Report 09-001, BN2A-20 Islander, YJ-RV2 impact with terrain Espiritu Santo, Vanuatu, 19 December 2008

Report 09-001

BN2A-20 Islander
YJ-RV2

impact with terrain

Espiritu Santo, Vanuatu

19 December 2008

Introduction

On 2 January 2009 the Government of the Republic of Vanuatu requested assistance from New Zealand in the investigation of a fatal air accident that had occurred on 19 December 2008. The request was approved and on 21 January 2009 a Transport Accident Investigation Commission investigator arrived in Vanuatu. An engineering specialist joined the team 3 days later.

The investigation team was delegated full powers to investigate the accident under the authority of the Director of the Civil Aviation Authority of Vanuatu (CAAV). The team visited the accident site, examined the wreckage and interviewed the survivors and other witnesses associated with the flight on 19 December 2008.

This report summarises the investigation and is produced on behalf of the Director of CAAV. It is in accordance with the standards and practices of the International Civil Aviation Organization as described in Annex 13 Aircraft Accident and Incident Investigation. Any requests for further information regarding the accident or subsequent investigation should be forwarded to the Director of CAAV.

Britten-Norman BN2A Islander

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Abbreviations

CAAV	Civil Aviation Authority of Vanuatu
DME	distance measuring equipment
ELT	emergency locator transmitter
GPS	global positioning system
HF	high frequency
IFR	instrument flight rules
kg	kilogram(s)
km	kilometre(s)
m	metre(s)
NDB	non-directional beacon
UTC	coordinated universal time

Glossary

altitude	the vertical distance of a level, point or object measured from mean sea level
height	the vertical distance of a level, point or object measured from a specified datum, usually the local terrain

Data Summary

Aircraft registration:	YJ-RV2
Type and serial number:	Britten-Norman BN2A-20 Islander, 145
Number and type of engines:	2 Lycoming IO-540-K1B5 reciprocating engines
Year of manufacture:	1970
Operator:	Air Vanuatu (Domestic) Limited
Date and time:	19 December 2008 at about 1110[1]
Location:	75 kilometres (km) north-east of Luganville, Espiritu Santo, Vanuatu latitude: 15° 03.00´ south longitude: 166° 42.94´ east
Type of flight:	regular public transport
Persons on board:	crew: one passengers: 9
Injuries:	crew: one fatal passengers: one fatal, 2 serious and 6 minor
Nature of damage:	aircraft destroyed
Pilot's licence:	commercial pilot licence
Pilot's age:	38
Pilot's total flying experience:	8395 hours (about 1300 hours on type)
Investigator-in-charge:	IR M^{c}Clelland

[1] All times in this report are local (UTC +11) and are expressed in the 24-hour mode.

Executive Summary

On Friday 19 December 2008, YJ-RV2, a Britten-Norman BN2A-20 Islander aeroplane, was on a regular passenger service between Lajmoli and Pekoa International Airport near Luganville on Espiritu Santo when it struck the side of a mountain range. The plane's sole pilot died in the late-morning accident about 75 km north-east of Luganville, while the front-seat passenger died later of his injuries. Two other passengers were seriously injured, and all the other passengers suffered minor injuries.

The investigation found that the plane was overweight when it left Lajmoli and flying too low to avoid hitting the mountains. When the pilot realised this, his only choice was to make a controlled landing into trees to reduce damage and injuries, which he tried to do. The steep slope and vegetation meant the front of the aircraft was severely damaged, resulting in the deaths.

After the accident the survivors feared an explosion from leaking fuel and believed they needed to reach help by walking out. The investigation found the survivors would have been better to stay near the aircraft to wait for rescue. By climbing the 25 metres to the top of the ridge they would have had a better idea of their location, discovered cell phone coverage from Big Bay, and been able to phone for help.

The crashed plane was spotted from the air by searchers about 75 minutes after air traffic services could not contact it on radio. Poor weather that developed after the accident delayed rescuers reaching the site by helicopter until 0700 the next day, with the main group of 7 walking survivors located later in the mid-afternoon. An eighth survivor, with serious injuries, had been slow to leave the aircraft and was left behind. He attempted to follow the main group but did not catch up. He was found 2 days after the accident by searchers from a local village, and spent a third night in the bush before being airlifted to hospital.

Contributing to the injuries was the condition of the seat belts. The front-seat passenger was unable to connect his diagonal strap because of a missing fitting, and one of the passengers towards the rear of the aircraft was unable to fasten his seat belt because it was too short. A second seat belt was also short, but was able to be fastened owing to the smaller size of the passenger.

The pilot had not given the usual safety briefing at the start of the flight, and was not as talkative as usual. The flight was the final leg of an extra return service put on to pick up passengers delayed by a flight cancelled the day before.

The investigation identified several safety issues that were forwarded to the Director of the Civil Aviation Authority of Vanuatu for his consideration. The safety issues included aircraft weight and balance, aircraft seat belts and safety briefing cards, pilot qualifications and training, passenger education and the use of standardised flight routes to make finding missing aircraft faster.

(Note: this executive summary condenses content to highlight key points to readers and does so in simpler English and with less technical precision than the remainder of the report to ensure its accessibility to a non-expert reader. Expert readers should refer to and rely on the body of the full report.)

1 Factual Information

1.1 History of the flight

1.1.1 On Friday 19 December 2008, YJ-RV2, a Britten-Norman Islander aeroplane, was scheduled to fly a routine commercial passenger service for Air Vanuatu (Domestic) Limited (the operator). The service was to start from Bauerfield International Airport, Port Vila and was to include 5 flights or legs, taking the aircraft north via an intermediate landing at Norsup and onto Pekoa International Airport (also known as Santo Airport) near Luganville on Espiritu Santo (see Figure 1).

1.1.2 At Santo Airport the aircraft was to be refuelled and after a stopover of about 2 hours the service was to continue north to Gaua and Mota Lava before returning to Santo where it was planned to terminate. The pilot arrived at the operator's base at about 0700 and started his before-flight duties. The flight departed Bauerfield on schedule at 0730 and progressed normally to Santo.

