Australian Government
Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY INVESTIGATION REPORT
Aviation Occurrence Report – 200603140
Final

Fuel Starvation
2.4 km north-west Bathurst Island Aerodrome, NT
1 June 2006
VH-JDJ
Beech Aircraft Corp A36

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Figure 1. Melville Island Special Edition 1, SC52-16 Copyright © Commonwealth of Australia, Geoscience Australia (2000)

Abstract

On 1 June 2006, at about 0848 Central Standard Time, a Beech Aircraft Corp A36 Bonanza aircraft, registered VH-JDJ, was approaching to land at Bathurst Island aerodrome.

Air traffic services radar data recorded the aircraft overflying the aerodrome and that the pilot joined the circuit on left downwind for a landing on runway 15. The aircraft impacted terrain 2.4 km north-west of the aerodrome. The pilot, who was the sole occupant of the aircraft, sustained fatal injuries.

The aircraft was assessed as being intact prior to the impact with terrain and no anomaly was identified with the aircraft that could have affected its normal operation.

Data recovered from an onboard engine data recording system was consistent with an interruption of the fuel flow and the loss of engine power about 42 seconds before impact. The pilot may have been attempting to perform an emergency landing to a nearby clearing when control of the aircraft was lost.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an operationally independent multi-modal Bureau within the Australian Government Department of Transport and Regional Services. ATSB investigations are independent of regulatory, operator or other external bodies.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The ATSB performs its functions in accordance with the provisions of the Transport Safety Investigation Act 2003 and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to enhance safety. To reduce safety-related risk, ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated.

It is not the object of an investigation to determine blame or liability. However, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to proactively initiate safety action rather than release formal recommendations. However, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation, a recommendation may be issued either during or at the end of an investigation.

The ATSB has decided that when safety recommendations are issued, they will focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on the method of corrective action. As with equivalent overseas organisations, the ATSB has no power to implement its recommendations. It is a matter for the body to which an ATSB recommendation is directed (for example the relevant regulator in consultation with industry) to assess the costs and benefits of any particular means of addressing a safety issue.

About ATSB investigation reports

How investigation reports are organised and definitions of terms used in ATSB reports, such as safety factor, contributing safety factor and safety issue, are provided on the ATSB web site www.atsb.gov.au.

FACTUAL INFORMATION

History of the flight

On 1 June 2006, at about 0701 Central Standard Time[1,2], a Beech Aircraft Corp. A36 Bonanza (Bonanza) aircraft, registered VH-JDJ, departed Kununurra, WA on a private category visual flight rules (VFR) flight to Bathurst Island, NT. The flight was one in a series of flights conducted by the pilot, for the purpose of visiting clients in regional and remote areas of the country. The pilot was the sole aircraft occupant.

At about 0900, the pilot of an aircraft overflying Bathurst Island advised air traffic services (ATS) of the detection of a 121.5 MHz radio distress beacon. At 0912, a Cospas-Sarsat[3] satellite download to an Australian Search and Rescue (AusSAR[4]) local user terminal, confirmed the activation of a radio distress beacon in the vicinity of Bathurst Island.

The Rescue Coordination Centre at AusSAR coordinated the search for the source of the distress beacon. At approximately 1100, a search aircraft located the wreckage of the Bonanza, about 2.4 km north-west of the Bathurst Island aerodrome, in scrub-type terrain that was moderately populated with trees approximately 10 to 25 m in height. The aircraft wreckage was located slightly left of the extended runway 15 centreline, about 1,200 m north-west of the runway threshold.

At about 1220, a rescue helicopter, with medical personnel on board, landed in a nearby clearing and found that the pilot had succumbed to injuries sustained in the accident.

Examination of recorded radar data

A review of the recorded ATS radar data for the day of the accident identified a VFR aircraft on the direct track between Kununurra and Bathurst Island at an altitude of 5,500 ft[5] above mean sea level. At 0834, when about 30 NM from Bathurst Island, the aircraft commenced a descent from cruise altitude and arrived overhead the aerodrome at 0846, at an altitude of 1,400 ft. That was about 1 hour 45

1 The 24-hour clock is used in this report to describe the local time of day, Central Standard Time (CST), as particular events occurred. Central Standard Time was Coordinated Universal Time (UTC) + 9.5 hours. To simplify the tracking of relevant events as they occurred on the day of the occurrence, all times have been converted to Central Standard Time.

