ACCIDENT

Aircraft Type and Registration:	Fokker F27 Mk 500 Friendship, TC-MBG
No & Type of Engines:	2 Rolls-Royce Dart 532-7 turboprop engines
Year of Manufacture:	1971
Date & Time (UTC):	1 February 2008 at 2115 hrs
Location:	Stand 201, Edinburgh Airport
Type of Flight:	Commercial Air Transport (Cargo)
Persons on Board:	Crew - 3 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Propeller, engine and ground power unit severely damaged
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	56 years
Commander's Flying Experience:	4,080 hours (of which 2,745 were on type) Last 90 days - 74 hours Last 28 days - 26 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft was scheduled to operate a night cargo flight from Edinburgh to Coventry. The weather conditions at Edinburgh Airport were wintry with snowfall, which required the aircraft to be de-iced. Shortly after both engines had been started, the commander signalled to the marshaller to remove the Ground Power Unit (GPU) from the aircraft, which was facing nose out from its stand, down a slight slope. As the marshaller went to assist his colleague to remove the GPU to a safe distance prior to the aircraft taxiing off the stand, the aircraft started to move forward slowly, forcing them to run to safety. The flight crew, who were looking into the cockpit, were unaware that the aircraft was moving. It continued to move forward until its right propeller struck the GPU, causing substantial damage to the GPU, the propeller and the engine. The ground crew were uninjured. No cause as to why the aircraft moved could be positively identified.

History of the flight

TC-MBG was operating from Stand 201 on the North Cargo Apron, at Edinburgh Airport. Its operator had been subcontracted by another operator which regularly uses the airport.

The crew had flown the aircraft together the night before from Coventry to Edinburgh without incident. On that sector and the planned sector back to Coventry, the commander was line training the co-pilot. Due to forecast high winds at Edinburgh, the aircraft was repositioned by the handling agent to face into wind, after the crew had gone off duty. This placed the aircraft pointing nose out of the stand, facing down a slight slope.

Prior to the accident, the crew, which included a travelling company engineer, reported for duty at 1900 hrs for a scheduled departure time of 2050 hrs. A GPU was connected to the right side of the aircraft when they boarded, to provide electrical power prior to engine start. There were two ground handlers in attendance to oversee the departure, a marshaller, who supervised the start up and an assistant. It was dark at the time.

The aircraft was loaded and prepared for departure without event. De-icing was necessary due to falling snow and this caused a delay. When it was completed, the company engineer went outside to inspect the aircraft and collect the de-icing certificate. At approximately 2113 hrs, with the 'Pre-Flight' checklist completed, the co-pilot requested and received start clearance from ATC. The co-pilot then commenced the 'Before Start' checklist. As he called "Parking brake", expecting to hear the commander reply "Set" to confirm the parking brake was on, they were interrupted by the return of the company engineer, who verbally confirmed to the commander that the nosewheel was chocked. The co-pilot's parking brake call-out was not subsequently responded to by the commander. Using hand signals, the commander then requested and received clearance from the marshaller to start the aircraft's engines.

After start, with the engines stabilised, the commander noticed that the main and brake pneumatic system pressures had fallen to 1,600 psi. He advanced the engine power levers in a bid to restore the pressure to 1,800 psi. The commander then signalled to the marshaller to disconnect the GPU, by indicating a 'T' with his hands which he then pulled apart. The co-pilot then started to read out the 'After Start' checklist to the commander. Upon receiving the signal, the marshaller went to assist his colleague remove the GPU to a safe distance. As the marshaller reached the GPU, the aircraft started to move forward slowly. Noticing this, he shouted to his colleague, who was between the GPU and its tug. They both ran clear of the aircraft as it continued to move forward. The flight crew were still progressing through the 'After Start' checklist when they heard a loud 'bang' from the right side of the aircraft. The commander checked the engine instruments and noticed that the right engine had failed. He shut down the left engine and secured the aircraft by pulling both engine shutoff handles, before vacating the aircraft with the company engineer, followed shortly by the co-pilot. Once outside, the commander noticed that there were no chocks in the vicinity of the nosewheel.