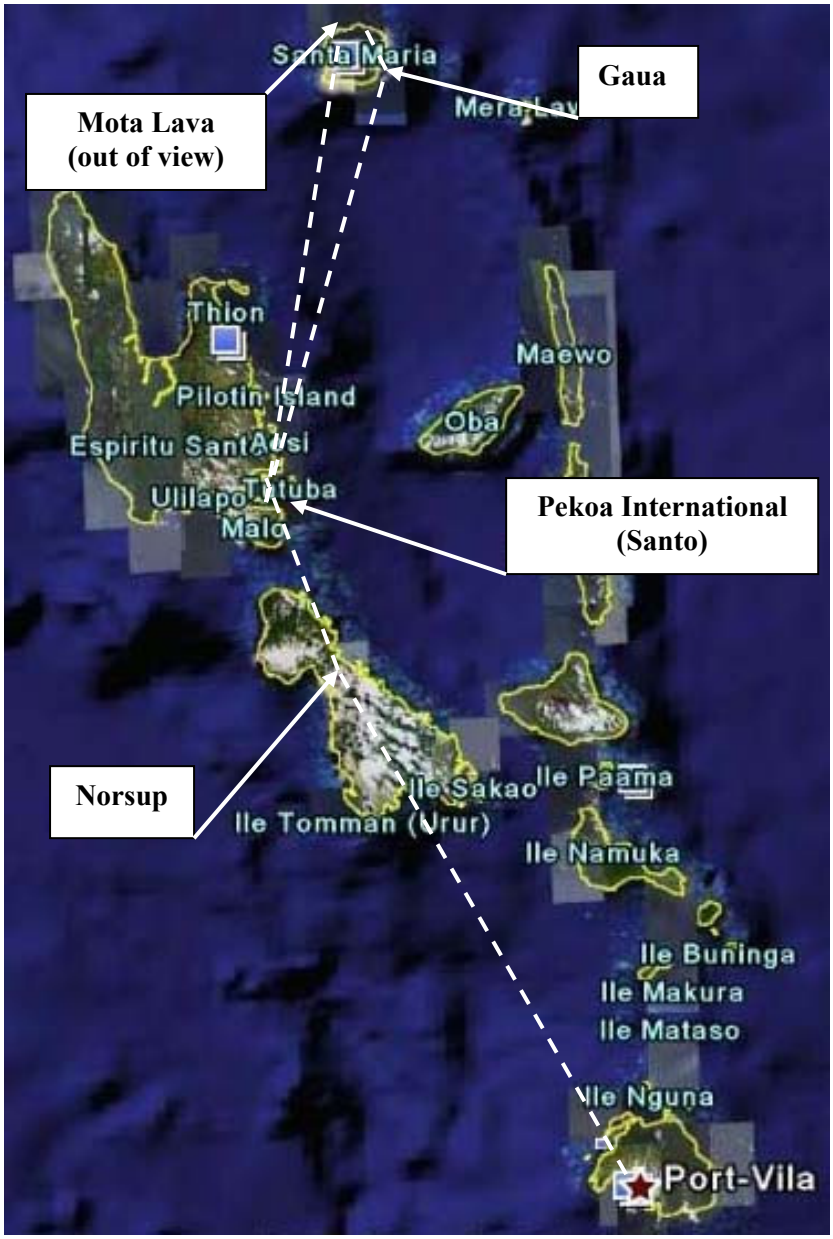

Figure 1
Route map

1.1.3 The operator's agent at Santo had early Friday morning called the company operations office in Port Vila and asked if a flight from Santo to Lajmoli and return could be added to the service (see Figure 2). The regular Thursday flight had been cancelled and 9 passengers had been left stranded at Lajmoli. The operations staff approved the request and the agent advised he would confirm with the pilot of YJ-RV2 when he arrived at Santo.

1.1.4 At Santo the pilot was met by the agent and agreed to the request for the additional flight to Lajmoli. No interruption to the original schedule was envisaged as the flight should have returned to Santo well before the planned 1230 departure north to Gaua. The aircraft was checked and 246 litres of fuel were added. The aircraft departed Santo for Lajmoli at 1016 with the pilot and 4 passengers onboard. At Lajmoli, the local agent, aware that YJ-RV2 was inbound, weighed the passengers and their bags in preparation for the return flight.

1.1.5 At 1043 YJ-RV2 landed at Lajmoli and the agent off-loaded the passengers and baggage while the pilot waited by the aircraft. The agent later reported that he informed the pilot of the planned load of 9 passengers and baggage, and that the aircraft would likely be at about maximum allowable weight. The pilot was reported to have advised the agent that he was happy to continue and instructed him to load the aircraft. The pilot remained near the aircraft while the agent loaded first the baggage then the passengers. The pilot instructed one of the passengers to enter the aircraft through the forward door and sit in the front-right seat next to the pilot.

1.1.6 The agent added the weight of the passengers and baggage to the load sheet for the flight, but he wasn't aware of the fuel weight so omitted this from the sheet. The load sheet, which included a passenger manifest, was returned to the pilot, who signed it. A copy was retained by the agent and later handed to the investigation team.

1.1.7 At 1055 the pilot started the engines and taxied the aircraft for grass runway 14. YJ-RV2 took off at 1058 and at 1100 the pilot called Santo air traffic services on the high frequency (HF) radio,reporting airborne and climbing to 7000 feet. He gave an estimated time of arrival at Santo of 1130.Witnesses, both on the ground at Lajmoli and passengers on board, later commented that the aircraft took longer to get airborne than normal and was slower to climb.

1.1.8 The pilot followed the coastline south and approaching the village of Wunavae turned left inland. Passengers later commented that the aircraft flew in a direct line towards the rising hilly ground and, based on their previous flying experiences, crossed several ridges at a lower-than-normal height. The passengers also commented that the pilot increased power on the engines as they flew in an easterly direction. The passengers later spoken to (7) reported no significant turbulence and while there was perhaps some light cloud about, they were able to see the terrain ahead.

1.1.9 The passengers recalled becoming increasingly concerned about the low height of the aircraft as it flew directly at a right-angle towards the last ridgeline before crossing over into Big Bay. Some of the passengers described the pilot closing the throttles and shutting down the engines as they approached the ridgeline. At about the same time they heard a loud buzzing sound, later identified as the aircraft's stall warning. Shortly afterwards, the aircraft struck the trees and bush and quickly came to a halt. No communication was heard from the pilot during this time, although he was observed throughout making movements typical of someone who was awake.

