics during servicing and repair. The defect rectification system involved the airline personnel operating the vehicles verbally reporting problems to a local representative of the ground handling agency, who in response could call the Glasgow mechanics to travel to Edinburgh, generate the appropriate

worksheets, and attempt to repair the defect. Worksheets, a weekly equipment status report, and information on outstanding defects were sent to the ground handling agency's Manchester headquarters.

Records showed that the tractor gearbox and torque converter were replaced in November 1992 and the tractor was then in regular use until the accident. The Edinburgh office of the ground handling agency reported in early January 1993 that the tractor was stuck in gear (no neutral), and at the end of January 1993 reported that the handbrake was unserviceable. A further five and six reports respectively on these defects had been made up until the time of the accident. The tractor was not recorded as unserviceable in this period, except on three occasions when apparently inoperable because recurring failure of the engine starter system prevented it from being started. The airline engineers and the ground handling company personnel each considered that it was the responsibility of the other to declare a vehicle unserviceable in the event of a deficiency affecting roadworthiness. The records made no mention of the bypass of the starter inhibit switch; reportedly it was a temporary measure pending delivery of a replacement switch. No specific reports were obtained of abnormal behaviour with 'R' selected.

Regulation and Enforcement of Ground Vehicle Standards

The Road Traffic Act does not apply to the Edinburgh Airport apron and manoeuvring areas, in common with other UK airports. Ground vehicle operations are subject to the Scottish Airports Bye Laws, made by the British Airports Authority (now BAA plc). Rules for drivers and vehicles are published in EAL Managing Director's Notices (MDN). These do not have the force of law, but form a mandatory condition of airport use by a tenant.

The rules include a requirement for an airside vehicle to have a Vehicle Apron Pass, validity one year. The conditions for issue, set out in MDN/26/92, include the requirement for the vehicle to be in good order and the application form requires certification by the applicant that 'the vehicle has been inspected by a Motor Engineer within the last three calendar months of the date of this application and that the mechanical and electrical condition of the vehicle meets the standards required for the issue of a MOT certificate under the Road Traffic Act.' The term 'Motor Engineer' was not defined. Appendix 4 to MDN 8/92, dealing with airside driving procedures, also requires that 'Any vehicle in use airside at Edinburgh . . . . . MUST BE MAINTAINED TO MOT STANDARDS. NB EAL MT [Motor Transport] Manager may carry out spot checks on the road worthiness of any vehicles.' Records showed that a pass (No 154) for the tractor was issued on 3 June 1992, under a block application covering a number of vehicles.

Investigation indicated that in practice the airport authority accepted without investigation an applicant's declaration of vehicle inspection to MOT standards, and did not undertake any form of vehicle inspection, either regular or on a spot check basis, except possibly when obvious oil leaks or dirty exhausts *etc*, became apparent, or after an accident.

Apron Safety Regulation, Monitoring and Enforcement

Discussions indicated that the Health and Safety Executive (HSE) has jurisdiction over health and safety matters for all employee work areas of a UK airport. However, HSE has a policy of non-involvement with activities covered by another regulatory body with more specific interests and regulations. Thus it does not generally become involved in regulation of aircraft operations in view of the CAA responsibility in this area. HSE does consider worker safety aspects of ground vehicle operations on the airport apron to come under its remit, and at times investigates apron accidents that occur, but does not generally conduct routine apron inspections at UK Airports. HSE considers regulation, monitoring and enforcement of aircraft safety on the apron to come under CAA auspices.

The Air Navigation Order requires civil UK airports to be licensed by the CAA for most passenger public transport aircraft operations. It notes that the CAA shall grant an Aerodrome Licence if it is satisfied that ' . . . . . the aerodrome is safe for use by aircraft . . . . ', and the CAA has noted that an Aerodrome Licence renewal is subject to satisfactory findings from a detailed CAA annual inspection of that airport against the aerodrome licensing criteria. The CAA has indicated that this would generally not cover the maintenance or operating standards of ground vehicles, nor consider the possible dangers from ground vehicles to aircraft stationary on the apron, as this is considered by the CAA to be a workplace, where the provision of adequate safety standards is the responsibility of the aircraft operator, and their monitoring and enforcement the responsibility of HSE. The CAA noted that it considers that it becomes responsible for regulation, monitoring and enforcement of an aircraft's safety once the aircraft is moving under its own power. Its concern with apron accidents where an aircraft is damaged is in ensuring that the aircraft is restored to an airworthy condition before further flight. However, certain aspects of ramp operations (*eg* aircraft refuelling with passengers on board) are specifically regulated by the CAA.