The Airport Fire and Rescue Services (AFRS) were on scene within two minutes. Upon arrival they chocked the nosewheel, as no chocks were present and laid a blanket of foam beneath the right engine to cover the leaking fuel.

Edinburgh Airport Managing Director's Directive 04/07

Managing Director's Directive (MDD) 04/07, 'Aircraft Pushback and Powerback Procedures', was issued by Edinburgh Airport on 28 March 2007. It stated the following:

> *'Straight pushbacks are forbidden from any North Cargo Apron stand. If any aircraft on these stands has been previously repositioned to face out (e.g. because of prevailing wind conditions), such aircraft must be pulled off* ***stand and lined up on the taxiway centreline <u>before</u>*** *starting engines.'*

The airport operator commented that MDD's are sent out electronically to the general managers and station managers. They added that it is the responsibility of the handling agents to ensure that all applicable Airport Notices are brought to the attention of any new operator or airline company.

Commander's comments

The commander stated that when he had operated from Edinburgh on the two days before the accident, the aircraft was positioned in the same manner as when the accident happened, ie on the same stand and facing outwards, to avoid high tailwind conditions. On these previous occasions ATC had given clearance for the aircraft to taxi off the stand under its own power. He added that he had not received a copy of MDD 04/07 from his company until 25 February 2008, 24 days after the accident.

The commander stated that the brake pressure gauge was reading approximately 1,800 psi when he checked it during the 'Pre-Flight' checks and that he had checked that the parking brake was set during the 'Before Start' checklist. He added that throughout the 'After Start' checklist they were not aware of the aircraft moving prior to the impact with the GPU.

Marshaller's comments

The marshaller stated that he had supervised TC-MBG when it had operated from the North Cargo apron, facing nose out with the same operating crew, over the preceding two days. He added that on the night of the accident, the aircraft's nosewheel was chocked when he went to assist his colleague to remove the GPU. He stated that he had felt slightly under pressure to expedite the departure as there had been a delay due to the aircraft requiring de-icing.

ATC controller's comments

The ATC controller stated that at the time of the accident, he was working both Tower and Ground frequencies. When TC-MBG called for start clearance, he was initially unsure of its callsign due to the poor quality of the co-pilot's transmission. He was not aware that the aircraft was facing out of the stand and could not see it from his position in the control tower, due to the darkness and the distance involved.

Recorded data

The event was captured on the 30-minute Cockpit Voice Recorder (CVR). The recording indicated that the commander was providing instruction to the co-pilot. Although the flight was delayed awaiting de-icing services, the checklists were completed in an unhurried fashion. The number two engine was started, followed by the number one engine. Sound spectrum analysis of the recording showed that both engines stabilised at around 8,000 rpm. The commander then said "A LITTLE BIT MORE POWER TO CHARGE THE SYSTEM A LITTLE BIT", after which the engine speeds increased to around 8,600 rpm. Approximately 20 seconds later, whilst progressing through the 'After Start' check list, the sounds of the propeller striking the GPU were heard. This started with 0.7 second of propeller strike noise followed by a one second gap, a further one second period of propeller strike noise and then a louder mechanical sound, possibly associated with the engine breaking free of its mounting.

The aircraft is of an age when only a very limited number of parameters were required to be recorded by Flight Data Recorder (FDR). None of these would have assisted with this investigation. No data on the accident were recorded in any case, as the FDR start/stop logic had not yet triggered it to start recording.

The standards for more modern aircraft require more parameters to be recorded. Retrospectively increasing the number of parameters recorded by an FDR on older aircraft may be prohibitively expensive due to interfacing issues. However, current imaging technology potentially provides a cheaper alternative means of capturing a wide array of additional parameters via cockpit image recording. Minimum standards for such equipment have been specified in EUROCAE document ED-112. Work is currently underway to incorporate ED-112 into ICAO requirements and introduce cockpit image recorders. Once such recorders have become available and their associated costs are better understood, consideration should be given to reviewing the cost/safety benefit case for retrofitting them to aircraft with limited FDR parameter sets.