1.1.10 Within a couple of minutes of impacting into the bush, the passengers started vacating the aircraft. Fuel was smelled about the aircraft and seen dripping from the wing. The passengers were unable to rouse the pilot and front-seat passenger, who were trapped in the now-deformed front of the aircraft. A second passenger, who had suffered a severe head wound and suspected broken leg, was slower to vacate the aircraft and remained semi-conscious near its right side. The remaining 7 passengers assembled at the rear of the aircraft, near the rear left baggage door. Thinking that the pilot and front-seat passenger were dead, and fearing the aircraft might catch fire, they agreed to start walking downhill towards the coast and Wunavae village. The eighth passenger, now aware that the main group had departed downhill, attempted to follow but was unable to catch up owing to his injuries.

Figure 2
Location Map – Espiritu Santo

1.1.11 At about 1115, Santo air traffic services called the pilot of YJ-RV2 to coordinate his arrival with those of several other aircraft also approaching Santo. The controller received no response, so requested other aircraft to call YJ-RV2 on various radio frequencies. Again there was no response. At 1130 the controller declared the aircraft overdue and informed the authorities and the operator. The crews of a company ATR 42 and a DH6 Twin Otter on scheduled local flights were asked to conduct an initial search for YJ-RV2, focusing on the direct track from Lajmoli to Santo. A third private aircraft also assisted in the search. At about 1245 the crew of the ATR 42 located the wreckage of YJ-RV2 at about 4000 feet (1200 m) in the mountainous area west of Big Bay. The crew was unable to fly close enough to confirm if there were any survivors.

1.1.12 At 1500, a light helicopter based in Port Vila departed for Santo and the accident site.[2] Inclement weather prevented the helicopter reaching the site that evening and rescue operations were halted until the next day. Additional support was also requested from New Caledonia, and a French military Super Puma helicopter and medical team arrived in Santo on Saturday morning.

1.1.13 At about 0700 on Saturday 20 December, the first rescue personnel reached YJ-RV2 and confirmed that the pilot was dead and the front-seat passenger critically injured. There was no sign of the remaining 8 passengers. The critically injured passenger was initially evacuated to Luganville Hospital and was subsequently taken to Australia for further treatment. He died of his injuries on 1 January 2009.

1.1.14 During Saturday morning a group of searchers from Wunavae village started walking towards the accident site looking for survivors.[3] About mid-afternoon, the group of 7 passengers was located by the crew of the Super Puma some 3 to 4 km west of the accident site and airlifted to Santo for treatment. The last passenger was located by the villagers the following day and after a third night in the bush was airlifted to hospital.

1.2 Injuries to persons

1.2.1 The pilot was considered by the attending doctor to have sustained immediate fatal injuries. The passenger positioned in the front-right seat next to the pilot sustained critical injuries and died 13 days after the accident.

1.2.2 The remainder of the passengers received a range of injuries from grazes and cuts to broken limbs and internal injuries. Several passengers received follow-up medical treatment a month after the accident, including skin grafts and scans.

1.3 Damage to aircraft

1.3.1 The aircraft was destroyed. However, some parts were considered salvageable and were removed from the site for further examination. These included the engines, propeller blades and landing gear. Refer section 1.12 for further descriptions of the damage.

1.4 Other damage

1.4.1 Minor to local vegetation.

1.5 Personnel information

1.5.1

pilot:	aged 38	
licence and ratings:	commercial pilot licence multi-engine instrument rating	
aircraft ratings:	Cessna 172, BN2A Islander, DHC-6 Twin Otter	
medical certificate:	class 1, valid until 28 February 2009	
most recent 12-monthly competency check:	27 January 2008	
most recent 6-monthly instrument rating competency check:	20 July 2008	
most recent 12-monthly route and aerodrome check:	9 November 2007	
flying experience:	all types	8395 hours
	BN2A Islander	about 1300 hours
	previous 90 days	109 hours
	previous 7 days	26 hours
duty time:	4 hours	
rest before duty:	about 13 hours	

[2] At the time of the accident this was the only helicopter based in Vanuatu.
[3] The accident site was about 2 days walk from Wunavae.

1.5.2 The pilot started flying in 1991, obtaining his private pilot licence in September 1996. He then completed his commercial pilot training in New Zealand before returning to join the operator[4] as a co-pilot on the DHC-6 Twin Otter in September 1997. He also flew the BN2A Islander during this time, becoming a captain on the type in February 1999.

1.5.3 In December 2001 he left the operator to work for another company in the region. He returned to the operator in December 2002 and obtained his DHC-6 captaincy. He was based in Port Vila and regularly flew both the DHC-6 and the BN2A.

1.5.4 The pilot's 12-monthly route and aerodrome check had expired nearly 6 weeks before the accident. A note on the pilot's file stated that a one-month extension had been granted in accordance with Civil Aviation Rules.[5] However, the extension had expired some 10 days before the accident. The operator advised that some of the check and training staff had been away in the lead-up to Christmas and the pilot allocated to conduct the check suddenly found out that his check approval qualification had also recently expired.

1.5.5 The pilot had a planned day off on Wednesday 17 December and completed a 7.4-hour duty day the day before the accident, flying 4.6 hours in another BN2A Islander aircraft. On Friday 19 December 2008, the pilot was originally scheduled to fly a DHC-6 Twin Otter as part of the weekly pilots' roster issued at the start of each week. However, owing to aircraft availability and amended passenger loads, the operations plan for the Friday was changed and the pilot was re-allotted to fly YJ-RV2 originating from Port Vila.

1.5.6 On the morning of 19 December 2008, the pilot appeared to others to be in good health. There were no reports of his suffering from any known medical condition that might have affected the conduct of the flight. He had previously expressed some frustration at last-minute changes to the weekly flying programme, but he was observed by family and fellow workers to be his normal self before beginning the flight from Port Vila.

1.5.7 The passengers from Lajmoli reported that the pilot did not give the normal passenger safety briefing before departure and several passengers said he was uncommunicative while on the ground at Lajmoli. They also said he didn't speak to any of the passengers during the flight as was his normal custom.