Civil Aviation Authority Requirements for Air Operators' Certificate (AOC) Holders

CAP 360 Part 2 details the arrangements required for AOC Holders with regard to Maintenance Support, including the contracting out of ground handling. It requires that a written agreement be in existence, detailing the tasks to be performed on behalf of the operator by the handling agency. It notes that the standard International Air Transport Association (IATA) Ground Handling Agreement (AHM 810) provides a generally acceptable basis for such an agreement. It notes that *'It is the*

responsibility of the (aircraft) Operator or his principal maintenance contractor to ensure that the continuing performance of the ground handling contractor is such as to ensure safe operation of the operator's aircraft, and that necessary training has been performed.'

Ground handling agency companies are not regulated by the CAA, or by the airport authorities, and no standards are generally laid down with regard to handling staff training standards. The standard IATA Ground Handling Agreement makes reference to the types of services to be provided, but again does not refer to any minimum staff training requirement.

Early in 1993, the CAA re-issued a Notice to AOC Holders, number 1/93, entitled Ramp Safety Management. It noted that the greatest number of recorded occurrences involved damage to aircraft by vehicles, which was sometimes not discovered until the aircraft reached its destination. It noted that the duty to ensure the safety of ground handling personnel is covered primarily under the Health & Safety at Work etc (HSW) Act 1974, and that the CAA was additionally concerned that injury to people could be directly related to aircraft damage and adversely affect operational safety. It also noted that the nature of the incidents that had occurred suggested that complacency, a lack of awareness of the dangers inherent in proximity to aircraft as well as inadequate training and procedures have been contributory factors.

The notice re-emphasised that it is the aircraft operating company which is ultimately responsible for the safe operation and fitness of the aircraft for the intended flight. In situations where it is not possible for the aircraft operator to monitor handling functions directly, it noted that a quality system should be in operation to monitor the agency's performance. It stated that *'Quality involvement should be directed towards the manner in which the agency trains and qualifies its personnel for work on and around the aircraft, including its performance monitoring practices and its response to hazardous actions by personnel. The adequacy and maintenance of ground handling equipment essential to safety should also be taken into account..'*

Currently, the CAA does not carry out any direct monitoring of an operator's performance of this function, nor is there any direct assessment of ramp safety standards attained at any particular airport as part of the annual aerodrome licensing inspection. The notice concludes by stating that it is the responsibility of the HSE to enforce the HSW Act 1974, and that they have the power to inspect airport ramp areas and activities. Discussions with HSE, however, indicated that regular inspections are not carried out, because of a lack of available manpower and expertise in this area.

Safety Recommendations

In summary, this investigation revealed severe deficiencies in apron safety standards, that subjected ground handling staff, public transport aircraft, passengers and crew to potentially catastrophic hazards. The tractor was unserviceable on several counts due to known faults that had not been rectified, the system for reporting vehicle faults was inadequate, there was no agreed mechanism for declaring a vehicle unroadworthy and no form of roadworthiness certificate. The ground handler who

died in the accident had not received appropriate training in aircraft ground handling safety, vehicle apron driving, or in his shift leader function, and basic personnel medical checks were not made. Rules pertaining to ground vehicle safety were in existence, but there was an absence, within either the operating companies or regulatory bodies involved, of management systems aimed at monitoring or enforcing them. Experience and the number of recorded accidents/incidents suggest that such deficiencies apply not just at Edinburgh, but also at other airports. This experience is shared by the CAA who, indirectly in response to an earlier AAIB Recommendation (92-52), have established a 'Working Group' to address specifically apron safety within the context of procedures and safety management systems at all UK licensed airports. The 'Working Group' is constituted of representatives from airport authorities and airline associations in addition to the CAA's own safety specialists. In addition, the CAA will be consulting with the HSE.

In view of these findings the following recommendations are made:

Recommendation 93-76

It is recommended that the Civil Aviation Authority established 'Working Group' should progress with urgency their consideration of apron safety with a view to recommending a set of requirements/criteria for the management and operation of airport apron areas to be published by the CAA, thereby providing a standard against which apron operations will be audited and monitored. The CAA should also aim, in consultation with the HSE, to establish clear divisions of responsibility for the safe conduct of apron activity. (Issued 17 December 1993)

Recommendation 93-77

It is recommended that the BAA plc should ensure, through its safety management, monitoring and independent audit arrangements, that EAL, and all other airports within the BAA group, implement the following minimum operating standards and that adequate enforcement procedures are in place:

All apron telephones should be placarded with the appropriate emergency number.