Examination of the accident site

A photograph of the accident scene, taken on the morning after the event, is shown at Figure 1. Chocks had been placed at all the wheels at this stage. According to the AFRS, no chocks were found in the vicinity of any of the wheels on their arrival and they chocked the wheels as a precaution, prior to applying foam. Two chocks were found in the wreckage of the GPU, with one of them being visible in Figure 1.

The power lead was found trailing on the ground between the GPU and the aircraft, although the ground power receptacle door on the aircraft had been closed. Following disconnection, the lead would normally be folded into one of the recessed trays that run the length of each side of the GPU's chassis and which are also

Figure 1

View of the accident site. Position of chock is indicated. The other is located within GPU debris in foreground used to store chocks. The tractor unit was not attached to the GPU; the ground handler was in the process of attaching it at the time of the occurrence. (Note: the handling agent had modified its GPUs in order to reduce the possibility of towing a unit away whilst connected, via its power cable, to the aircraft. As a result the GPU must first be unhitched from the tractor and the towbar raised to a near vertical position. The latter action applies the wheel brakes and operates a mechanical interlock which, by means of an associated relay, allows electrical power to be supplied to the aircraft.)

The GPU had sustained substantial damage as a result of being struck by the right propeller. The sliding portion of the cover, which was made from steel, had been torn from the chassis and thrown some 7-8 metres, landing in front of the outboard section of the aircraft's right wing. The control panel had also been removed from its mountings but had remained attached to the GPU by electrical cables. The roof of the tractor had suffered a glancing blow from a propeller blade and the rear window had received a number of impacts from flying debris.

As can be seen in the photograph, the aircraft's right engine nacelle had almost separated from the wing, remaining attached only by the exhaust duct and some conduits. The instability of the nacelle during the accident sequence and the close proximity of the fuselage had resulted in the propeller striking and breaking an adjacent window transparency.

Description of the aircraft pneumatic system

The F27 aircraft is equipped with a pneumatic system in which pressurised air is used to operate the brakes, nosewheel steering and landing gear. A schematic diagram is presented at Figure 2a and b. It consists of two separate systems, the main and alternate/emergency, each with an air storage bottle and an additional bottle for the main braking system. The entire system is charged by means of compressors, one driven from the accessory gearbox of each engine, or from a compressed air supply via a charging valve in the rear of each engine nacelle. The nominal working pressure is 3,000 psi. The aircraft manufacturer stated that, with both engines running at 10,000 rpm, the charging rate is around 20 minutes per 1,000 psi increase in pressure.

An isolating valve is incorporated within the system, which, as can be seen in Figure 2a, actually consists of two valves, both operated by a single control rod. The purpose of the valve is to preserve stored pressure in the event of a leak elsewhere in the system.

The Maintenance Manual noted that:

'...operational requirements allow a leakage of 100 psi per hour based on pneumatic system capability.'

Fokker F-27 expanded checklist

The operator of TC-MBG stated that they use the aircraft manufacturer's checklists, as published in the Airplane Flight Manual. The 'Pre-Flight' checklist pneumatic system check reads as follows:

'Pneumatic pressures…………………..Check

- *Min for take-off*

MAIN system	*1500 psi*
BRAKE system	*1500 psi*
ALTN system	*2500 psi'*

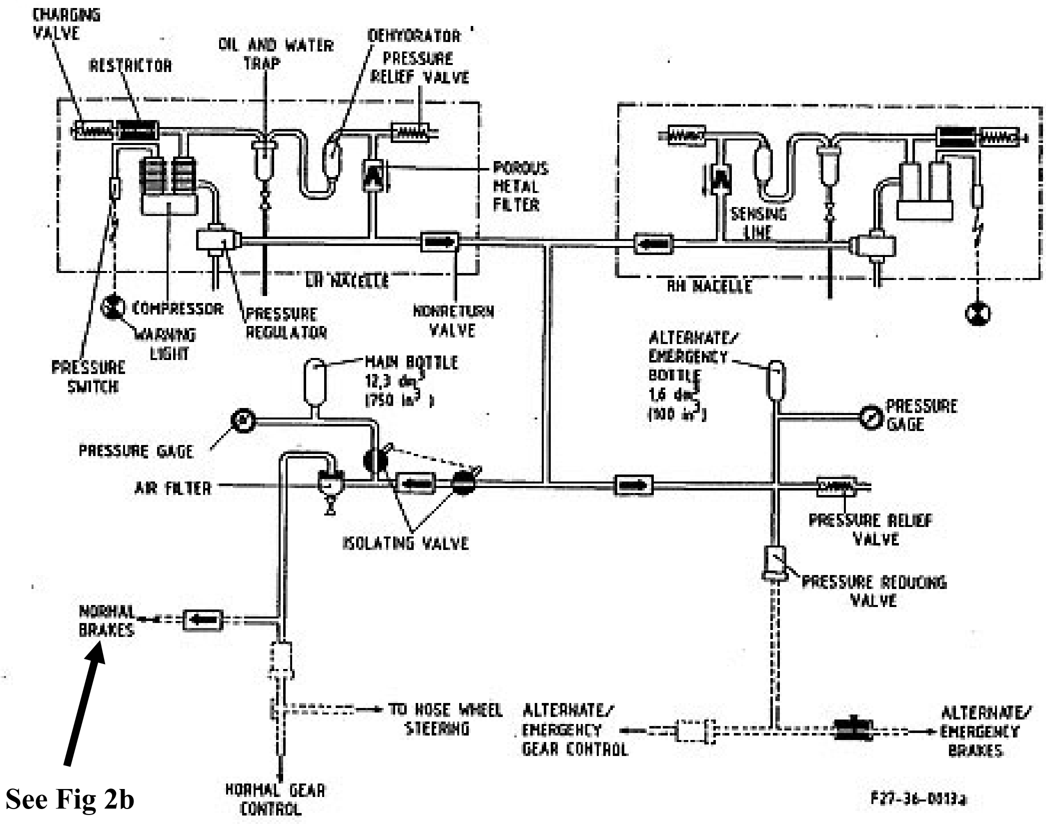

Figure 2a

Pneumatic system schematic diagram

Tests on the braking system

When the aircraft was first examined by the AAIB the brake pressure gauge was indicating close to zero. A charging trolley was obtained and the system was charged to approximately 2,000 psi, with the intention of attaching a tug to the aircraft in order to test the efficacy of the parking brake. However, a tug did not become available for approximately one and a half hours, during which time it was observed that the brake pressure had decayed to around 1,100 psi. Following the arrival of the tug, the system was recharged and, with the tug gently pulling and pushing the aircraft, satisfactory operation of the parking brake was demonstrated.

At a later date, it was decided to conduct a more accurate assessment of the leakage rate of the system. Accordingly, the pneumatic system was charged to 3,000 psi with the isolating valve open. The parking brake was set and the isolating valve closed. One hour later the pressure readings were observed as follows: main 2,800 psi, brakes 2,550 psi, alternate/emergency 3,000 psi. The isolating valve was then opened, thus connecting together the main and brake systems, with the pressure equalising at 2,700 psi; the alternate/emergency system remained at 3,000 psi.

Forces acting on the aircraft

The accident occurred shortly after the engines were accelerated beyond 8,000 rpm. Information from the propeller manufacturer indicated that the propeller blades would remain at the zero angle pitch stop until around 13,000 engine rpm, with the result that the total thrust from both propellers in the prevailing conditions of 0°C and 6 kt headwind was only of the order of 55 kg force.

