Aircraft Type and Registration:	Socata TB20 Trinidad, G-MIMI
No & Type of Engines:	1 Lycoming IO-540-C4D5D piston engine
Year of Manufacture:	1985
Date & Time (UTC):	21 March 1993 at approximately 1425 hrs
Location:	Roves Farm, Sevenhampton, near Swindon
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 2
Injuries:	Crew - Fatal Passengers - Fatal
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence (Groups A &B) with IMC and Night ratings
Commander's Age:	33 years
Commander's Flying Experience:	228 hours (of which 105 were on G-MIMI) Last 90 days - 18 hours Last 28 days - 12 hours
Information Source:	AAIB Field Investigation

The pilot and his passengers flew uneventfully from Biggin Hill to Dublin on 20 March. The next day they visited Dublin airport's information service office where the pilot self-briefed on the weather and NOTAMS for the return flight to Biggin Hill. There he filed a VFR flight plan via the Brecon and Compton VOR beacons stating an endurance of five hours, an initial cruising level of flight level (FL) 55 and an intended departure time of 1235 hrs UTC. After refuelling with 145 litres of AVGAS the aircraft took off at 1239 hrs. The weather at Dublin was fine but en route there was a cold front 100 nm wide with a ground position stretching from Pembroke to Humberside which was moving slowly south-east. In the area of the front, the medium level cloudbase was 7,000 feet amsl with varying amounts of layered strato-cumulus and stratus cloud extending beneath it to 800 feet amsl; the freezing level was about 7,000 feet. During the period of the planned flight, Biggin Hill remained clear of the cold front and the weather there was suitable for VFR arrivals.

The leg from Dublin to the FIR boundary at VATRY (341°R 38 nm from Strumble VOR) was flown with the sun about 25° right of the nose. The aircraft was assigned a discreet transponder code by Dublin ATC and transponder performance was satisfactory all the way to the FIR boundary. From

VATRY the aircraft turned left for Brecon and contact was made on the London FIR frequency. Shortly after passing VATRY the aircraft would have encountered the beginning of the medium level cloud associated with the cold front. At 1338 hrs the pilot made contact with Cardiff Approach stating his DME range as 24 nm from the Brecon VOR/DME at FL 65 and he requested a radar advisory service. He was assigned a transponder code but the aircraft was not identified because, unbeknown to the pilot, the aircraft's transponder returns had become intermittent at 1321 hrs and had stopped at 1325 hrs (46 minutes after take off). At 1344 hrs the pilot reported 10 DME to run to Brecon, that he was in instrument meteorological conditions (IMC) but on top of cloud at FL65 and 'squawking' mode C. He was then invited to descend to FL55 to remain clear of controlled airspace which he agreed to do and the aircraft was identified on primary radar overhead the Brecon VOR. The pilot then set course for Compton on the 106°R from Brecon. At 1356 hrs he was given his position as 5 nm east of ALVIN (by the Severn estuary) and instructed to 'free-call' Lyneham. RTF contact with Lyneham was established shortly afterwards and the pilot reported that he was IMC at FL 55 and requested a radar advisory service. One minute later, at 1357:48 hrs (78 minutes after take off), the pilot stated "LYNEHAM THIS IS GOLF MIKE INDIA MIKE INDIA, WE'VE GOT AH COMPLETE NAVIGATIONAL AIDS FAILURE THIS TIME, AH REQ". The transmission was cut short and the Lyneham controller asked the pilot to repeat it; the reply was a very brief transmission of carrier wave only and this was the last transmission heard from G-MIMI.

The Lyneham controller had been unable to identify the aircraft. Sixteen minutes after the last RTF call from G-MIMI (at 1414 hrs) he noticed a primary radar contact, somewhat intermittent (possibly because the aircraft was at low-altitude), in a left hand orbit near Highgrove. This position was one mile north of the aircraft's declared intended track and 17 nm beyond the position at which the navigation aids and radio failed. The controller passed advisory headings for the aircraft to fly and he alerted nearby ATC agencies to the aircraft in difficulty. The contact faded but at 1420 hrs he saw another primary contact tracking 110°M three miles north-west of Swindon. At 1422 hrs this contact began orbiting north-east of Swindon close to the crash site and at 1424 hrs the contact finally disappeared.

