Cessna 172, G-TOME, 25 January 2001 at approximately 1300 hrs

AAIB Bulletin No: 8/2001 Ref: EW/G2001/01/17 Category: 1.3

Aircraft Type and Registration:	Cessna 172, G-TOME
No & Type of Engines:	1 IO-360-L2A piston engine
Year of Manufacture:	2000
Date & Time (UTC):	25 January 2001 at approximately 1300 hrs
Location:	10 nm South of Braemar, Grampian, Scotland
Type of Flight:	Private
Persons on Board:	Crew - 2 - Passengers - 2
Injuries:	Crew - 2 - Passengers - None (1 Serious) - (1 Minor)
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	53 years
Commander's Flying Experience:	78 hours (of which 40 were on type) Last 90 days - 12 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and other information gathered by the AAIB

History of the flight

The pilot intended to fly from Peterborough (Conington) to Inverness. The planned route was via the VOR/DME navigation beacons at Ottringham and St Abbs and then direct to Inverness. Prior to the flight the pilot obtained the relevant meteorological information. This included appropriate terminal area forecasts, current aerodrome reports and the area forecast for the Scottish region. He determined that, apart from a few areas of poor weather in Scotland, the forecast conditions were good. The serviceable aircraft departed Peterborough airfield at 1029 hrs and the flight proceeded uneventfully.

The handling pilot recognised that he did not have a great deal of experience and when conducting lengthy flights he usually arranged to be accompanied by a more experienced pilot. On this

occasion the pilot in the right hand seat held a FAA Airline Transport Pilots Licence and had a total of 4,475 hrs of which 200 hours were on Cessna 172 types.

Once north of Dundee, whilst at FL 50, the crew contacted the Scottish Area Traffic Control Centre (ScATCC) at 1248 hrs and requested a Flight Information Service (FIS). When approximately 50 nm from Inverness the aircraft entered cloud and immediately began to accumulate ice. The pilot described the build up of ice on the leading edges of the wings as considerable and extremely rapid. (The Cessna 172 has no de-ice or anti-ice capability and is not approved for flight in icing conditions). The accompanying pilot, in the front right seat, requested from ATC the meteorological conditions at Inverness. These were reported as 'VFR with scattered clouds at 2,800 feet'. At 1256 hrs the crew requested FL 60 in an attempt to climb above the cloud. Since this placed the aircraft above the airspace monitored by the FIS officer he asked the crew to call Lossiemouth Radar on 119·35 MHz.

The aircraft initiated the climb to FL 60 but remained in cloud. The rate of accumulation of ice increased and the airspeed reduced until the aircraft was unable to maintain the climb. The pilot then requested a descent to FL 45, which he had calculated to be the minimum safe altitude in that area. During the descent the aircraft encountered severe turbulence and pronounced down draughts while ice continued to accumulate on the aircraft. Even with full power selected the airspeed reduced and the pilot had difficulty in controlling the aircraft; he described the controls as 'sluggish and appearing to freeze from time to time'. He then briefly saw snow capped hills below and decided that he should attempt to land before the aircraft stalled. The aircraft struck the ground at an altitude of 2,690 feet. On contact with the ground the aircraft broke up, but all on board managed to extricate themselves from the wreckage. The front seat occupants received minor injuries, which included a broken wrist and chest pains; the rear seat occupants were virtually uninjured.

Search and Rescue

The Lower Airspace Radar Service (LARS) controller at RAF Lossiemouth received a transmission, addressed to Scottish Information, from an unknown aircraft. The transmission mentioned cloud layers and descent but was otherwise unintelligible. The aircraft called again but the only elements of this transmission that were decipherable were the call sign and 'FL50'. The aircraft was given a transponder setting but there was no response. The controller made further attempts to contact the aircraft without success and contacted ScATCC to establish whether they were in radio contact with the aircraft. Given the nature of the distorted radio calls, the terrain where he believed the aircraft to be, and the lack of radar return, the controller notified his supervisor; this was at approximately 1310 hrs.

The supervisor at RAF Lossiemouth checked with local ATC agencies and ascertained that neither Inverness, Aberdeen nor ScATCC were in contact with the G-TOME. The brief traces from the radio direction finder indicated that the aircraft was to the south of Lossiemouth and a local aircraft was asked to act as an airborne relay but without success. Another aircraft, in transit, was asked to attempt to contact G-TOME on the emergency RT frequency of 121·5 MHz, again without success. However, this aircraft did report an emergency locator transmission (ELT) in the area of Ben Rinnes (5732N 00314·8W). The supervisor at RAF Lossiemouth had informed the Distress and Diversion cell at ScATCC of the situation and the Aeronautical Rescue Co-ordination Centre (ARCC) commenced operations at 1328 hrs. The ARCC asked two Tornado aircraft, operating nearby, to assist. These aircraft confirmed the previously reported position of the ELT near Ben Rinnes but they then had to recover to Lossiemouth. A Nimrod aircraft in the circuit at RAF

Kinloss was then tasked and it located a strong ELT in the area of Lochnagar (5654N 00317·7W) at 1413 hrs.