1.6 Aircraft information

1.6.1 YJ-RV2 was a Britten-Norman BN2A-20 Islander, serial number 145, manufactured in 1970. It was powered by 2 Lycoming IO-540-K1B5 reciprocating engines, serial numbers RL-8303-48E and L-13888-48E, capable of producing 300 horsepower each. The engines were fuel injected and normally aspirated. The aircraft was fitted with a fixed tricycle landing gear.

1.6.2 YJ-RV2 had seating for 10 persons, including the pilot in the front-left seat.[6] The seating was in 5 rows of 2, with the rear 4 rows being a bench-seat arrangement. Entry was via 3 doors, forward left for the pilot and front-seat passenger, centre right for rows 2 and 3, and rear left for rows 4 and 5. Baggage was stowed in the rear of the aircraft, with a cargo net to stop items moving forward.

1.6.3 The operator purchased YJ-RV2 in late 2005 and the aircraft was refurbished and checked before entering revenue service in April 2006. The most recent weight and balance check for YJ-RV2, completed on 3 February 2006, recorded an aircraft empty weight of 1967 kg. The operator's load sheets stated the maximum approved take-off weight was 2858 kg. Refer to section 1.16 for further load information.

[4] Then known as Vanair.
[5] Under the Civil Aviation Act No.16 of 1999, the Civil Aviation Authority of Vanuatu adopted the New Zealand Civil Aviation Rules for use in Vanuatu.
[6] The aircraft was fitted with dual controls and a second pilot or instructor could occupy the front-right seat if required.

1.6.4 Maintenance records showed the aircraft was maintained in accordance with the approved operator's maintenance schedule. A 100-hour check was completed on 18 December, the night before the accident. The aircraft had flown 15 314 hours at this time and completed 26 340 cycles.[7] A review of the aircraft logbook and work cards recorded no defects that may have affected the conduct of the flight. All applicable airworthiness directives and service bulletins were recorded as completed.

1.6.5 The aircraft's maintenance review and certificate of airworthiness were valid until 30 May 2009.

1.7 Meteorological information

1.7.1 A trough covered the northern part of Vanuatu, with light to moderate easterly winds. Isolated thunderstorms were forecast, with visibility reducing to possibly as low as 6000 m. Isolated moderate turbulence was also forecast below 5000 feet.

1.7.2 Santo air traffic services staff reported the weather at the aerodrome at about the time of the accident to be a surface wind 050º true at 8 knots, unlimited visibility, scattered cloud at 2000 feet[8], temperature 31º Celsius, dew point 25º Celsius and pressure 1008 hectopascals.

1.7.3 Witnesses at Lajmoli reported early-morning showers, which had cleared by the time YJ-RV2 landed at 1043. The wind was a light south-easterly on the surface. Passengers onboard the aircraft reported scattered cloud along the tops of the mountains between Lajmoli on the west coast and Big Bay to the east. Two of the passengers reported flying near cloud as they approached the ridgeline. The passengers recalled flying through some light turbulence but could not recall any large up or down draughts encountered.

1.8 Aids to navigation

1.8.1 Lajmoli was not equipped with any navigation aids. Santo had a non-directional beacon (NDB) and distance measuring equipment (DME).

1.8.2 YJ-RV2, like most of the operator's aircraft was fitted with DME and an automatic direction finder (ADF) for tracking NDB signals. YJ-RV2 was also fitted with a global positioning system (GPS) for area navigation and initial letdowns to aerodromes. The GPS was removed from YJ-RV2 for further examination but retained no historical track information that was useful to the investigation.

1.9 Communication

1.9.1 Communication was via high frequency or very high frequency (HF or VHF) radio. No communication problems were reported on the day of the accident and no distress call was heard from the pilot of YJ-RV2.

1.10 Aerodrome and route information

1.10.1 Lajmoli Aerodrome, located on the north-western coast of Espiritu Santo, consisted of a single grass runway orientated 32/14[9] and was 720 m in length. The aerodrome was 50 nautical miles (93 km) north-west of Santo, on a bearing of 300º magnetic. Between the 2 aerodromes was a range of mountains paralleling the western coastline. The mountains rose to between 1100 and 1550 m in the north, with a second ridgeline in the south climbing to about 1880 m. Between the 2 ridgelines were several low saddles.

[7] A cycle is a take-off and landing.
[8] Cloud coverage was reported in eighths or oktas of the sky covered. Scattered was 3 – 4 oktas.
[9] 320º and 140º magnetic.

1.10.2 Pilots flying between the 2 aerodromes would typically climb to a safe height before crossing the mountains and continuing directly to their destination. Should the mountains be covered in cloud, pilots would fly a dogleg and track via the lower saddles then onto their destinations. Should the weather preclude flying through the saddles, pilots would either follow the coastline around or climb in a safe area to the minimum safe altitude before navigating by reference to instruments to their destination.

1.11 Flight recorders

1.11.1 YJ-RV2 was not fitted with a flight data or cockpit voice recorder, nor was it required to be under civil aviation regulations.

1.12 Wreckage and impact information

1.12.1 The accident site was at about 1200 m above sea level, on the western-facing slope of a heavy bush-covered mountainside, some 25 m below a saddle on the ridgeline (see Figure 3). The aircraft was located among trees on a 35º slope that ran down to a small gully. This formed the start of a riverbed that the survivors had followed in their attempt to reach Wunavae. The slope above the site steepened to the ridgeline, where it dropped sharply away to a steep-sided valley leading to the east and Big Bay. From the ridgeline, Big Bay was visible to the east and the coastline and general area of Wunavae village to the west.

1.12.2 Damage to the vegetation showed that RJ-RV2 had struck the bush in a wings-level attitude on a heading of about 055º magnetic. The initial impact was on the right wing, which slewed the aircraft right through about 45º where it struck the ground and slid backwards nearly 2 m before coming to rest (see Figure 4). The distance between the initial impact with the bush and the aircraft coming to rest was calculated to be less than 20 m. All aircraft components were accounted for at the site.

1.12.3 The aircraft had sustained several severe strikes along the leading edges and underneath of both wings. However, the nose of the aircraft had taken the brunt of the impact and had been forced backwards and upwards – intruding into the space occupied by the pilot and front-seat passenger.

1.12.4 The fuel tanks, one located in each wing, had been punctured, with the right tank completely drained of fuel. Some fuel remained in the left tank. The fuel lines running to each engine were checked and fuel was found in the gascolators for both engines. It was observed to be of the correct type. A check of the fuel filters found them unobstructed and free of contaminants. A check of the fuel supply at Santo where the aircraft had last been refuelled, found the fuel to be appropriately stored and of the correct specifications.