2 First light at Kununurra on 1 June was 0652 (0522 Western Standard Time).

3 Cospas-Sarsat is the international, satellite-based system used in support of the search and rescue of persons in distress.

4 In general terms, AusSAR coordinates the response to aviation SAR incidents across Australia.

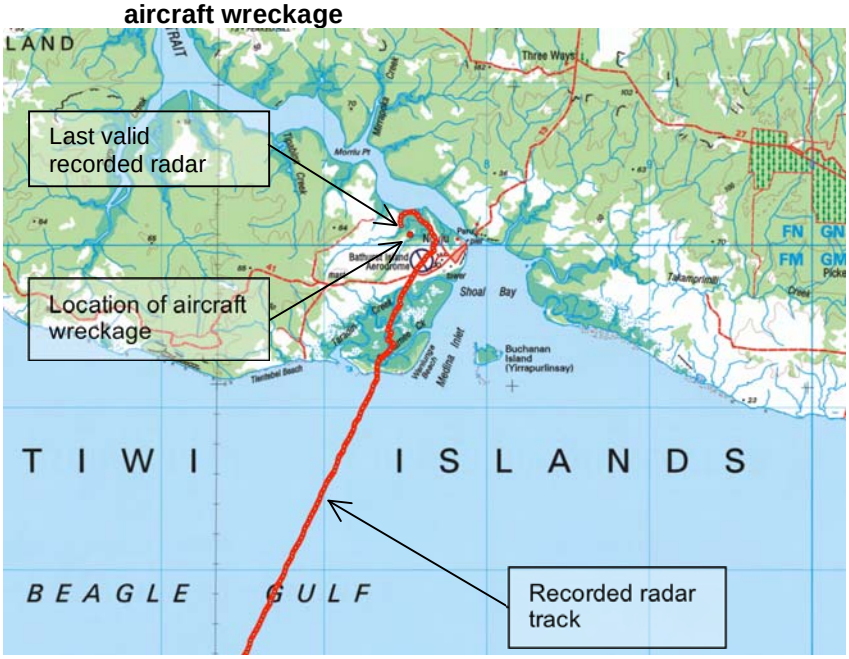
5 Altitude information is encoded by the aircraft's radar transponder to the nearest 100 ft.

minutes after the Bonanza departed Kununurra.[6] The recorded radar track was consistent with the VFR aircraft joining the circuit mid-left downwind for a landing on runway 15.

The aircraft continued downwind and recommenced its descent from 1,000 ft just prior to turning onto the base leg of the circuit. The aircraft then turned onto a long final approach for runway 15. The last valid radar return was at 0848, at an altitude of 600 ft.

Figure 1 depicts the aircraft's recorded radar position during the final stages of the flight.

Figure 1: Bathurst Island aerodrome, recorded radar track and location of aircraft wreckage



Pilot information

Type of licence	Private Pilot (Aeroplane) Licence (PPL), issued July 2002
Flying experience	539 hours
Flying experience – in VH-JDJ	440.9 hours
Flying experience (preceding 30 days)	39 hours
Medical certificate	Class 2[7], valid to 09 June 2007 and issued without restriction

There was no evidence in the pilot's logbook to indicate the completion of any aeroplane flight reviews (AFR) or aircraft proficiency checks in accordance with Civil Aviation Regulation (CAR) 5.81 since the issue of his PPL. In addition, a review of records maintained by the Civil Aviation Safety Authority (CASA) did

6 The distance between Kununurra and Bathurst Island was 265 NM. The average groundspeed over that sector was 151 kts, and close to the flight planned performance for the Bonanza of 150 kts.

7 A Class 2 medical standard is the relevant medical standard for the holder of a PPL.

not record the conduct by the pilot of a flight test or any conversion training since that time.[8]

During January 2005, the pilot's logbook recorded a 1.6-hour return flight from Maroochydore to Gympie, Qld, during which he was accompanied by a flying instructor. That instructor's logbook recorded the flight as an AFR. However, the instructor did not have any specific recollection regarding the conduct of that flight. The instructor reported that he would most likely remember if aspects of the flight were unusual, if there had been the need for significant post-flight discussion with the pilot, or if there had been a requirement for significant remedial training. A review of the records maintained by the flying school operator could not locate any other record relating to an AFR being conducted with the pilot during January 2005.