It should be noted that neither the aircraft in transit nor the Tornado aircraft were fitted with direction finding equipment and their reported location of the ELT was based upon the point at which the ELT reception was at it loudest. The Nimrod aircraft, however, was fitted with the appropriate equipment and was able to provide an accurate location. There were no further reports of an ELT in the area of Ben Rinnes.

Meanwhile the ELT to the south of Lochnagar had also been identified by the Cospas-Sarsat system at 1343 hrs. A further ELT was also reported in the Dalwhinnie area (5651N 004·20W) about 30 nm to the west of Lochnagar. It is unclear who reported this final ELT location and, although a mountain rescue team (MRT) was deployed to this location, nothing was found.

At this stage there were thus three ELTs reported from separate locations although the ELT at Ben Rinnes was quickly discarded from the possible search scenario. A Sea King helicopter, based at Prestwick, was tasked and was airborne at 1345 hrs. Whilst in transit it was directed to the ELT reported in the Dalwhinnie area. At 1404 hrs a Sea King helicopter lifted off from RAF Lossiemouth and was subsequently directed to the Lochnagar area. At 1413 hrs a further Sea King, from RAF Boulmer, joined the search and was also directed to the Lochnagar area. The MRTs from RAF Kinloss, RAF Leuchars, Braemar and Cairgorms were also deployed.

A replay of the Aberdeen radar system indicated that radar contact with the aircraft had been lost at 1259 hrs. At this time it was on the 155° radial from Inverness at a range of 44·8 nm.

The first helicopter crew, directed to the Lochnagar area, noted that the signals from the ELT were of a random nature in the mountainous terrain and reported that the co-ordinates provided by the Nimrod were of significant value. When, at 1510 hrs, they reached the nominated position the crew quickly located four walkers in a snow gully. The helicopter crew concluded from the lack of equipment and inadequate clothing that the walkers were probably from the missing aircraft. However, the helicopter was unable to land in the prevailing conditions of severe down draughts and low cloud. They remained on scene until the Sea King from RAF Boulmer, arrived at 1551 hrs with elements of an MRT on board. This helicopter was able to land the MRT close to the walkers during a calm period and it was quickly ascertained that they were indeed the survivors from the crashed Cessna. All of the survivors were then taken by helicopter to the hospital at Aberdeen where they were diagnosed as suffering from mild hypothermia.

Meteorological conditions

The synoptic situation at 1200 hrs on 25 January 2001 showed a low pressure system to the west of Scotland with a moderate to strong, unstable, southwesterly airstream covering much of the UK. There were numerous showers mainly over western Scotland.

The point at which the accident occurred was adjacent to the boundary between two zones which had markedly different conditions forecast. To the west of a line from Cape Wrath to Perth the forecast conditions were:

Generally: 20 km visibility with nil weather,

cloud 3-6 octas cumulus base 2000 feet, tops 8,000 feet

3-6 octas alto cumulus base 9,000, tops 15,000 feet

Widespread: 7 km visibility in rain showers,

cloud 7 octas cumulus base 1,500 feet, tops 15,000 feet

Occasional: 3,000 metres in thunderstorms with hail,

cloud 7 octas cumulonimbus base 1,200 feet, tops 27,,000 feet

Warnings: Cloud on hills, moderate icing and moderate turbulence in cloud.

Severe turbulence south and east of the low below 6,000 feet

To the east of this line, which included the route for the planned flight, the forecast conditions were:

Generally: 25 km visibility with nil weather,

cloud 4 octas cumulus base 2,500 feet, tops 6,000 feet

Isolated: 8 km visibility in rain showers,

cloud 7 octas cumulus base 2,000 feet, tops 15,000 feet

Warnings: Cloud on hills, moderate icing and moderate turbulence in cloud.

Moderate turbulence over land to the north west, below 6,000 feet

An aftercast, provided by the Meteorological Office, indicated that the following conditions prevailed at the accident site:

Altitude (ft)	Wind velocity	Temperature (°C)	Dewpoint (°C)	Relative Humidity
2,000	210° / 40 kt	- 01	- 03	75%
4,000	210° / 45 kt	- 04	- 04	98%
5,000	220° / 45 kt	- 06	- 06	98%

The aftercast indicated that the cloud was 6 octas cumulus and stratocumulus base 3,000 feet, tops 10,000 feet. It is highly likely that moderate turbulence and icing occurred in the cloud.