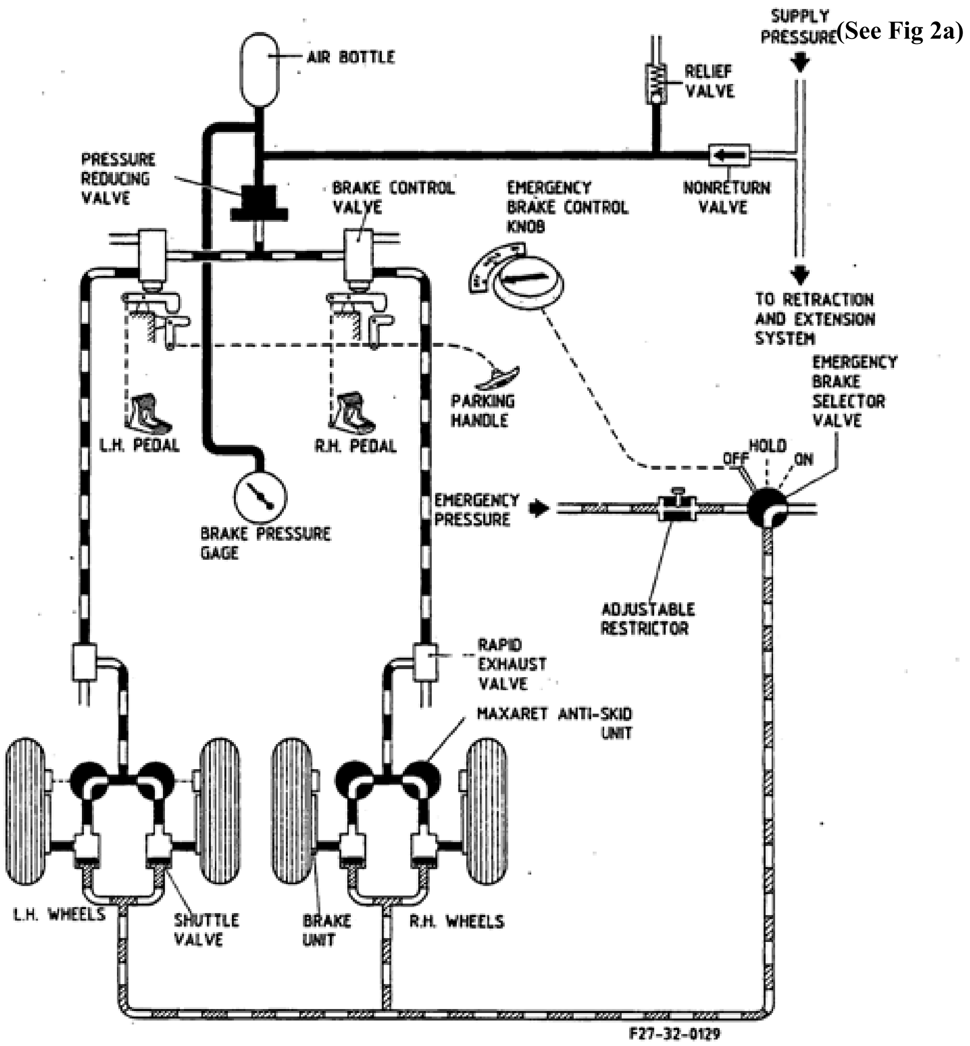

Figure 2b

Brake system schematic diagram

The slope of the hard standing where the aircraft was parked was approximately 1.5%. The aircraft was facing down the slope, with the result that the component of the aircraft weight of around 17.5 tonnes acting down the slope was some 260 kg force.

The only other force contributing to the forward movement of the aircraft was the exhaust efflux from the engines, but the aircraft manufacturer indicated that this force would have been "negligible".

Analysis

There are three unresolved issues surrounding this accident. The first concerns whether the aircraft was, in fact, chocked when it began to move. The commander stated that he signalled to the ground crew to remove the GPU and not the chocks and the marshaller stated he did not remove them at this time. According to the AFRS, no chocks were seen in the vicinity of the nosewheel when they arrived at the scene, although two were found in the wreckage of the GPU. The degree of interference with the debris following the accident cannot be established with certainty, so the reported absence of chocks does not necessarily mean that they were absent at the time of the event.