Despite the lack of the relevant entry in the pilot's logbook to certify completion of the AFR, the pilot's continued operation of the Bonanza after that date was consistent with the pilot believing that he had satisfied the requirements of CAR 5.81.

The pilot spoke to his partner prior to departing Kununurra on the morning of the occurrence. Telephone records indicated that that call was made at 0636. He was reported to be in good spirits, and was at the airport waiting for daylight before departing for Bathurst Island.

The pilot was reported to normally telephone his partner each evening and, on an 'as required' basis, to telephone his office staff for business purposes. During recent telephone conversations, the pilot had not recounted any problems with the aircraft, or with his flying.

Records from the pilot's accommodation in Kununurra indicated that he dined in the restaurant the evening prior to the occurrence and settled his accommodation account at 2140 that night.

A printout of flight briefing data for the day of the occurrence indicated that the pilot accessed the computer-based flight planning system at 0601 that morning. The investigation concluded that the pilot had an available rest period of 8 hours 21 minutes.

Aircraft information

Engine

An examination of the aircraft's maintenance records indicated that the aircraft's Continental IO-520 engine had operated 62 hours since overhaul.

The aircraft was equipped with an engine data monitoring system (EDM) that monitored various parameters that were associated with the engine's operation,

8 CAR 5.81 required the holder of a PPL to complete, with an approved person, an AFR, an aircraft proficiency check, a flight test or aeroplane conversion training at intervals not exceeding 2 years. It was a requirement for the approved person to certify the successful completion of an AFR or of an aircraft proficiency check in the pilot's logbook. An approved person was a flight instructor holding authorisation to conduct flight reviews, an approved testing officer or a CASA flying operations inspector.

including cylinder head temperature (CHT) for each of the engine's six cylinders, exhaust gas temperature (EGT) for each cylinder exhaust, the fuel flow to the engine, and the aircraft's battery voltage. That instrument presented information to the pilot via a cockpit display that also incorporated a non-volatile memory (NVM).

The EDM was recovered from the accident site for technical examination.

Fuel system

The aircraft was equipped with main and auxiliary fuel tanks. The auxiliary tanks were optional accessory equipment and were installed in accordance with a Supplemental Type Certificate (STC) following aircraft manufacture. The main fuel tanks were located in each wing and each had a capacity of 140 L useable fuel. The auxiliary tanks were located on the tip of each wing and each had a capacity of 75 L. The aircraft's total useable fuel was 432 L.

The STC stipulated that the tip tanks were for use only during level flight. They were not equipped with boost or auxiliary pumps, instead providing fuel to the fuel selector under the effect of gravity.[9]

The cockpit fuel selector had 5 positions for selection by the pilot: OFF, L. MAIN, R. MAIN, R. TIP and L. TIP. The tip tanks were also equipped with a tank cross feed and an ON/OFF cross-feed selector. The number of possible fuel tank selections increased the task complexity for a pilot to manage the in-flight consumption of fuel.

Two separate cockpit fuel quantity gauges indicated the contents of the left and right main tanks. A third fuel gauge indicated the quantity of fuel in the aircraft's tip tanks. A switch located beside that gauge allowed the pilot to select which tip tank contents was being indicated.

The aircraft's maintenance documentation indicated that the aircraft's fuel quantity indicating system was last calibrated in November 2002.

An additional STC was available to further modify the aircraft fuel system and to simplify the management of the increased-capacity fuel system. In that system, each tip tank transferred fuel into its respective main tank, without the pilot having to separately manage tip tank selections during the flight.

The additional fuel system STC was not incorporated in the Bonanza.

Stall warning

The aircraft was equipped with an aural stall warning system. As the aircraft approached the aerodynamic stall, the stall warning horn would activate. The wing-mounted stall warning actuator was examined and found to be capable of normal operation.

9 If air entered the fuel line, then the supply of fuel to the fuel selector would be unreliable.

Weight and centre of gravity

The investigation estimated that, at the time of the occurrence, the aircraft's operating weight was about 1,420 kg and the centre of gravity was within the stipulated limits.

Meteorological information

The weather conditions along the route were forecast to be fine, with some areas of smoke/haze and light and variable winds.

The aerodrome forecast valid for the pilot's arrival at Bathurst Island indicated a south-easterly wind at 12 kts, visibility better than 10 km, no forecast cloud below 5,000 ft and no significant weather in the vicinity of the aerodrome. The forecast temperature at the time of the accident was about 20° C.