1.12.5 No useful instrument readings could be obtained. The aircraft battery switch was turned to ON and the emergency locator transmitter (ELT) was found armed, but had not activated.[10] The magneto switches for the port or left engine were in the OFF position, while the magnetos for the starboard or right engine were set to ON. The throttle levers were both fully closed with the propeller-control and fuel- mixture levers in about the halfway position. However, the mounting for the engine controls displayed a deep indent below the levers that had bent the throttle levers over to the left and likely moved the propeller- and mixture-control levers forward. The flaps were found in the fully retracted position

1.12.6 The propellers for both engines were found to have little or no rotational damage, indicating the propellers had either stopped or were rotating at very low speed at the time of impact. The engine controls were found to have been moved through to “engine cut-off”. Closer examination of the engines at the site determined they were in good condition with no pre-impact damage observed. Considering the state of the engines, the position of the engine controls and the reports by the passengers, a bench examination and testing of the engines was considered unnecessary.

[10] The ELT was later tested and found to function as designed.

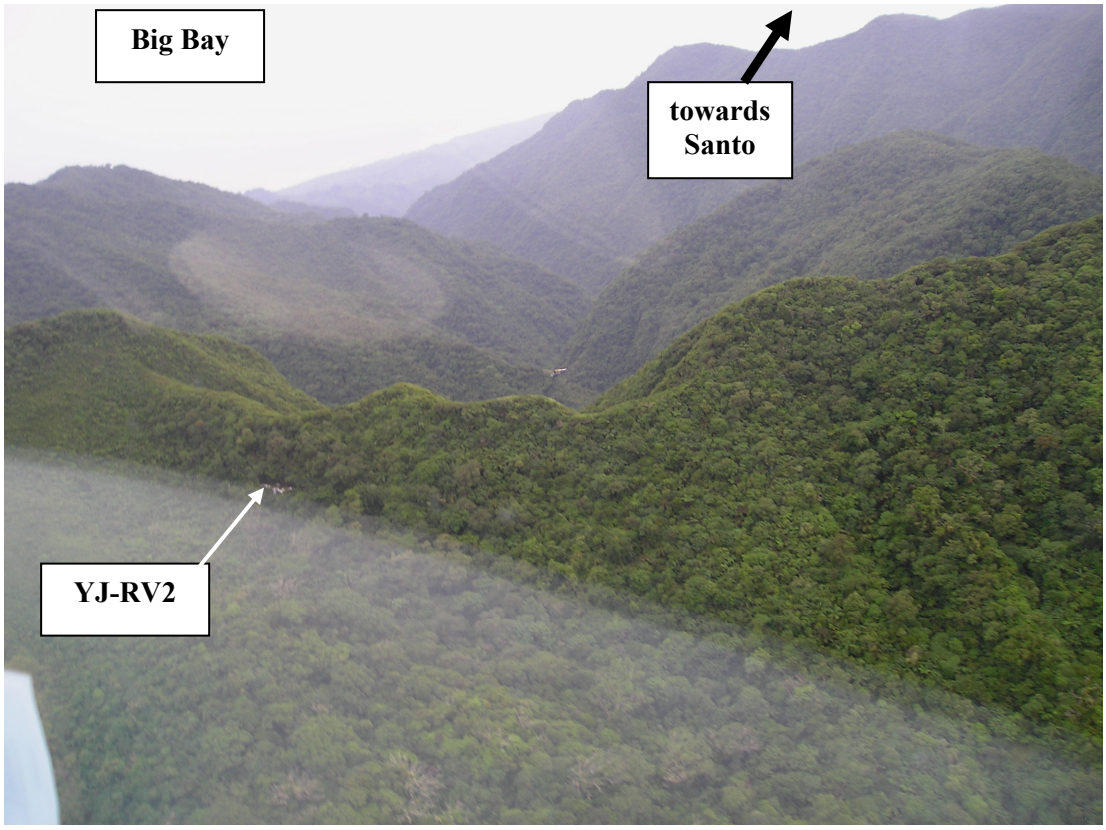

Figure 3
Accident site

1.12.7 The seats were all found still attached to the aircraft floor with the seat belts in place. However, the seatback for row 2 had partially broken at its base, probably from the passengers behind being thrown forward during the impact.[11] The 10 seat belts were checked and found to function as intended with one exception and 2 limitations. The front-seat passenger's diagonal belt could not be used as there was no mount or attachment on the lap belt to which the diagonal strap could connect. The lap belts for 2 of the seats were found to be shorter than the rest, allowing only a small adult or child to be secured. The passenger seated in one of these 2 seats later commented that he had been unable to do up his seat belt and had held onto both loose ends during the flight. He sustained head and leg injuries during the accident.

1.12.8 The passenger safety briefing cards located in pouches on the backs of the seats were checked. Two of the cards were for a different aircraft type, the operator's DHC-6 Twin Otter.

1.12.9 The cargo net securing the baggage in the rear compartment was found partially unhooked. Several passengers later commented that some items may have entered the cabin during the impact. However, the passengers also commented that after the accident some passengers had entered the cargo compartment and retrieved several personal items, including laptop computers, before starting to walk downhill. The pre-impact condition of the cargo net could, therefore, not be accurately determined.

1.12.10 The passengers' bags and cargo were removed from the aircraft and an initial estimate of their weight made. The bags were later taken to Santo and weighed more accurately using calibrated scales. See section 1.16 for further comment on aircraft weight.

[11] There was minimal leg room between rows and any sudden deceleration could place pressure on the seat back.

Figure 4
YJ-RV2

1.13 Medical and pathological information

1.13.1 No pathology or toxicology of the pilot was able to be completed. Medical examination post-mortem showed the pilot received fatal neck and head injuries during the impact. There was evidence that he was wearing his shoulder harness at the time of impact. It was not known if the pilot was taking any prescription or illicit medication.

1.14 Fire

1.14.1 There was no fire.

1.15 Survival aspects

1.15.1 All of the passengers had previously flown in the BN2A Islander and were familiar with the seating arrangement and location of the passenger briefing cards. All of the passengers spoken to stated that they normally received a safety briefing before departure and they would be instructed to fasten their seat belts for the duration of the flight. The flight on 19 December was unusual in that respect.