The pilot of the first search and rescue (SAR) helicopter to arrive at the site described the meteorological conditions as follows:

'The weather on scene was a nearly solid cloud base at around 3,000 feet, with snow / sleet showers and a southerly wind of approximately 50 kt at 3,000 feet. We experienced moderate to severe

turbulence and down draughts. These down draughts were such that, on occasions, we were unable to maintain altitude using normal power constraints. As an experienced mountain flier in helicopters of 10 tonnes I would have been very wary of crossing the hills below a significant altitude and we experienced very uncomfortable conditions that delayed us reaching the survivors after the initial sighting. The Sea King has a limited icing capability and therefore we remained clear of the cloud'

Emergency Locator Transmitters

G-TOME had been manufactured in the USA and was fitted with an emergency locator transmitter (ELT). Prior to operation within the UK the CAA require proof that such equipment will not interfere with other aircraft systems. The CAA holds an extensive list of compliant ELTs which can then remain in the aircraft; if the ELT is not an approved model then it should be removed. This particular ELT, which was compliant with CAA requirements, only transmitted on 121.5 and 243 MHz.

Radio distress beacons designed to assist SAR operations fall into three broad categories, each being named according to its main use. ELTs are aviation beacons, generally fitted to aircraft; emergency position indicating radio beacons (EPIRBs) are maritime beacons fitted to vessels and personal locator beacons (PLBs) are generally intended for land use although they may also be carried on a person, both at sea and in the air.

These beacons are compatible with the Cospas-Sarsat system, an international organisation that uses satellites to detect active distress beacons operating on the frequency of 121.5MHz and/or within the 406.0 to 406.1 MHz band. Some satellites also detect beacons operating on the NATO distress frequency of 243.0 MHz. Beacons operating on 121.5 and 243 MHz transmit a modulated carrier wave that, apart from being able to be detected by satellite, can be heard by any aircraft listening out on the emergency frequencies and also can be homed onto by SAR aircraft using their direction finding equipment. The characteristics of a 406 MHz beacon are very different from those using 121.5 and/or 243 MHz. These beacons transmit only for half a second every 50 seconds, their signal being a pulse of data containing information unique to that beacon such as a country code, whether it is a maritime or aviation beacon or a PLB and a unique identifier. 406 MHz beacons should be registered on a database held in the country as coded, together with such information as beacon owner, the vessel or aircraft carrying the beacon and a 24-hour point of contact. The information provided by these newer beacons is of great value to SAR agencies in expediting a rescue or in eliminating unnecessary action in the event of a false alarm.

The satellites process the beacon signals and downlink resultant data to ground stations where it is further processed and refined before being forwarded on to a Mission Control Centre, part of a network that ensures that, wherever on the Earth's surface a beacon is detected, the distress alert data is provided quickly and free-of-charge to the rescue co-ordination centre (RCC) responsible for the region in which the alert lies. The system comprises both geostationary satellites and those in polar orbit. At the time of the accident to G-TOME there were 8 orbiting satellites that use Doppler to establish the location of a beacon. For frequencies of 121.5 and 243 MHz, the satellite must have both the beacon and a ground receiving station in view for the alert to be reported, thus there are regions of the world, mainly in the southern hemisphere, where alerts on these frequencies cannot be reported to any ground station. A satellite detecting a 406 MHz beacon, however, notes the time of beacon detection and, as it goes round in its orbit, downlinks this, together with all the information coded into the beacon to every ground station in the world. Thus, 406 MHz beacons should always be detected and reported whereas those on 121.5 and/or 243 MHz may not be,

especially in the Southern Hemisphere. One other factor, especially significant in the case of G-TOME, is that once Cospas-Sarsat has detected a 406 MHz beacon, any further detections can be linked to the original alert by the unique identifying information coded into the beacon signal, in the case of 121.5 and/or 243 MHz beacons, this will not be the case. The longer a 121.5 or 243 MHz beacon transmits, the more likely it is that the matching criteria employed by the system will produce a separate location for the same beacon. This is especially true in mountainous terrain and is the reason why several different locations were produced for the G-TOME ELT.

When an orbiting satellite first detects a beacon, it uses Doppler to calculate how far from itself the beacon is at the time of closest approach. It cannot however determine on which side of its track the beacon lies so, for every detection, two positions are reported - the real position and a mirror image, equidistant on the opposite side of the track. These two positions could be over 2,000 miles apart, posing a huge problem for RCCs. The Doppler ambiguity can be resolved by several means: reports from high-flying aircraft, there being a known incident in progress or by a second satellite pass. When another satellite detects the same beacon, two positions are again reported; one of these positions will match one of the positions from the first satellite but the other position will not match. The MCC then reports the resolved position to the RCC. Although a second pass usually occurs within an hour of the first pass, depending on the relative positions of the satellites to each other, it can sometimes take longer for the ambiguity to be resolved.