The second issue is whether the parking brake was set. The crew could be heard going through the 'Before Start' checklist on the CVR, but, as a result of an interruption from the travelling engineer, there was no verbal response to the challenge "Parking brake set". Nevertheless, the commander stated that he had set the brake correctly and no comment was heard on the CVR to indicate that the parking brake was not set, or reset, after the impact.

The third issue concerns the amount of leakage in the aircraft pneumatic system and the likely brake pressure available immediately prior to the accident. Subsequent tests showed that the leak rates for the brake and main systems were respectively 450 and 200 psi/hr. These values clearly exceeded the Maintenance Manual limit of 100 psi/hr, although it is possible that the pneumatic pipes within the right engine nacelle were subjected to a series of shocks and vibrations during the accident, resulting in the exacerbation of existing leaks or the generation of new ones.

Pneumatic system leaks can be expected on a 37-year-old aircraft such as this, but even with minimal leakage, the charging system (which is capable of generating 1,000 psi increase every 20 minutes at 10,000 rpm) could struggle to maintain adequate pressure in the event of a long taxi with frequent brake and steering applications. The alternate/emergency system is available for occasions when brake pressure falls below the minimum value, although it would not normally be used when starting the aircraft.

If it is assumed that the aircraft arrived on the stand earlier in the day with the system fully topped up at 3,000 psi, it is likely that this pressure would have almost entirely dissipated, with the as-found leak rate, during the 15 hours or so the aircraft was parked. Furthermore, the aircraft was moved once during the day, using a tug, in order to position it facing in the direction of forecast high winds. This would have involved at least one parking brake release/set cycle, which would have further reduced the stored pressure. The crew reported observing a brake pressure of 1,800 psi when they boarded the aircraft prior to the accident, which would suggest that the leak rate may have been considerably less than the subsequent tests indicated. However, if the pressure had been observed to be low, the crew had the option of summoning a charging trolley, and, moreover, would have had the time to do so whilst awaiting the de-icing vehicle. Despite the delay, the CVR indicated that the checklists were being worked through in an unhurried manner, with no evidence to suggest an intention to make up for lost time with a rushed departure. Thus, lack of system pressure is perhaps the least likely of the possible scenarios.

Of the forces acting on the aircraft causing it to move forward unexpectedly, gravity would have been the most significant, with a small contribution from the propeller thrust (assuming the propellers were at their ground fine settings) and a smaller contribution from the jet efflux from the engines.

The contracted operator and the subcontracted/aircraft operator had not received a copy of MDD 04/07 prior to the accident and the flight crew of TC-MBG had been given approval to self-manoeuvre the aircraft off the North Cargo Apron on several occasions prior to the accident, contrary to the instructions in the MDD. Had these instructions been followed, the accident is unlikely to have occurred. This is due to the fact that once the aircraft had been towed onto the taxiway centreline, the fall of the taxiway would have been laterally across the aircraft, so that the component of gravitational force would have acted sideways, instead of forwards. Even if the aircraft were not restrained with the brakes or chocks, it is unlikely to have moved.

Handling agent's actions

A representative for the handling agent stated that they have several procedures in place to audit the performance of their ground crew both internally and externally, covertly as well as overtly. These processes are formally recorded and actions are taken to address any deficiencies found.

The handling agent had assumed that the airport operator sent MDDs to operators directly, but this accident showed that this was clearly not the case. As a result, the handling agent is introducing a formal procedure to ensure that in future all MDDs are sent to aircraft operators.

Conclusion

The aircraft moved forward inadvertently after engine start, causing its right propeller to strike a GPU. Possible explanations include that the parking brake was not set, the chocks had slipped from the nosewheel, or the chocks were removed prematurely. There was insufficient evidence to determine which of these scenarios was the most likely.

Contributory factors were: the aircraft was facing down a slight downslope, the ramp was slippery due to the weather conditions and the flight crew increased engine speed to top up the pneumatic system pressure. The airport operator's instructions contained in MDD 04/07 required aircraft facing nose-out on North Cargo Apron stands to be towed onto the taxiway centreline, prior to starting engines. Had these instructions been complied with, the accident would probably have been avoided.