All persons operating vehicles on the apron should hold airside driving permits, issued on the basis of satisfactory completion of an apron safety training course, and a practical driving test on the vehicle to be operated. In addition, evidence of a satisfactory medical standard (especially with regard to sight and hearing standard) should be presented at the time of permit issue or periodic renewal.

All vehicles used on the apron should be required to possess an airside vehicle permit. To qualify for such a permit, the vehicle should be maintained to a sufficiently high standard such that they could pass a serviceability test similar to that of an MOT for public road vehicles, but including all of the

special functions associated with some of the specialist vehicles. Evidence of a satisfactory inspection, and of routine and corrective maintenance should be presented at the time of issue or renewal of the permit.

In order to ensure that a high standard of apron safety is maintained, regular safety checks should be carried out on airside vehicles, and regular apron safety audits should be carried out by a member of the airport management tasked with overall responsibility for apron safety.
(Issued 17 December 1993)

Recommendation 93-78

It is recommended that the Airport Operators Association circulate to its members the details of this accident, with a view to implementation of Recommendation 93-77 at all UK airports used for Public Transport operations. (Issued 17 December 1993)

GENERAL VIEW OF ACCIDENT SITE

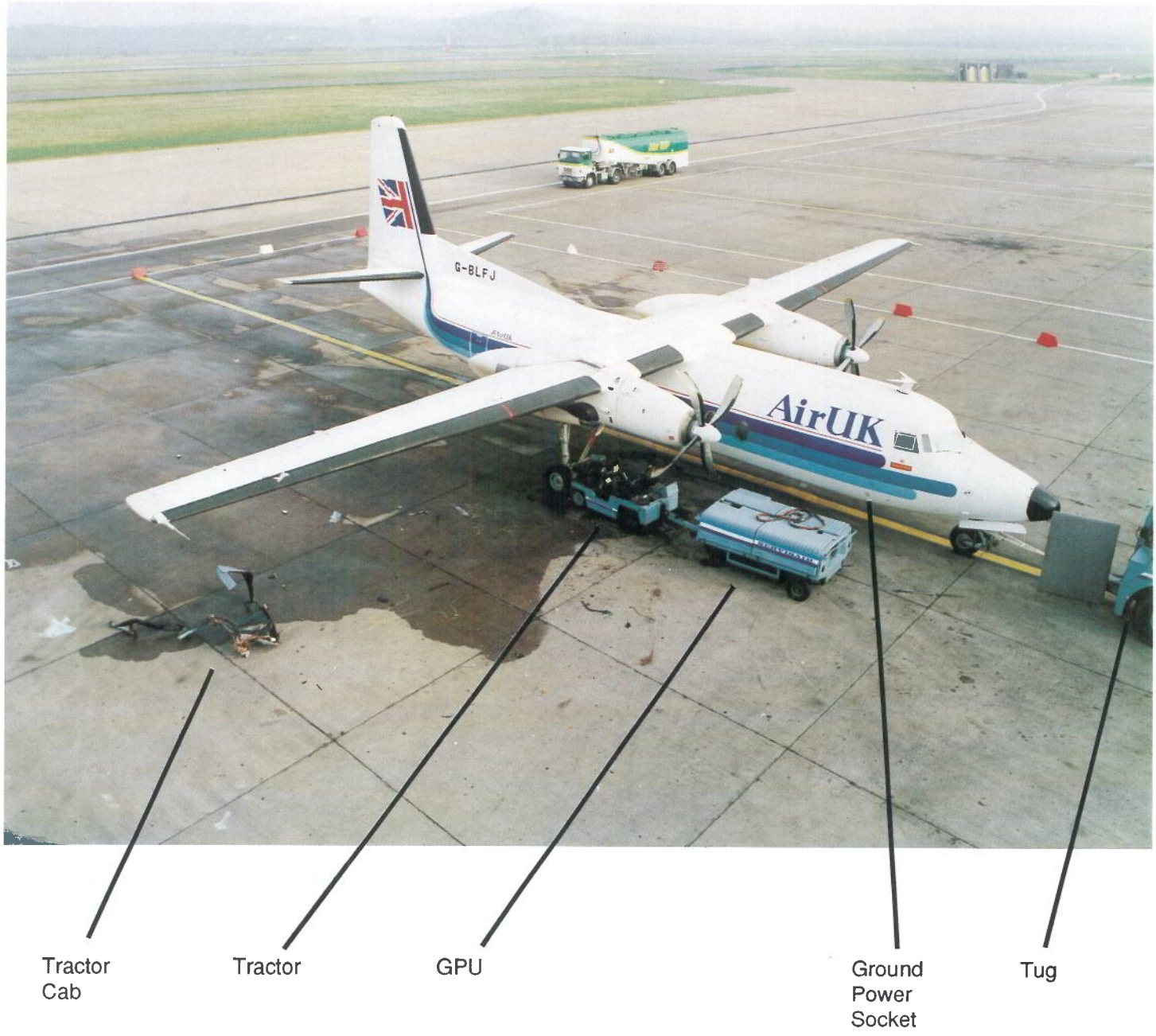


Fig 1

GENERAL PLAN VIEW OF SITE

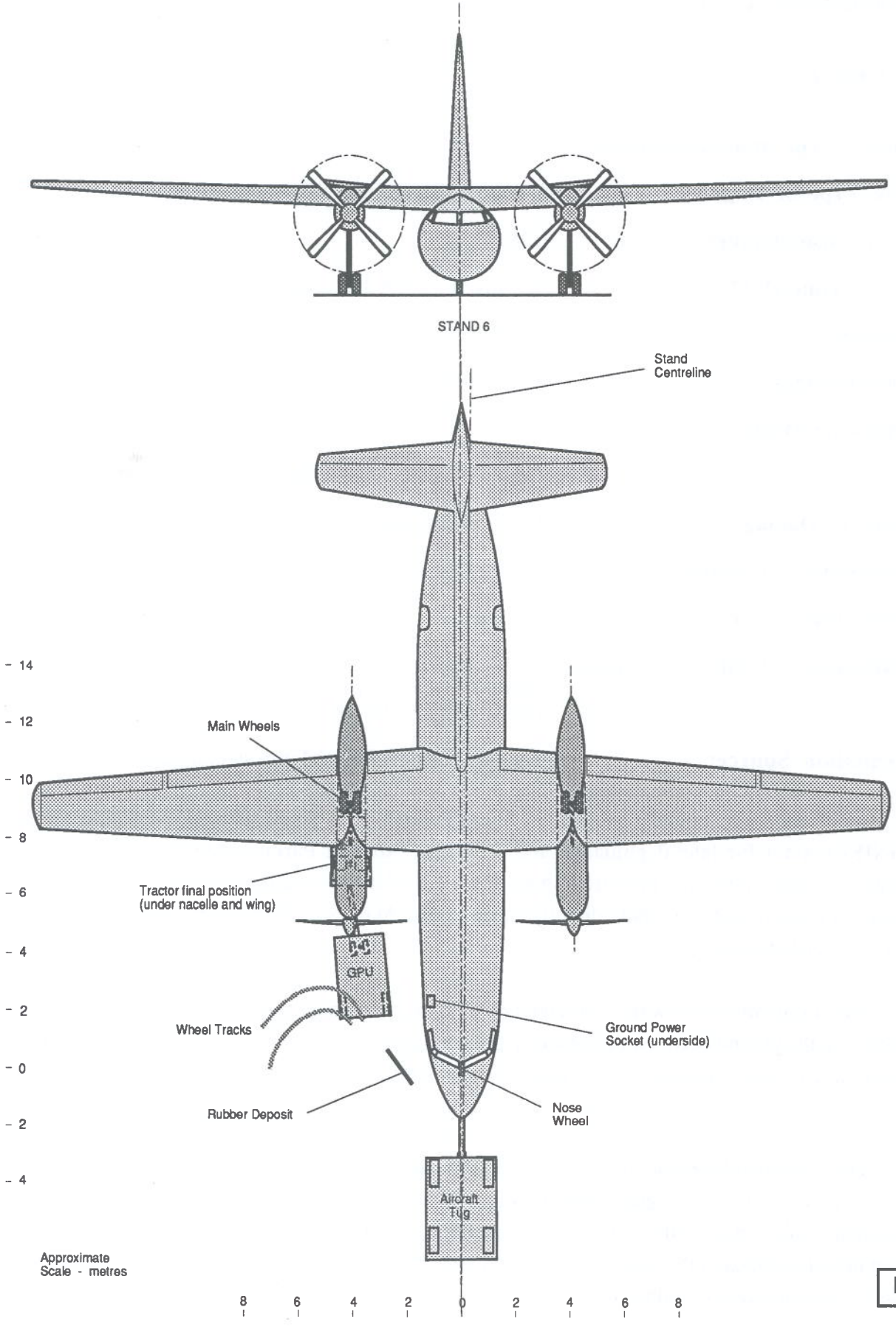


Fig 2