1.15.2 Search action for YJ-RV2 was initiated at about 1130 following unsuccessful attempts by Santo Tower to contact the pilot to try to coordinate the aircraft's approach to Santo with other inbound aircraft.

1.15.3 The group of 7 passengers quickly agreed to leave the accident site as they feared the aircraft might catch fire or explode owing to the leaking fuel. They thought the pilot and front-seat passenger had died and because the terrain was steep and rugged it would be better to leave the seriously injured passenger behind and seek help.

1.15.4 The passengers believed that any rescue would be many days away, if they were found at all. They were not aware of the ELT, its location on the aircraft or its operation. Despite there being good cellular telephone coverage over much of Vanuatu, there was no coverage at the site. However, had the passengers climbed the 25 m to the top of the ridge they would have been within coverage of telephone towers located in Big Bay and been able to call emergency services using one of the cellular telephones they had with them.

1.16 Tests and research

1.16.1 The incomplete load sheet signed by the pilot at Lajmoli gave a zero fuel weight[12] of 2787 kg for YJ-RV2. This comprised:

basic aircraft weight		1967 kg
pilot		77 kg
passengers (including carry-on bags)		647 kg
baggage		96 kg
	Total	2787 kg

1.16.2 A fuel load of 260 kg was later inserted by the local agent, giving a total starting weight of 3047 kg. A standard allowance of 15 kg was made for engine start, taxi and engine run-up, to give a calculated take-off weight of 3032 kg, or 174 kg over the maximum allowable weight stated on the load sheet.[13]

1.16.3 The basic aircraft weight for YJ-RV2 of 1967 kg was considered accurate as it was taken from the weight and balance check completed on 3 February 2006, prior to the aircraft entering service. The weight of the pilot was taken from the load sheet and confirmed by other records. The weight of the 9 passengers and carry-on bags was checked against the loading scales at Lajmoli, which were later examined and found to be accurate.

1.16.4 The baggage weight of 96 kg was checked against the weight of the actual bags later removed from the aircraft and weighed. The baggage was found to weigh at least 130 kg, 34 kg more than that entered on the load sheet.[14] This gave a revised minimum zero fuel weight of 2821 kg.

1.16.5 The weight of the fuel when RJ-RV2 took-off from Lajmoli was calculated to be a minimum of 235 kg. The weight was based on the fuel load recorded by the pilot in the load sheet for the leg from Santo to Lajmoli, minus fuel for start and taxi at both locations plus the estimated consumption for the 27 minutes of flight-time from Santo to Lajmoli. It was also validated against the start fuel load at Port Vila and the estimated average consumption for the flights north.

1.16.6 The minimum total weight of the aircraft as it took off from Lajmoli was therefore calculated to be:

basic aircraft weight		1967 kg
pilot		77 kg
passengers (including carry-on bags)		647 kg
baggage		130 kg
fuel		235 kg
	Total	3056 kg

This was 198 kg in excess of the maximum allowable weight stated on the load sheet for the aircraft.

[12] The weight of an aircraft excluding any fuel.
[13] No engine run-up was reported at Lajmoli and the taxi time was considered minimal.
[14] Allowance was made for some items that were wet and others that may have been carried onboard and weighed with the passenger.

1.16.7 The centre of gravity for the recalculated take-off weight of 3056 kg was calculated to be near the rear limit but still within the approved centre of gravity range. It was also within limits for the weights recorded on the pilot's load sheet. Discussions with other operators of the same aircraft type confirmed that the pilot of YJ-RV2 should not have experienced any control problems for the recalculated centre of gravity, provided there was no loss of engine power on one of the engines.

1.17 Organisational and management information

1.17.1 Air Vanuatu was formed in 1981 with a change in name from its predecessor, New Hebrides Airways. In September 2004, the operator merged with the domestic carrier, Vanair.

1.17.2 Air Vanuatu operated a range of aircraft on international, regional and local services, including 3 BN2A Islander aircraft on domestic routes. An ATR 42 and 2 DHC-6 Twin Otters were also used for domestic flights, with the ATR also undertaking regular regional services. Pilots were normally rated on both the BN2A Islander and DHC-6 Twin Otter, or on the ATR only. Some check and training staff were qualified on all 3 types.

1.17.3 At the time of the accident the operator was preparing to introduce to service the Harbin Y-12 aircraft similar to the Twin Otter. This aircraft was planned to replace the BN2A Islander. It was the operator's intention to utilise a 2-pilot crew for both the Twin Otter and the Y-12.

1.17.4 The accident flight on 19 December 2008 was filed as an instrument flight rules (IFR) flight, as was common practice by the operator. This normally meant that pilots maintained their own terrain separation visually and, should the weather prevent this, climb to the minimum safe altitude for the route and continue to their destinations by reference to aircraft instruments and local navigation aides. The minimum safe altitude normally ensured the aircraft was at least 1000 feet above the highest terrain for that area. The minimum safe cruising altitude for the Lajmoli-to-Santo track was calculated to be 7000 feet.

1.17.5 At the destination the pilot would descend using the navigation aids and continue visually when able. Air traffic services would ensure separation from other aircraft where applicable. At unattended aerodromes pilots would coordinate their movements over the local radio frequency.

1.17.6 The operator published a domestic route chart showing tracks and distances between aerodromes. Again it was common practice for pilots to fly visually where possible and therefore the actual routes flown often did not follow the routes published in the chart.

1.17.7 Pilots flying by visual reference and maintaining their own terrain separation were still required to maintain a minimum height above the terrain of 500 feet in accordance with the Civil Aviation Rules.

2 Analysis

2.1 The accident occurred during a routine flight on a route with which the pilot was familiar. The service had proceeded normally until reaching Santo, where the pilot was asked to undertake an additional flight to Lajmoli and return. The pilot accepted the additional task, which should not have disrupted his planned schedule for the remainder of the day, but it did shorten the rest period previously scheduled in Santo.

2.2 The pilot's demeanour at Lajmoli was out of character. However, there was no evidence to indicate he was reluctant to accept the extra flight or of any personal problem that would explain his actions. He may simply have been focusing on returning to Santo as promptly as possible and continuing with the original schedule.