Communications

Broadcasts made on the Kununurra aerodrome frequency were recorded in order for the aerodrome operator to record aircraft movements. An examination of that recording showed that the pilot broadcast his departure from Kununurra at 0701, and indicated he was tracking to Bathurst Island, on climb to 5,500 ft.

Pilots' radio transmissions on the aerodrome frequency at Bathurst Island were not recorded, and that frequency was not monitored by ATS. However, two-way communication was possible with Brisbane ATS from within the circuit area at Bathurst Island. There was no indication that the pilot had attempted to contact Brisbane ATS to advise of an emergency or other abnormal operation.

A review of the relevant radar data indicated that another aircraft crossed the coast of Bathurst Island about 4 minutes after the last recorded radar contact with the Bonanza. The pilot of the other aircraft did not recall hearing any radio transmissions of any kind from an aircraft operating at Bathurst Island.

Wreckage information

Overview of wreckage

Examination of the aircraft's wreckage indicated the aircraft impacted the ground in a left wing-low, steep nose-down attitude. Although the aircraft remained substantially intact, it sustained significant damage due to impact forces (Figure 2). There was no post-impact fire.

The aircraft collided with the upper tree canopy during the final stages of the descent. Fragments from the outboard portion of the right wing and the right wingtip fuel tank were found along the wreckage trail and had detached from the aircraft during the contact with the trees. Damage to the foliage was consistent with the aircraft descending steeply as it approached the ground.

The aircraft travelled approximately 30 m from the point of first tree contact along a track of about 100 degrees magnetic. The aircraft came to rest within 5 m of the point of the initial ground impact.

Figure 2: Accident site and surrounds

A small clearing that may have been suitable as an emergency landing area was located a short distance beyond the aircraft wreckage and along the final flight path as evidenced by the wreckage trail.

There was no evidence of a bird strike or of a collision with any other object prior to the impact sequence. All damage to the aircraft was assessed as being impact-related.

Wreckage examination

All aircraft components were accounted for at the accident site, and the aircraft was assessed as being intact prior to the impact with the tree canopy. The landing gear was in the extended position, with the nose and left main gear collapsing during the impact sequence.

Continuity of the flight controls was established and the wing flaps were retracted (up position) at the time of impact.

The propeller sustained relatively minor damage and the propeller hub was intact. A sapling that was cut by a propeller blade indicated that the propeller was rotating immediately prior to the impact with the terrain. The engine was recovered from the accident site for technical examination.

During the impact sequence, the right tip tank detached from the right wing. Although the tank was intact, it did not contain a significant quantity of fuel. The left tip tank remained attached to the left wing. Although that tank sustained impact damage, it remained substantially intact and did not contain a significant quantity of fuel.

The left main tank was intact. Approximately 65 L of fuel was recovered from that tank, and a sample was retained for testing. The right main tank was breached along the leading edge of the wing, and the fuel line from that tank sustained impact-related damage and was fractured in the vicinity of the wing root. Hydraulic damage to the lower wing skin was consistent with the tank containing a substantial quantity of fuel at the time of impact. It was reported that, during the subsequent salvage of aircraft components, a quantity of about 20 L of fuel drained from the right main tank.

All of the fuel tank caps were secure, and there was no evidence that any fuel was lost overboard during the flight.

The aircraft fuel selector was in the R. TIP position (Figure 3), and there was no evidence that the selector had moved as a consequence of impact forces. The cross-feed selector for the tip tanks was in the OFF position. The switch for the tip tank fuel gauge was positioned to indicate the contents of the left tip tank.

Figure 3: Aircraft fuel tank selector

The cockpit switch for the electrically-operated auxiliary fuel pump was in the OFF position. That switch was installed between the throttle and propeller RPM controls, and there was no evidence that the switch was knocked during the impact sequence.

A number of components from the aircraft's fuel system were recovered for examination/testing. Those components included the cockpit fuel selector and selector valve, the cockpit fuel quantity gauges, and the fuel tanks' floats and sender units.

An examination of the aircraft cabin indicated that the pilot had his lap belt and shoulder harness fastened at the time of the accident.

