7AC/1/99

<u>Accident Report</u>

7th October 2012
V.C, Bird International Airport, Antigua (TAPA)
Britten-Norman BN2A-26
Registration VP-MON
Montserrat Airways Limited doing business as
Fly Montserrat

FOREWORD

In accordance with Annex 13 to the Convention on International Civil Aviation this investigation is intended neither to apportion blame, nor to assess individual or collective liability. Its sole objective is to draw lessons from the occurrence which may help prevent future accidents.

Consequently, the use of this report for any purpose other than for the prevention of future accidents could lead to erroneous interpretations.

Synopsis

Registered Owner and Operator	Montserrat Airways Limited doing business as Fly Montserrat
Aircraft Type and Registration:	Britten-Norman BN2A-26 Islander, VP-MON serial number 082)
No & Type of Engines:	Two Lycoming O-540-E4C5 piston engines
Year of Manufacture:	1969
Location	V.C. Bird International Airport, Antigua (TAPA)
Date & Time (UTC):	Sunday**,** 7th October 2012 at 2010 hrs
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew: 1 Passengers: 3
Injuries:	Crew 1 (fatal) Passengers 2 (fatal) 1 (serious)
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	31 years
Commander's Flying Experience:	710 hours total of which 510 were on type Last 28 days- 25 hours Last 24 hours – 0.5 hours
Information Source:	ECCAA Accident Investigation

All times in this report are UTC; Antigua time is UTC - 4 hrs

The Investigation

The accident was notified to the Eastern Caribbean Civil Aviation Authority (ECCAA) immediately and senior staff attended the accident site and began an investigation.

The investigation was conducted under the Antigua Civil Aviation Regulations 2004. In accordance with established international arrangements, the Air Accidents Investigation Branch (AAIB) of the United Kingdom, representing the State of Design and Manufacture of the aircraft and (through its registration in a British Overseas Territory) the State of Operator, appointed an Accredited Representative to participate in the investigation. The AAIB Accredited Representative was supported by an AAIB Advisor. Britten-Norman, the aircraft manufacturer, was informed of the accident and offered assistance. Montserrat Airways Limited, the operator, cooperated with the investigation.

FACTUAL INFORMATION

History of the flight

Background to the flight

The aircraft was operating a VFR scheduled commercial air transport flight from VC Bird International Airport, Antigua (TAPA), to John A Osborne Airport, Montserrat (TRPG).

The accident occurred during the aircraft's fourth sector of the day. Prior to the accident flight, another pilot had flown two sectors in it, from John A Osborne to VC Bird and return, before going off duty. The accident pilot reported for duty at 1130 hrs, completed pre-flight preparations, and operated the aircraft to VC Bird.

After the aircraft's arrival at VC Bird, the airport closed to VFR traffic because of cumulonimbus activity and heavy rain. The airport re-opened for VFR operations shortly before the aircraft's departure. A cumulonimbus cloud was present on the approach to Runway 07, and although the surface wind was westerly, Runway 07 was in use for departures.

On board the aircraft were the pilot, three passengers, and bags weighing 150 lb. The fuel load on departure was 65 USG of AVGAS. The takeoff mass was shown on the loadsheet as 5,540 lb, which was below the structural maximum takeoff weight of 6,600 lb; the performance-regulated takeoff weight at the ambient temperature of 24 °C was greater than the structural limit.

Departure

The passengers and pilot travelled in a bus from the airport terminal to the aircraft. The passengers boarded the aircraft, and the baggage was loaded into the compartment behind the rear-most seats. The pilot then boarded the aircraft. The pilot was not observed to carry out a drain of the fuel system's water traps (the operations manual did not stipulate that a drain check should be carried out).