At the time of the accident it was raining at Brize Norton (10 nm from and at a similar altitude to the crash position). The visibility was about 4,000 metres, the wind was 230°/06 kt and the cloudbase was 8 oktas at 1,100 feet with patches of stratus at 800 feet. At the farm where the aircraft crashed an 'open day' for the public was in progress and people were driving cars to and from the farm. Several eye-witnesses on the access road to the farm saw the aircraft orbiting the area at low altitude and the majority reported that the engine sounded normal. One witness who was in a barn about half a mile from the crash site heard an aircraft engine which prompted him to look out through the open side of the barn. He saw the aircraft tracking from west to east, in straight and level flight at very low height and the engine sounded to be "revving" as if on take off. The sound of the engine then ceased and he saw the aircraft pull-up into an estimated 40° nose-up attitude and gain height. At the apogee of its brief climb, the aircraft appeared to be stalling and then the right wing dropped, the aircraft inverted and it nose-dived into the ground. The witness did not see the aircraft hit the ground but he did hear the impact.

Maps, en route charts and approach charts appropriate to the flight were found in the cockpit. The pilot's kneepad had relevant charts clipped to it with notes regarding the frequencies and radials appropriate to the flight but there was no evidence of a flight log containing headings to fly and leg times adjusted for wind. On the pilot's half-million map there were two airfields marked which were close to the aircraft's final orbits; South Marston and a gliding site at Sandhill Farm. South Marston was marked as disused and its runways have been obstructed by industrial development. The gliding site, however, was a grass field identifiable from the air by aircraft track marks and a number of parked glider storage and transport trailers which, being mostly white, were conspicuous. Aerial photographs of the field in which the aircraft crashed showed that it was clearly too small for an emergency landing and it had three large trees near the centre. The aircraft had struck one of these trees with its right wing. The rectangular field preceding the crash site was much larger and its longer dimension was aligned with the aircraft's pre-crash flight path. However, this field contained a large number of sheep which made it unsuitable for landing. If the aircraft had cleared the trees in the field in which it crashed, its track would have taken it towards the gliding strip at Sandhill Farm which was about one mile from the crash site.

Flight trials in a similar aircraft showed that visibility over the nose at the correct approach speed with gear down and flaps at take-off was sufficient to keep the landing area in view throughout an approach. Moreover, the low voltage warning light positioned close to the flight instruments was conspicuous in bright sunlight, within the normal instrument scan in IMC and could not be mechanically covered or dimmed.

Wreckage and Site Examination

The aircraft had crashed in a field 1 kilometre south of Sevenhampton. In the middle of the field there was a group of three trees and several fragments of the aircraft's right wingtip plastic fairing were found on the ground near the trees. The aircraft had hit the leftmost of the three trees, relative to its approach towards them. The impact with the tree had been light, affecting only the plastic wingtip fairing. The aircraft had flown on, in a direction of 055°Magnetic, and had crashed, inverted, 320 feet from the trees. The aircraft had hit the ground in a steep nose-down attitude of about 40° and there was some evidence suggesting that, at impact, the aircraft had been in a stalled or spinning condition.

The aircraft's forward speed had been low and it came to rest about 35 feet from the initial impact, upright and resting on its main landing gear and its badly damaged front fuselage. There had been no fire following the crash. The structure of the nose, the instrument panel, the forward cabin and the canopy had been destroyed; the rest of the aircraft was intact, with the exception of the outboard wing leading edges, which had been crushed in the initial ground impact, and the rear fuselage which was buckled.