Examination of components recovered from the wreckage

Engine

Technical examination of the engine found no evidence of the catastrophic failure of any of the engine's components. 'Glazing'[10] of each of the cylinders indicated potential anomalies with the engine break-in procedure, although that was not significant for the operation of the engine during the occurrence flight.

The engine's ignition system was tested and found to be capable of normal operation. The fuel control unit functioned normally when tested, and each cylinder's fuel injection nozzle was clear of any obstruction and capable of normal operation.

The engine-driven and auxiliary fuel pumps were tested and found capable of normal operation.

Fuel system

The cockpit fuel selector, selector valve, cockpit fuel quantity gauges and sender units for the main fuel tanks, and the sender unit for the left tip tank, all functioned normally when tested. Anomalies were detected with the sender unit from the right tip tank, which could contribute to inaccurate or intermittent readings. There was evidence of a previous attempt to repair the sender unit from the right tip tank. However, those repairs had been ineffective. The aircraft logbooks did not record any repair to that unit.

The fuel sample that was recovered from the aircraft's fuel tank was tested by a National Association of Testing Authority-approved laboratory. That test showed that the fuel complied with the relevant standards for aviation gasoline. Although there were some particulates detected in the sample, those were not assessed as significant for engine operation.

Medical and survival aspects

Medical and pathological information

Post-mortem examination of the pilot did not reveal any evidence of pilot incapacitation prior to the accident. Although some narrowing of the pilot's coronary arteries was identified, there was no evidence of any associated problems that might have affected the pilot's performance.

Toxicology testing did not detect the presence of any medication, drugs or alcohol. That testing did not include for the presence of carbon monoxide.

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10 Glazing describes a varnish-like veneer adhering to the honed surface on the inside of the combustion chamber. It consists of oxidised oil residue and for a newly overhauled engine, is typically caused when insufficient combustion pressures are generated inside the chamber during the initial period of engine operation.

Survival information

Personnel first arriving at the accident site located the pilot adjacent to the rear cabin doors on the right side of the aircraft. It was apparent that the pilot had survived the initial impact and extracted himself from the cockpit, before succumbing to his injuries.

Specialist medical advice indicated that injuries such as those sustained by the pilot were immediately life-threatening. In addition, urgent medical treatment would have been required if the casualty's medical condition was to not rapidly deteriorate.

The pilot's personal effects on board the aircraft included a mobile telephone and a satellite telephone. However, there was no evidence to indicate that, following the accident, he attempted to use either of those telephones.

Operational information

Refuelling records

Refuelling records indicated that the aircraft's last refuel was at Halls Creek on 30 May 2006, where a swipe card was used to purchase 268 L of aviation gasoline from the airfield fuel bowser. A number of other aircraft had also refuelled from the same fuel source that day. There were no reports from the pilots of those aircraft of any fuel-related problems.

Fuel consumption data recorded by the EDM system indicated that a total of 216 L of fuel was used since the aircraft was refuelled at Halls Creek. The aircraft's fuel consumption as recorded by the EDM system during recent flights was compared with the quantity of fuel added during refuelling. That comparison validated the accuracy of the data recorded by the EDM.

The analysis of fuel records and recorded EDM data were consistent with the aircraft being fully-fuelled at Halls Creek. The investigation estimated that, at the time of the accident, about 216 L of useable fuel remained on board the aircraft.

Fuel and flight management

Fuel management

Flight documents recovered at the accident site included a flight plan for the route sectors Kununurra to Bathurst Island to Darwin. Hand-written annotations on that document were consistent with the pilot's use of the wingtip fuel tanks during the occurrence flight, and indicated the following fuel management by the pilot:

- Left tip tank selected at 0710, with the pilot planning to again change tanks at 0755 (ie 45 minutes planned burn from left tip tank). Analysis of the recorded EDM data indicated that the left tip tank was selected after the fuel flow reduced to the cruise setting. That was consistent with the aircraft having reached the planned cruising altitude, and the mixture being leaned by the pilot.
- Left tip tank deselected at 0757 and selection of the right tip tank.

- The pilot planned to deselect the right tip tank at 0830 (ie 33 minutes planned burn from the right tip tank).
- There was no record of the deselection of the right tip tank, or of the selection of either main fuel tank.