The pilot called the VC Bird Ground Movement Control (GMC) controller for permission to start engines, and was instructed to wait while the controller contacted Montserrat ATC to enquire about the weather there. The pilot then asked for surface wind information for VC Bird and was informed it was from 240° at 10 kts. The controller gave permission for start and passed the

Montserrat weather, which was suitable for the operation. The pilot was instructed to taxi to holding position Bravo.

The pilot contacted the Tower controller and was instructed to enter, backtrack, and line up on Runway 07. The controller described the weather observed from the Tower to the pilot, and the pilot requested a left-hand turn-out after departure. The surface wind was transmitted as from 270° at 10 kts and the aircraft was cleared for takeoff.

The aircraft entered the runway at Bravo but did not backtrack. No power checks were carried out (other evidence indicated that power checks were routinely not carried out other than on each pilot's first flight of the day). The aircraft took off, and the early part of the climb appeared normal.

A number of eye witnesses observed the departure and accident sequence:

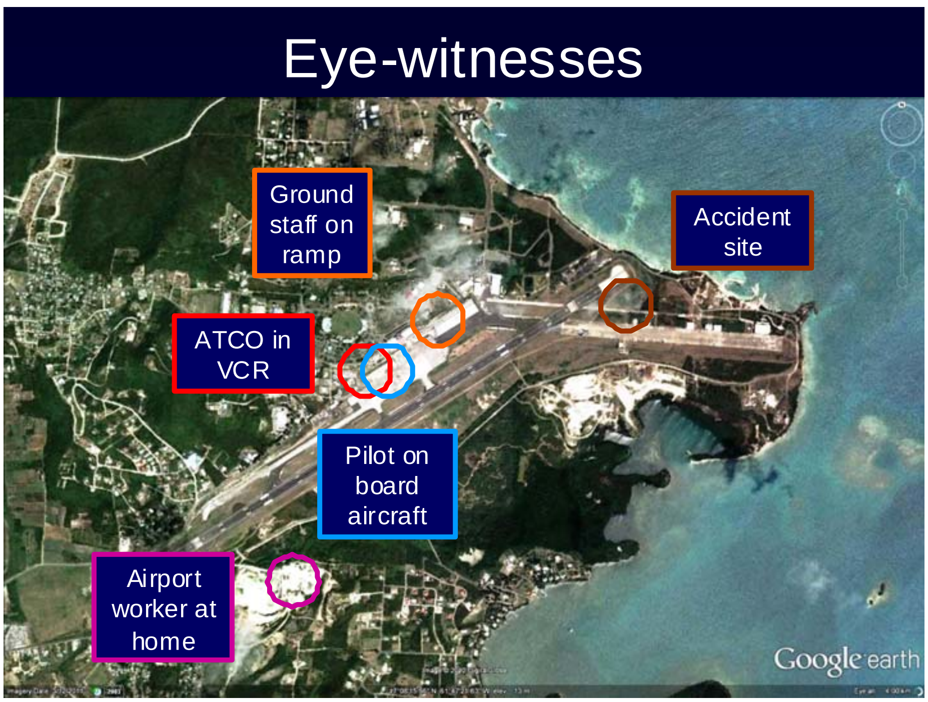

Figure 1

Locations of eye witnesses

Analysis of the eye witness reports, and consideration of their locations and fields of view, led to a deduction that this normal climb continued to a height of between 200 and 300 ft above the ground. The aircraft then appeared to 'sink', losing a small amount of height without yawing or rolling, before yawing to the right, then rolling to the right, and pitching nose down into an incipient spin to the right.

The surviving passenger recalled that the stall warning sounded, and its accompanying red light (which was mounted on the right-hand side of the instrument panel and in his line of sight) illuminated throughout this period and until impact. Witnesses described that the (incipient) spin continued until the aircraft struck the ground.

ATC staff in the visual control room activated the airport's crash alarm. The rescue and fire-fighting service (RFFS) responded promptly from their station; the crew of one RFFS vehicle, working on the airport, observed the accident and responded directly to it.