2.3 As no pathology or toxicology was able to be completed on the pilot, it could not be determined if he had any underlying condition that might have contributed to the accident. The pilot's roster pattern and opportunity to rest prior to the accident flight, alone, should not have resulted in his being fatigued. The fact that he was observed to have been his normal self when reporting for work that

day, together with the passengers seeing him moving around in his seat as the aircraft approached the ridgeline means he was unlikely to have fallen asleep; however, his being uncommunicative and forgetting or not bothering to conduct the safety briefing prior to the flight was reported to be out of character, and unexplained.

2.4 The pilot was capable of completing the duties assigned to him on 19 December. However, because of an administrative oversight, the operator had allowed the pilot to continue flying after his route and aerodrome qualification had expired. The pilot should have also been aware of this. There was no evidence to suggest the pilot would have had any problem revalidating the qualification. The operator needed to have in place better monitoring systems to prevent this situation occurring, but this oversight was not considered contributory to the accident.

The accident flight

2.5 After loading at Lajmoli, the pilot taxied the aircraft, took off and departed to the south. The aircraft climbed slowly and nearing Wunavae turned inland. While the pilot's intentions were not known, the flight path of YJ-RV2 was consistent with the pilot flying at low level towards a small saddle on the ridgeline, with the objective of then continuing directly on to Santo.

2.6 There was no evidence of any mechanical problem with the aircraft as it flew towards the final ridgeline. Had there been, the pilot had ample opportunity to turn away from the rising terrain and towards lower ground. The weather was suitable for flight under visual meteorological conditions, although caution needed to be exercised owing to some low cloud about the tops of the mountains along the track. Despite this, the passengers, and therefore presumably also the pilot, were able to see the terrain ahead clearly. The pilot increased the power setting as the aircraft climbed towards the last ridgeline leading to Big Bay. This was probably an increase to full power from the normal climb power set after take-off. This indicated the pilot had realised that he needed extra height in order to clear the terrain ahead, so wanted to increase the rate of climb.

2.7 As the aircraft approached from below the crest of the ridge, it likely encountered the effects of the easterly wind that was blowing at the time. The wind would typically have generated some turbulent air on the lee side from where the aircraft was approaching, but more importantly a downdraught close to the ridgeline as the easterly wind flowed over it. With the engines operating at full power and airspeed likely to be near the maximum rate of climb speed, and possibly reducing as the pilot attempted to gain more height, the aircraft eventually reached a point from where the pilot was unable to manoeuvre away from the steep, rising terrain. He was then left with no option than to close the throttles and land into the slope.

2.8 The damage, while significant, was consistent with a controlled slow-speed impact. The activation of the stall alert audio warning indicates that the speed was likely to have been about 45 knots at the time of impact. The steep slope and the prone position of the nose meant that even at this slow speed it would sustain heavy damage. It was therefore not surprising to see the front of the aircraft sustain the brunt of the impact and the nose being forced backwards and the space occupied by the pilot and front-seat passenger being compromised. With the front of the aircraft absorbing most of the impact forces there may not have been sufficient disruption to the rear of the aircraft to activate the ELT located aft of the baggage locker.

Aircraft weight and operation

2.9 According to the load sheet, YJ-RV2 was 174 kg overweight at take-off from Lajmoli. The willingness of the pilot to accept this condition, especially after being told the aircraft was likely to be at maximum weight, then not correctly completing the load sheet, could mean either that the pilot had become accustomed to overloading the aircraft, or that he felt under pressure to take the load offered. Neither of these cases was proved, but in this case the pilot knew that the passengers had been delayed one day already and if off-loaded could be stranded for several more days. The passengers would also have been reluctant to leave behind their personal baggage. In several cases this had been carried for 2 or 3 consecutive days to and from the aerodrome.

2.10 Operating single-pilot places increased responsibility on the pilot to manage or oversee all aspects of the flight correctly, including the weight and balance of the aircraft, control of baggage after being weighed and subsequent loading. The pilot, when considering his experience, should have known that the aircraft would be heavy. Had he completed the load sheet as required he could have identified that the aircraft was overweight and done something about it. Had a more accurate assessment of the baggage weights been possible, the agent and pilot might have identified the aircraft was at least 198 kg or 7% overweight at take-off.

2.11 Nevertheless, having decided to continue, the pilot would normally have realised that the aircraft was heavy judging by the take-off and climb performance. He therefore needed to manage the flight path according to the now degraded climb performance. The introduction of the new aircraft type with a 2-pilot crew will help to provide a better defence against an aircraft being accidentally or deliberately overloaded.

Mountain flying

2.12 Flying in mountainous terrain can provide many challenges for a pilot. The loss of horizon affects pilot orientation, the higher altitudes resulting in decreased engine performance but higher power requirements, and the weather is modified as it passes over the terrain. The wind becomes more turbulent, with localised up and down draughts.

2.13 While how much dedicated mountain flying the pilot had received could not be established, it was probably not extensive. Mountain-flying training did not feature extensively in the New Zealand training, in which the pilot completed his commercial training. A pilot could become sufficiently accustomed to low flying that they were content to fly at low level towards increasingly high terrain, without realising that greater height margins were required. However, comments by the passengers about the height of the aircraft as it approached the accident site would suggest that the low flying displayed in this accident was not routine.

2.14 An often-quoted golden rule of mountain flying is to "**always have an escape route***"*. Pilots need to ensure that they have their airspeed, height and flight path under control. To do otherwise can quickly limit options and if not promptly recognised and corrected, cause an accident.

2.15 The route flown on the day of the accident was typical for the conditions. At normal operating weights, company pilots could have expected sufficient aircraft climb performance to reach sufficient height by the time the aircraft approached the ridgeline to cross it safely. However, the additional weight, combined with the local environmental conditions, meant that YJ-RV2 was at a lower altitude or height than normal. The pilot most likely recognised this and that is why he increased the power setting as he approached the ridgeline in an attempt to increase the rate of climb.