An analysis of the recorded EDM data indicated that the engine used about 42 L during the selection of the left tip tank, and about 45 L between the time the right tip tank was selected and the end of the recorded EDM data. Although the capacity of each tip tank was 75 L, the engine-driven fuel pump drew fuel from the selected tank at a rate significantly higher than was being consumed by the engine. Excess fuel, drawn from the tip tanks but not used by the engine, was returned to the left main fuel tank.

The EDM recorded a total fuel consumption during the occurrence flight of 107 L.

Flight management

Although an Australian Domestic Flight Notification form was recovered at the accident site, a review of CENSAR[11] and NAIPS[12] records indicated that neither a flight notification nor SARTIME[13] was submitted for the occurrence flight. In addition, there was no evidence that the pilot had left a Flight Note with a responsible person.[14]

Performance information

Data contained in the aircraft manufacturer's Airplane Flight Manual (AFM) indicated that the airspeed to achieve maximum range glide was 110 kts (at 1,633 kg), and that the aircraft glide distance was about 1.7 NM (3.2 km) per 1,000 ft of height above terrain.[15]

The wings-level, nil flap stall speed published in the AFM, for an operating weight of 1,420 kg, was 59 kts indicated airspeed.

Checklists

The tip tank modification was not part of the aircraft's standard equipment and, accordingly, the aircraft manufacturer's AFM did not include a check of the fuel tank selection prior to commencing descent. However, the STC for the modification

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11 An automated, centralised SARTIME database software package used by ATS to manage pilots' nominated SARTIMEs.

12 The National Aeronautical Information Processing System, which provides flight briefing and notification functions.

13 The time nominated by the pilot, for the initiation of SAR action if a report of safe arrival was not received.

14 A SARTIME or a Flight Note left with a responsible person was required for a number of different types of flight, including all flights over-water and flights conducted in Designated Remote Areas.

15 In nil wind, landing gear and wing flaps retracted, engine cowl flaps closed and the propeller in a coarse pitch setting.

of the tip tanks restricted their use to during level flight. In that case, although not specifically stipulated by the STC, the position of the fuel selector should have been checked by the pilot prior to commencing the descent.

The AFM contained a pre-landing checklist. That checklist required the pilot to select the fullest (main) fuel tank prior to landing. The checklist did not stipulate the use of the auxiliary fuel pump during takeoff and landing.

The AFM emergency procedure for an engine failure included the pilot selecting a main fuel tank, and switching the auxiliary fuel pump ON.

Additional information

Search and rescue

The Search and Rescue (SAR) response was initiated when the pilot of the aircraft overflying Bathurst Island detected a distress beacon transmitting on 121.5 MHz. That response was by search aircraft and ground parties. During that time, it was not clear if the distress signal was from a surface vessel or from an aircraft.

A 121.5 MHz analogue Emergency Locator Transmitter (ELT) was installed in the Bonanza. That beacon activated on impact with the terrain, and provided the initial distress alert that was detected by the pilot of the overflying aircraft and Cospas-Sarsat satellite-based system. The accuracy of a satellite-derived position from an analogue ELT is typically within 20 km of the signal source.

The source of the distress signal remained unidentified until the SAR aircraft sighted the aircraft wreckage, approximately 1 hour and 50 minutes after the accident.

The Cospas-Sarsat satellite system will cease processing 121.5 MHz analogue signals from 1 February 2009. The system will, however, continue to process signals transmitted by digital distress beacons on 406 MHz. The accuracy of a satellite-derived position for a digital beacon is typically within 5 km of the signal source. A unique code is transmitted with the digital distress signal that identifies the transmitting station and assists with planning the SAR response.

The location of a digital distress beacon that includes an integral global positioning system (GPS) receiver can be determined by the Cospas-Sarsat system to within a few metres.

ATSB research - fuel starvation

In December 2002, the Australian Transport Safety Bureau (ATSB) produced a safety study titled *Australian Aviation Accidents Involving Fuel Exhaustion and Starvation*[16] (available at www.atsb.gov.au). The study focussed on the period 1991 to 2000, and found that the private/business and agricultural categories of operation accounted for the highest rates of both fuel starvation and fuel exhaustion accidents.

16 'Fuel exhaustion' referred to occurrences where the aircraft had become completely devoid of useable fuel. 'Fuel starvation' referred to occurrences where the fuel supply to the engine(s) was interrupted, although there was fuel on board the aircraft.