The pilot and one passenger were fatally injured on impact. Another passenger succumbed to her injuries before she could be extricated from the wreckage, and the third passenger, who had sustained serious injuries, was taken to hospital.

Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	1	2	0
Serious	0	1	0
Minor/none	0	0	0

Damage to aircraft

The aircraft was destroyed as a result of severe damage sustained by the forward fuselage and wing tips during the impact. Figure 1 shows the aircraft as it was found.

Figure 2
View of the aircraft as found after the accident

Other damage

None.

Personnel information

Pilot:	Male, aged 31 years
Licence:	Commercial Pilots Licence issued by Transport Canada, with Air Safety Support International (ASSI) validation
LPC/OPC renewed:	2/5/2012
Medical certificate:	Transport Canada Category 1 valid until 31 January 2013
Flying experience:	See section 1.5.1.3
Previous rest period:	64 hrs

The pilot's training history

Private pilot's licence

The pilot obtained a Private Pilot's Licence (PPL) issued by the ECCAA in Antigua in 2008. No training records were retained by the training organisation, but examination of his log book showed that his training began with seven flights totalling 4 hrs 30 mins of dual exercises covering effects of controls, straight and level flight, climbing and descending, turning, and an introduction to stalling, before his training moved into the circuit. He completed 8 hrs 30 mins of dual training in the course of 13 flights before flying his first solo circuit.

Commercial pilot's licence

In 2009, the pilot began training in Canada, first obtaining a Canadian PPL and then a Commercial Pilot's Licence with Multi-Engine Piston and Instrument Ratings. At the completion of this training, his log book showed a total of 201.1 hrs flying experience[1].

The flying training college provided copies of his training records. They appeared to show that all necessary exercises in the syllabus had been completed, but there were no narrative accounts of his performance other than on flight test reports for grant of qualifications.

The flight test reports included a score for his performance of each element, between one and four. According to the Transport Canada marking scale, grades of four or three were applied when performance was well-executed or observed to include minor errors. Grade two applied when: 'Performance is observed to include major errors', specifically:

- *Aircraft handling is performed with major deviations and/or an occasional lack of stability, over/under control or abrupt control input.*

- *Technical skills reveal deficiencies either in depth of knowledge or comprehension of procedures, aircraft systems, limitations and performance characteristics that do not prevent the successful completion of the task.*

- *Situational awareness appears compromised as cues are missed or attended to late or the candidate takes more time than ideal to incorporate cues or changes into the operational plan.*

[1] From this time, his flight times were recorded in hours and tenths of hours rather than hours and minutes.

- *Flight management skills are not consistent. Instrument displays, aircraft warnings or automation serve to avert an undesired aircraft state by prompting or remedying threats and errors that are noticed late.*

- *Safety margins are not compromised, but poorly managed.'*.

Grade one applied when: '*Performance is observed to include critical errors or the* Aim *of the test sequence/item is not achieved'*. The pilot was not graded one on any exercise.

The report for his commercial pilot flight test showed that he scored 2 for the following exercises, with accompanying notes:

Test element	Comment
Stall	*'Attitude on recovery unnecessarily nose low. Aim accomplished'*
Slipping	*'Initial skidding manoeuvre. Candidate quickly noticed error and corrected in a timely manner'*
Short Field Landing	*'Candidate touched down with the longitudinal axis at an angle to the runway centreline. Aim accomplished'*
En-route procedure	*'Heading control poor and to test limits'*

The report for his multi-engine rating flight test showed that he scored 2 for the following exercises, with accompanying notes:

Test element	Comment
Circuit	*'Altitude control'*
Steep turn	*'Roll out heading control'*
Arrival, approach and landing, one engine inoperative	*'Airspeed control'*

The report for his instrument rating flight test showed that he scored 2 for the following exercises, with accompanying notes:

Test element	Comment
Arrival	*'Altitude control'*
Holding (VOR)	*'Airspeed control'*
Engine failure (Multi-engine)	*'Altitude control'*

The pilot's employment history

The pilot worked for the accident operator, and then another Islander operator, before returning to work for the accident operator

The other Islander operator

The pilot was employed by another operator, with a fleet of Islander aircraft, from December 2011 until April 2012. That operator reported that the pilot was taken on as a trainee pilot, to build flight time, and that his only flying was on empty sectors, with a training captain. He did not fly as pilot-in-command and did not qualify as a line pilot with the company.