2.16 An acceptable course of action in this case would have been for a pilot to gain sufficient height, at least 500 feet above terrain as required by Civil Aviation Rules for flights under visual flying rules[15], well before the ridgeline. The pilot could have manoeuvred the aircraft, for example by delaying his turn inland or by orbiting, to achieve this. The recognised method of approaching a ridgeline was to do so at an angle rather than directly on. This would have provided the pilot with an escape route away from the ridgeline. Lastly, the airspeed should have been above the optimum climb speed to allow for fluctuations owing to turbulence and the ability to convert any excess speed to height. All these factors would have allowed the pilot greater opportunity to assess the conditions, especially the wind, and retain the option of turning safely away if necessary. Only when the pilot was comfortable that the ridgeline could be safely crossed should he have continued to cross over.

2.17 The topography of Vanuatu is such that pilots will regularly fly over mountainous or adverse terrain. And while the operator continues the practice of allowing pilots to fly under visual meteorological conditions while maintaining their own terrain separation, pilots will often be confronted by the elements of mountain flying. Pilots therefore need to be educated in this aspect of their flying.

[15] Civil Aviation Rule Part 91.311 Minimum heights for VFR (visual flight rules) flights.

Survival

2.18 Why the pilot did not give the passengers a safety briefing or ensure that their seat belts were secure could not be determined. He may have assumed that the local agent would perform the checks or been focused on quickly departing from Lajmoli and returning to Santo.

2.19 The presence of incorrect briefing cards made no difference in this accident. The passengers were familiar with flying in the Islander aircraft and were able to share the correct cards around. However, had there been a rush to re-read the cards quickly for an impending ditching or some other similar event, the lack of cards could have been detrimental to the outcome.

2.20 The finding of 2 shortened seat belts was of concern. Had the impact forces been more severe, the injuries sustained by the passenger unable to fasten his belt could have been equally more severe or even fatal. Also, the front-seat passenger should have been able to connect his shoulder harness. Civil Aviation Rules[16] directed that each passenger occupy a seat and fasten their safety belt, including shoulder harness if equipped. It could not be determined if the front-seat passenger would have survived had he been able to wear his shoulder harness.

2.21 The decision by some of the survivors to leave the accident site and start walking towards Wunavae, while possibly understandable, was not the right choice. While a post-accident fire was a possibility, the passengers would have been advised to remain clear of but in the vicinity of the aircraft to increase the likelihood of their being found. An aircraft can often provide shelter, survival resources and a large visual target for searchers to locate, as shown by the prompt initiation of the search and the crew of the ATR sighting the wreckage about 75 minutes after the aircraft was reported missing.

2.22 Another benefit of staying near the aircraft is that the ELT would normally be expected to activate, providing a signal to guide searching aircraft. Should the beacon not activate automatically, it can be turned on manually, although this would require the person to know where the switch was to activate the transmitter.

2.23 A final consideration for staying by the aircraft would be to attend to those persons more severely injured and possibly unable to walk out. Had the passengers taken more time to check the condition of the injured, a more informed diagnosis of the front seat-passenger might have been possible. However, it was difficult to determine if he would have survived had even basic first aid been given.

2.24 Fortunately the searchers from Wunavae were able to locate the last passenger. The passenger, already disorientated when found, may not have survived much longer without assistance.

2.25 Had the passengers taken a little more time and reviewed the situation, they could have considered climbing the 25 m to the top of the ridgeline. There they would have been better able to orientate themselves and been able to alert emergency services immediately and accurately – thus prompting a faster rescue and again increasing the chances of the front-seat passenger surviving.

2.26 As previously discussed, the practice of filing an IFR flight plan then a pilot picking the best route dependent on weather was a practical and efficient means of flying the short island routes. However, were an aircraft to be lost, the task of searching would be made more difficult as all possible routes that could be flown would need to be checked. By identifying commonly used routes, and the pilot advising air traffic services which route was to be followed, searchers could concentrate on the likely route, thus saving resources and potentially locating a lost aircraft quicker.

[16] Civil Aviation Rule Part 91.207 Occupation of seats and wearing seat restraints.

3 Findings

Findings are listed in order of development and not in order of priority.

3.1 The pilot was appropriately licensed to fly the aeroplane, but his route and aerodrome qualification had been allowed to lapse. However, this lapse was unlikely to have contributed to the accident.

3.2 There was no evidence that the pilot was not fit to conduct the flight, but he was observed by the local agent and passengers to be less communicative than usual, both before and during the flight.

3.3 The aeroplane had been maintained in accordance with approved standards and there was no evidence of mechanical failure that could have contributed to the accident.

3.4 The weather was suitable for the pilot to maintain appropriate terrain separation visually.

3.5 The aeroplane was overloaded by at least 7%, which affected its climb performance and made it unlikely that it would be able to cross the final ridge without deviating from the path flown by the pilot.

3.6 The aeroplane did not have sufficient height margin to approach the lee of the ridge where downdraughts were foreseeable, and the pilot had not approached the ridge from a direction that would have afforded him an escape route when he decided to abort the crossing.

3.7 The poor configuration of the seat belts in the aeroplane increased the risk of injury to the occupants, and may have contributed to the death of one passenger.

3.8 The chances of survival for those passengers who survived the impact were reduced by their decision to leave the accident site.

4 Safety Issues

The following safety issues have been identified for the Director of the Civil Aviation Authority of Vanuatu to consider:

4.1 The weight and balance of the aircraft were not verified by the pilot before the flight departed Lajmoli. Was this an isolated case or symptomatic of a broader issue with the operator?

4.2 The aeroplane seat belts and safety briefing cards were not compliant with Civil Aviation Rules, nor was there a passenger safety briefing. Was this an isolated case or symptomatic of a broader issue with the operator?

4.3 The pilot's route and aerodrome qualification had been allowed to lapse. Was this an isolated case or symptomatic of a broader issue with the operator?

4.4 A high percentage of domestic flying in Vanuatu involves flying in or around mountainous terrain. Was this accident an isolated case or is there a general training deficiency in mountain-flying techniques with this and other operators in Vanuatu?

4.5 The aeroplane was promptly located but there was potential for it to be well away from the search area without anyone's knowledge. Is there benefit in having standardised visual routes for improved flight following?

4.6 Had the passengers stayed near the aeroplane after the accident, their rescue would have been effected significantly sooner. Is a public education programme warranted to inform passengers about the benefits of staying near an accident site versus walking away to seek help in this kind of terrain?

Approved on 17 June 2009, for release to the Director of Civil Aviation Vanuatu.

Hon W P Jeffries
Chief Commissioner