The ATSB safety study identified that inattention to fuel supply and mismanagement of fuel supply contributed to 58% of the total fuel starvation accidents. The study also found that one in four pilots involved in a fuel-related accident had appeared to misjudge the approach and lose control of, or stall the aircraft after the resulting engine(s) power loss.

New investigation techniques

Engine data monitoring system

The engine operating data that was recorded by the EDM was successfully downloaded from the system's NVM. That data included the engine's operating parameters at 6-second intervals during the occurrence flight, which indicated that the fuel flow dropped to zero approximately 42 seconds before the last data was recorded to the NVM (Figure 4). Associated with the reduction in fuel flow were reductions in the EGT and CHT for each cylinder.

The recorded battery voltage indicated that the propeller continued to rotate (windmill) following the interruption to the fuel flow, up until the last recorded data. The characteristics of the EDM's data file indicated that the EDM did not complete a normal shut down, consistent with an interruption of the unit's power supply at impact.

Figure 4: Recorded fuel flow and battery voltage

INDEX	TIME	E1	E2	E3	E4	E5	E6	C1	C2	C3	C4	C5	C6	DIF	CLD	BAT	FF	USD
1224	0:04:46	1382	1383	1383	1392	1375	1363	339	349	328	340	328	356	29	0	28.2	13.7	28.0
1225	0:04:52	1382	1378	1388	1392	1375	1363	339	351	328	342	328	356	29	0	28.2	13.9	28.0
1226	0:04:58	1423	1420	1432	1434	1415	1402	342	353	330	342	328	358	32	0	28.2	12.9	28.0
1227	0:05:04	1444	1445	1457	1458	1438	1427	344	353	330	344	330	360	31	0	28.2	13.3	28.0
1228	0:05:10	1403	1402	1411	1413	1395	1386	347	355	333	346	330	360	27	0	28.2	13.6	28.2
1229	0:05:16	1349	1352	1359	1364	1349	1339	350	357	335	346	333	362	25	0	28.2	15.7	28.2
1230	0:05:22	1321	1323	1330	1339	1321	1311	352	357	335	346	333	362	28	0	28.2	15.2	28.2
1231	0:05:28	1321	1323	1330	1339	1321	1311	352	359	337	348	335	364	28	0	28.2	15.2	28.2
1232	0:05:34	1288	1290	1294	1300	1287	1278	352	359	337	348	335	364	22	0	28.2	13.5	28.2
1233	0:05:40	1288	1285	1289	1300	1280	1268	348	357	335	345	332	362	32	-12	28.2	14.7	28.2
1234	0:05:46	1295	1294	1289	1307	1280	1273	344	355	333	342	329	359	34	-32	28.2	11.1	28.2
1235	0:05:52	831	850	846	873	836	849	339	349	329	337	323	354	42	-28	28.2	0.0	28.2
1236	0:05:58	551	578	579	614	565	588	329	339	321	328	314	345	63	-67	28.2	0.0	28.2
1237	0:06:04	421	447	452	488	450	468	319	331	314	320	306	337	67	-91	28.2	0.0	28.2
1238	0:06:10	349	372	376	413	379	392	308	323	306	313	298	329	64	-83	28.2	0.0	28.2
1239	0:06:16	304	326	332	368	337	347	299	315	299	307	291	322	64	-77	28.2	0.0	28.2
1240	0:06:22	274	295	300	335	306	315	290	308	292	300	284	315	61	-72	28.4	0.0	28.2
1241	0:06:28	251	270	275	310	282	289	282	301	286	295	278	308	59	-68	28.2	0.0	28.2
1242	0:06:34	234	253	256	289	263	270	275	294	279	289	272	302	55	-61	28.2	0.0	28.2

ANALYSIS

The circumstances of the occurrence were consistent with a fuel starvation event, resulting in the loss of engine power, and followed by a loss of aircraft control as the pilot attempted to make an emergency landing in a nearby clearing.

The aircraft's engine data monitoring system (EDM) recorded a loss of fuel flow to the engine about 42 seconds prior to the end of the data recording. The recorded higher than the nominal battery voltage during that period was consistent with the operation of the alternator due to the windmilling propeller. The investigation concluded that the interruption to the fuel flow occurred while the aircraft was still airborne, and not as a consequence of the impact with terrain.