406 MHz beacons have two distinct advantages in relation to detection times. Firstly, and unlike the 121.5 and 243 MHz beacons, the 406 MHz beacon transmits data identifying the individual beacon and, via a database, a 24 hour point of contact (POC). Using this information it is often possible to quickly trace the source and status of the beacon by speaking to the POC. A geostationary (GEO) satellite, although without the benefit of using doppler, can often instantly detect the 406 MHz beacon transmission data and immediately forward it, via the Local User Terminal in Devon, to the UK Mission Control Centre at RAF Kinloss. Secondly, using the Low Earth Orbiting (LEO) satellites' doppler capability, it is usually possible, by virtue of the 406 MHz beacon's tighter frequency stability specification, to considerably reduce the location margin of error when compared with that of the 121.5 and 243 MHz beacons.

A summary of the positions of the ELT passed by the Cospas-Sarsat system, together with an associated probability, is provided below

Cospas-Sarsat positions

Time (hrs)	Position A	Probability	Position B	Probability
1343	N 56 34.9 W 003 32.2	98%	N 56 37.1 W 005 07.0	37%
1406	N 56 42.0 W 003 23.1	99%	N 56 54.0 W 003 15.3	73%
1519	N 56 42.1 W 003 23.1	99%	N56 52.9 W 003 16.4	50%

1525	N 5642.6 W 003 22.5	99%	N 56 35.6 W 003 03.2	01%
1630	N 5647.6 W 003 21.1	99%	N 56 50.7 W 003 21.8	55%

On 1 Feb 2009 the Cospas-Sarsat system will stop the satellite processing of the 121.5 and 243 MHz frequencies and will only detect beacon transmissions in the 406.0 to 406.1 MHz band. Homing equipment operating within that band is being obtained for fitment to SAR aircraft and helicopters. In any event, 406 MHz beacons invariably have a lower-powered auxiliary transmitter fitted. Operating on 121.5 MHz, the auxiliary transmitter enables SAR aircraft to conduct the final homing to a beacon once the aircraft has arrived at the beacon location reported by the satellite system.

Contribution of the location aids

The position of the ELT provided by the aircraft in transit, and apparently confirmed by the two Tornadoes, confused the unfolding scenario since none of these aircraft was suitably equipped to precisely locate the ELT. The experienced ARCC controllers quickly discarded this location. The 'ON TOP' location provided by the Nimrod aircraft was less than 1 nm from where the wreckage was located. This was the position passed as the initial location to the crew of the first rescue helicopter, directed to the area of Lochnagar, and they were then able to locate the survivors very quickly. The position of the last recorded radar return was approximately 2 nm from the wreckage and was thus also of considerable value to the ARCC. There is no record of how the ELT near Dalwhinnie was reported, however, in order to investigate this transmission elements of the available resources were necessarily diverted.

The aircraft disappeared from the radar screens at 1259 hrs and the first SARSAT response was at 1343 hrs. Its 'A' position, which carried a probability of 98%, was 23 nm to south of the wreckage. The next 3 positions passed by the 'A' channel were approximately 13 nm to the south and the final position was 8 nm distant. The 'B' channel was more erratic and this is reflected in the generally low levels of probability, however, the positions at 1406 hrs, 1519 hrs and 1630 hrs were all less than 10 nm from the accident site.

Survival

The LARS radar controller at RAF Lossiemouth provided initial notification of this accident. The subsequent ELT signals were used by the SARSAT system to provide an initial datum as well as alerting the ARCC. The Nimrod utilised the ELT signals to provide an accurate datum for the SAR helicopters and the crew of the Sea King from Lossiemouth, who were the first to sight the survivors, used signals from the beacon to provide a homing to the crash site. However, the signal became more confused as they flew amongst the high ground and they then relied heavily on the position passed by the Nimrod and this significantly assisted a positive homing to the beacon. The SAR helicopter carrying the MRT only heard the ELT signals once on scene; this was due to terrain screening on its approach to the area.

Without this location aid it is unlikely that the survivors would have been found since they had no other means of location such as flares or bright clothing. The weather conditions were harsh and the survivors, two of whom were injured, had no warm or protective clothing nor were any emergency rations available. They were first sighted at 1510 hrs as they attempted to walk off the hills into a snow gully; they were thus walking away from the beacon, which was their sole location aid. When rescued they were already suffering from mild hypothermia. Sunset that evening was at 1626 hrs after which the chance of locating the survivors would have been remote. They would then have been forced to spend the night on the hills in extreme conditions without appropriate clothing, protection or any location aids.