The propeller showed evidence of rotation at impact and this evidence was sufficiently distinct to imply a high rotational speed or moderate power at impact. Both wing fuel tanks had ruptured and from the large areas of withered grass which developed in front of the wing impact ground marks it was evident that there had been a substantial amount of fuel in each tank. The landing gear on this aircraft was retractable but the main landing gear legs were found to be locked down. The normal landing gear selector switch was selected to 'DOWN' and the emergency release had been pulled. The wing flaps switch was at the 'INTERMEDIATE' position and it was later determined that the flap motor had achieved that position and the flap operating rods, though damaged in the crash, were still attached to the flaps and motor. The flaps had, therefore, been extended to the 'INTERMEDIATE' position, a position which would have been appropriate for slow flight.

When the battery was removed it was found that the filler cap of one cell was not in place and this was later found underneath the squab of the rear seat. However, the fluid level in that cell, as in the others, was found to be correct and no evidence of acid spillage around the battery was detected. After the aircraft had been recovered to the AAIB Headquarters at Farnborough the battery (nominally 12v) was tested in the battery bay of the Defence Research Agency, Farnborough and it was found to be discharged as received. It was tested according to standard procedures and was assessed, when charged, as fit for aircraft use except for some impact damage that it had sustained.

The reported evidence of progressive radio failure in flight, the condition of the battery and the selection of the emergency landing gear release were consistent with there having been a loss of electrical power. The position of the flaps appeared to contradict this as they can only be operated electrically but nevertheless the wreckage was examined for any evidence which might be associated with a loss of electrical power.

The TB20 aircraft has an electrical system which is conventional in most respects. A 'Main Switch', operates a battery relay which connects the battery to the aircraft's systems, and an 'Alternator Switch' controls alternator field current. These switches, and the switches operating the aircraft's main electrical services, are each operated by two push-buttons; one button which is pushed for 'ON' and one which is pushed for 'OFF'. The 'OFF' buttons on the Main and Alternator switches are each protected from inadvertent operation by a collar around the button. The protected switches, and in particular the Alternator switch, had been damaged and torn from their locations and their pre-crash condition and their susceptability to inadvertant operation could not be assessed. If the Alternator Switch is intentionally or inadvertently switched off or if power from the alternator is interrupted by some defect then electrical power is drawn solely from the battery. It is required that, should the alternator not be producing power, then the battery must be able to supply the aircraft's electrical requirements for more than 30 minutes.

The switches described above also act as circuit breakers and there is also an array of conventional circuit breakers. In G-MIMI none of these switches or circuit-breakers could be considered to give, from their post-crash condition, a reliable indication of their pre-crash position. The aircraft's electrical wiring and connections were examined with particular attention being paid to the battery and alternator circuits. None of the wiring showed any sign of electrical distress, all the mechanical damage seen was consistent with accident damage. There was no evidence of there having been any pre-existing disconnections in the wiring system.

Although the alternator's mountings and pulleys had been damaged in the impact the drive belt was intact and the belt tension adjuster nut was found to be secure and tight. The alternator could not be run because of impact damage but it was dismantled and its individual components examined. No pre-existing defect was found in the alternator's component parts. The voltage regulator, which controlled the output from the alternator, had also suffered damage in the crash and on one circuit board a few individual components had been damaged. These were replaced and when the regulator was retested it was found to be servicable.

The aircraft was fitted with a low voltage detection system. This was designed to detect a reduction in voltage from the 14 volts supplied by the alternator to the 12 volts supplied by the battery. Thus, if the alternator stopped supplying power the circuit voltage would reduce to battery voltage and a light on the instrument panel would illuminate. The Civil Aviation Authority has particular requirements for the design of such low voltage warning systems (Airworthiness Notice No 88) and often foreign manufactured light aircraft which are imported into Great Britain have to be modified to the British standard. (G-MIMI, manufactured in France, had originally been exported to the USA but it was resold in 1989 and imported into the UK.) The low voltage detector in G-MIMI did conform to the British standard in that the system was designed to detect a drop in voltage at an aircraft busbar and was not simply an alternator failure detector. However, the warning light was amber in colour and not red as specified. The low voltage detector unit had been damaged in the accident but each of its individual electronic components was checked and found to function correctly.