The normal operation of the aircraft's fuel system during examination and test, and the availability and quality of the fuel in the aircraft's main fuel tanks, suggested that the interruption to the fuel flow was most probably the consequence of low or no fuel in the tip tanks. The as-found position of the fuel selector in the R.TIP position was consistent with the 0757 flight plan annotation by the pilot, and the lack of any indication that the pilot had subsequently deselected that tank prior to the accident.

The investigation concluded that the interruption of the fuel flow was the consequence of the fuel selector being positioned to the right tip tank. In that case, exhaustion of the contents of the right tip tank, or the combined effect of a low quantity of fuel remaining in that tank and a temporary un-porting of the tank outlet as the pilot manoeuvred the aircraft, had the potential to interrupt the fuel flow to the engine.

It could not be positively established whether the position of the selector switch for the tip tank fuel quantity indicator was as a result of action by the pilot, or of the impact with terrain. The investigation could not discount that, due to the switch's position on the instrument panel, it may have been knocked during the impact sequence, or as the pilot extracted himself from the aircraft cockpit.

Examination of the fuel quantity sender for the right tip tank showed the potential for it to provide the pilot with inaccurate or intermittent readings. However, the operation of the gauge would have been apparent to the pilot during his previous flights in the Bonanza, and he would have been aware of any limitations with the gauge's accuracy or operation. In addition, the pilot's experience operating the aircraft would have given him an expectation of the fuel consumption rate and influenced his tank selections, irrespective of any gauge indication. The investigation concluded that any inaccurate or intermittent readings from that gauge were unlikely to have influenced the pilot's management of fuel consumption from those tanks.

The proximity of the pilot's planned deselection of the right tip tank to the commencement of the descent to Bathurst Island suggested that the pilot most probably intended to select one of the main tanks prior to commencing the descent. It was possible that, during the period immediately prior to commencing the descent, the pilot was distracted, and omitted to complete the planned tank change.

Despite the relative complexity of the aircraft fuel system, there were a number of opportunities for the pilot to have detected the initial oversight of having not deselected the right tip tank as originally planned. Those opportunities included the

completion of the recommended Airplane Flight Manual (AFM) pre-landing checklist items on arrival at Bathurst Island, and the completion of the AFM emergency checks in response to the loss of engine power.

Had the pilot carried out the pre-landing checklist as recommended in the manufacturer's AFM on arrival at Bathurst Island, he should have detected that the fuel selector was not selected to the fullest tank.

In order to restore engine power, the AFM emergency checklist required the pilot to reposition the fuel selector to one of the main tanks and to select the auxiliary fuel pump to ON. However, following the loss of engine power, the pilot was also faced with identifying an area suitable for an emergency landing from a low altitude above terrain. The position of the aircraft late downwind, or on a wide base when the engine power loss occurred, was most probably beyond the aircraft's glide range to the runway. That would have compounded the problem faced by the pilot.

The aircraft's final ground track, as indicated by the wreckage trail as the aircraft descended through the tree canopy, may have indicated that the pilot was attempting to reach a nearby clearing when control of the aircraft was lost. The steep descent angle through the trees, steep nose-down attitude on impact with ground, and low forward speed was consistent with an aerodynamic stall/incipient spin precipitating the loss of aircraft control.

The Search and Rescue (SAR) response was initiated as a result of the automatic activation of the aircraft's emergency locator transmitter (ELT). Had the ELT failed to activate, a SAR response would not have commenced until it was noticed that the pilot was overdue.

FINDINGS

Contributing safety factors

- The pilot did not detect the incorrect selection of the fuel selector to the right tip tank during his pre-landing checklist.
- The right tip tank was either empty or critically low on fuel.
- Following the loss of engine power, the pilot did not reposition the fuel selector to a main fuel tank as required by the Airplane Flight Manual emergency checklist.
- The pilot lost control of the aircraft, possibly as he was attempting to manoeuvre the aircraft for an emergency landing on a nearby clearing.
- The accident site was in inaccessible terrain, and remote from immediate medical assistance.

Other safety factors

- The pilot may have been distracted at about the time he planned to select the main fuel tanks.
- The engine failed at low altitude, when the aircraft was most probably beyond gliding range of the runway.
- The pilot had not nominated a SARTIME for his arrival at Bathurst Island, nor had he left a Flight Note with a responsible person.

Other key findings

- The interruption to the fuel flow occurred while the aircraft was airborne, and not as a consequence of the impact with terrain.
- The fuel system was capable of normal operation prior to the impact with terrain.