When questioned about the pilot's performance, the operator's accountable manager stated that the pilot was *'very inconsistent'* and that the weak areas in his performance were *'maintaining airspeed and directional control'*. In particular, *'on departure and final approach… airspeed will bleed to critical levels without him noticing'*.

The operator reported that his training was terminated in April 2012, *'Because of his continued inconsistencies which were not improving'*.

The accident operator

The pilot was re-employed by the accident operator at the beginning of May 2012. No dialogue between the accident operator and his previous employer took place and no references were obtained. The accident operator did not examine the pilot's training records from his professional pilot training. He completed an Operator Proficiency Check (OPC); the accountable manager reported that he could recall nothing remarkable about the pilot's performance under training or test. The pilot then began line training accompanied by the accident operator's accountable manager.

The pilot's log book

The pilot's log book had been completed up to the beginning of August 2012, to a total of 632 hours flying. Analysis of records provided by the operator showed that from that time until the date of the accident, he completed a further 62 hours flying.

Contradictory evidence presented itself concerning a number of entries in the pilot's log book. It was not possible to determine his flying experience accurately, although no evidence suggested his total flying time was less than 500 hrs at the time of the accident.

Line maintenance engineer:

The operator's aircraft were maintained by a company based on the British Overseas Territory of Anguilla, with its maintenance approvals granted by ASSI. Fly Montserrat Ltd's designated line engineer had been issued with Licence Authorisation by ASSI (references ANGUILLA/OTAR66/AMEL/004 and MONTSERRAT/OTAR66/AMEL001), which permitted him to carry out his maintenance duties in Anguilla and Montserrat.

Aircraft information

General information	
Aircraft type	Britten-Norman B2A-26 Islander
Manufacture	1969, Construction No. 082
Engines	2 x Lycoming O-540 E4C5 piston engines
Propellers	2 x Hartzell HC-C2YK-2CUF constant speed
Registration	Fly Montserrat Ltd
Certificate of Airworthiness	Commercial Air Transport Category

Aircraft history

The prototype Britten-Norman Islander BN-2 aircraft first flew in June 1965, with certification being achieved approximately two years later. VP-MON was built in 1969, with the Constructor's Number 082. It was registered to Fly

Montserrat Ltd on 20 November 2009, having undergone a refurbishment by a company in British Columbia, Canada; this included being surveyed by ASSI. Prior to this the aircraft had been based in St Maarten, with the registration PJ-BIW, having undergone maintenance by the same Canadian company in 2003.

By the time the aircraft was acquired by Fly Montserrat, it had achieved 21,010 flight hours and 52,611 flight cycles. At the time of the accident these figures had increased to 22,064 and 55,851 respectively.

The maintenance was carried out by a company in Anguilla, which assigned a line engineer to Montserrat when necessary. The aircraft records indicated that the most recent scheduled maintenance was a 100 hr inspection which was conducted on 11 September 2012, with a 50 hr inspection dated 9 July 2012. The records also included the Certificate of Airworthiness, which had been issued on 20 November 2011, valid for one year.

Apart from the daily inspections (Check 'A'), the only recent maintenance concerned the left wing fuel filler cap, which had departed the aircraft during take-off from Antigua on 29 September 2012, its loss being discovered on arrival at Montserrat. The cap was subsequently recovered from the runway but was judged to be damaged to the extent it could not be reinstalled on the aircraft. VP-MON was grounded until 3 October, when a replacement cap was fitted. The records additionally indicated that the left fuel cap was previously replaced on 24 November 2010 due to the fact '*it leaked water into the tank*'. A Transport Canada Form 1, dated 9 November 2010, indicated that a repaired fuel cap was supplied by the Canadian company to Fly Montserrat's maintenance organisation.