The bulb from the low voltage warning light was recovered for examination. The glass envelope of the bulb had been broken but fragments of the filament were still present and it could be seen that some of the tightly coiled filament had been stretched. This can be evidence that the filament was hot, that is that the bulb was illuminated, at a time when it was subjected to high loads such as occur in a crash. The filament was examined by a metallurgist using a scanning electron microscope. He found that one of the filament's broken ends exhibited a high degree of ductile distortion in its fracture which, again, is an indication that the filament had been hot when it was broken. In a spectral analysis of the filament material he found indications of oxygen which imply that the tungsten filament had suffered some oxidisation, presumably because it was hot when the glass envelope of the bulb was broken and it came into contact with atmospheric oxygen. The evidence of bulb illumination, implying that a low voltage condition was being signalled to the pilot, must be treated with some caution as the bulb is at the supply voltage and only requires to be earthed to illuminate. It is at least a possibility that, given the damage suffered by the electrical wiring in the crash, a short circuit to earth could have briefly energised the bulb during the impact. Even though the battery was effectively discharged there could still have been sufficient charge in it to provide current to the low voltage warning bulb depending on what other demands were being made on it. If the bulb was energised during the flight then, once the battery became depleted, its state of illumination may have varied depending on the demands made on the electrical system. It was not possible to determine what other systems were switched on and demanding current at the time of impact. A number of radio and navigational sets appeared to have been switched on but, whatever their individual switch positions, they could have been switched off through the radio master switch. The radio master switch was in the 'OFF' position though this evidence cannot be considered reliable.

The deployed position of the electrically driven flaps appears anomalous given the evidence of electrical power loss. The operation of radio units is highly dependent on the correct voltage and current supply being available. It may be that even after the breakdown of proper radio operation, if the radios had then been switched off, then it might have been possible to operate the flap motor.

The landing gear electro-hydraulic powerpack was considered as a possible source of excessive in-flight current drain. Although the nose gear had been disrupted in the crash the main gear and the powerpack were undamaged and, with the nose gear pipework blanked off, it was found possible to operate the powerpack and retract the main gear; the pressure switch in the up-line correctly switched the powerpack off when the gear had retracted and hydraulic pressure successfully maintained the gear in the retracted position. Thus, though the nose gear was ommitted from this test, there was no sign that the powerpack may have been running excessively to keep the gear retracted.

Although the propeller showed some evidence of rotation and power, because of witness evidence which suggested that there was an absence of engine noise just before impact, the engine was stripped and examined. No pre-impact mechanical failure or deficiency was found in the engine, its fuel injector lines contained fuel and the injector system was successfully tested on a rig.

All three seat belts had suffered failures in the crash at their attachments to the aircraft structure. The lap and diagonal belts of the front seat occupants had each failed at the inboard anchor points of the lap belts where the harness bracket attached to structure adjacent to the wing mainspar and at the guide built into the fibreglass cockpit canopy frame which supported the diagonal belt above the shoulder of each occupant. The failures of the three rivets which secured each lap belt bracket had been predominatingly in tension. The fibreglass canopy frame had disintegrated, liberating the diagonal belt support attachments. The rear seat occupant's lap belt had become detached at its outboard end through failure of the local sheet aluminium structure. The Socata TB20 aircraft was certificated to American requirements which are accepted by the Civil Aviation Authority as being generally equivalent to British requirements. The requirements are framed in terms of a static load representing the deceleration that the seat belts should be able to sustain in restraining an occupant of 170 lb weight. A deceleration of 1g is equivalent to the normal force of gravity on the occupant. The requirements specify a minimum capability for the belts of 9g in the fore and aft direction and 3g vertically. For the TB20 compliance with the requirements was demonstrated by stress analysis. It was calculated, very approximately, that the average longitudinal deceleration during this impact would have been 48g.