There were no records that indicated when VP-MON's right fuel filler cap was last replaced, which suggested that it may have been on the aircraft at least since November 2009.

The Technical Log was recovered from the aircraft wreckage and it indicated no reported defects, other than the missing left fuel filler cap and its subsequent replacement, as indicated above. However, it was noted that the Daily/Check 'A' Inspection signature line had not been filled in on either the 6 or 7 October, the latter being the day of the accident. Enquiries suggested that the line engineer who normally conducted these inspections in all probability accomplished them on the days in question but simply omitted signing for them.

Aircraft fuel system

General

The fuel system on this aircraft type consists of an integral tank within each wing such that it is normally operated in a tank-to-engine configuration, although there is provision for cross-feeding. Refuelling is achieved via a filler cap on each wing upper surface. Each 65 US gallon tank is fitted with a sump on the wing underside, with holes in the tank floor that allows fuel to flow into it. Each sump is semicircular in section and is approximately 18 inches long and 3 inches in radius. The sump forms the lowest part of the tank and contains the water drain and fuel drain plugs. Fuel is drawn into the engine fuel feed line at the back of the sump via a coarse-mesh suction filter. It then passes through two electric boost pumps, each equipped with a nylon mesh filter, before being fed to a gascolator in the nacelle and thence to the carburettor float chamber.

Fuel suction filters and Modification NB/M/350

An illustration of the aircraft fuel tank installation is shown at Figure 3, where it can be seen that the fuel off-take, via the suction filter, is the subject of Modification No NB/M/350.

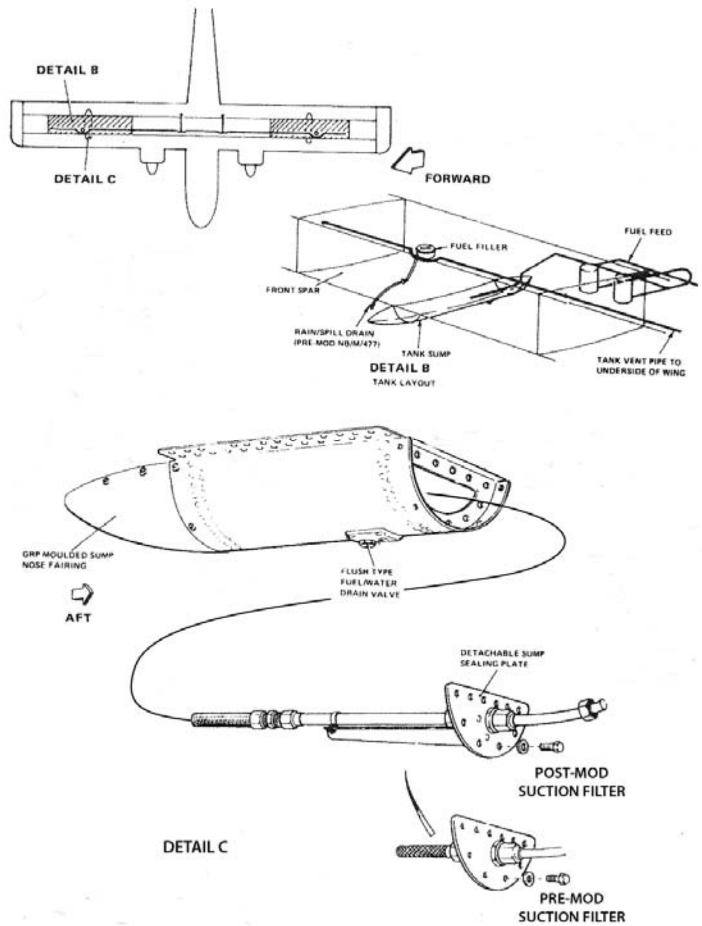

Figure 3

Fuel tank sump installation, showing pre- and post-modification NB/M/350 suction filters

NB/M/350 mounted the suction filter 8.5 in forward of the sealing plate, on the end of a tube. This also had the effect of raising the filter from 1.05 in to 2.25 in above the bottom of the sump. The purpose of the modification, which was issued in 1968, was to provide increased protection from water contamination of the fuel. Any water would collect at the bottom of the sump and would tend to move aft during takeoff and, with the filter attached directly to the sealing plate, be fed directly into the fuel line to the engine. However, the post-modification configuration is more likely to place the filter in the uncontaminated fuel above the water level, as illustrated in Figure 4.

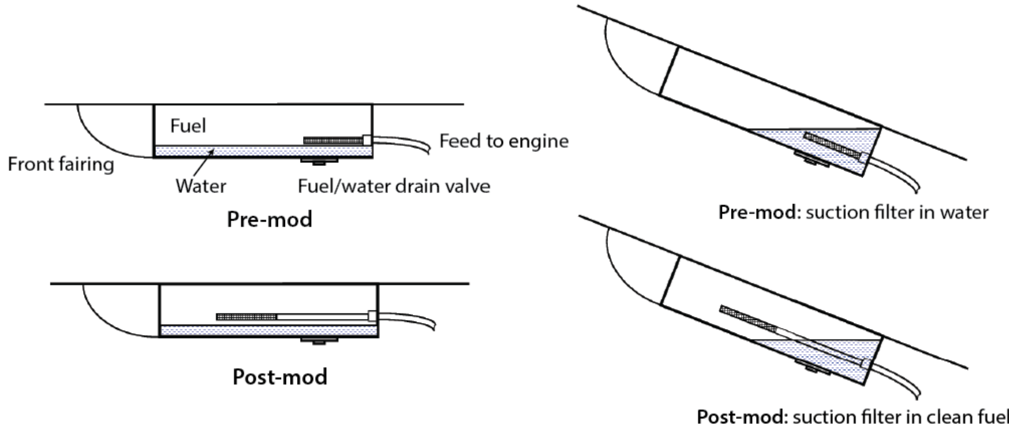

Figure 4
Fuel behaviour with pre- and post-mod suction filters

Although the modification was offered as a customer option, it was mandated in 1968 by the Australian airworthiness authority by means of an Airworthiness Directive, AD/BN-2/2. Thus all aircraft imported into that country were required to be modified in order to “meet the Australian certification requirements.” The AD was cancelled on 6 November 2008 as it was considered to be no longer required since “… all affected aircraft would have been modified by now”.

The modification was not routinely installed on new build aircraft until aircraft Construction Number 091 (VP-MON Construction Number was 082). The aircraft manufacturer did not know how many of the earlier aircraft had been modified.

Examination of the fuel tank sumps of VP-MON revealed that they were of the pre-modification standard.

Fuel filler caps and Modification NB/M/477

Two types of fuel filler caps can be found on BN-2A series aircraft. The earliest ones were fitted with cap/filler neck assemblies supplied by King Aircraft. In this design, the cap fitted into a ring/ neck component that was attached to the wing skin. The base of the neck incorporated a scupper, or rainwater drain, which was attached to a pipe that ducted any water through the forward wall of the fuel tank and, via a dry bay in the leading edge, to an overboard drain on the wing underside close to the tank sump. The scupper was effectively a circular channel that, when the cap was in place (retained in position by two pegs that engaged with cam profiles in the filler neck), the inner rim sealed against the lower face of the cap. This ensured that any rainwater that leaked past the top of the cap was guided into the channel and thence overboard. A drawing showing the filler neck is shown at Figure 5.

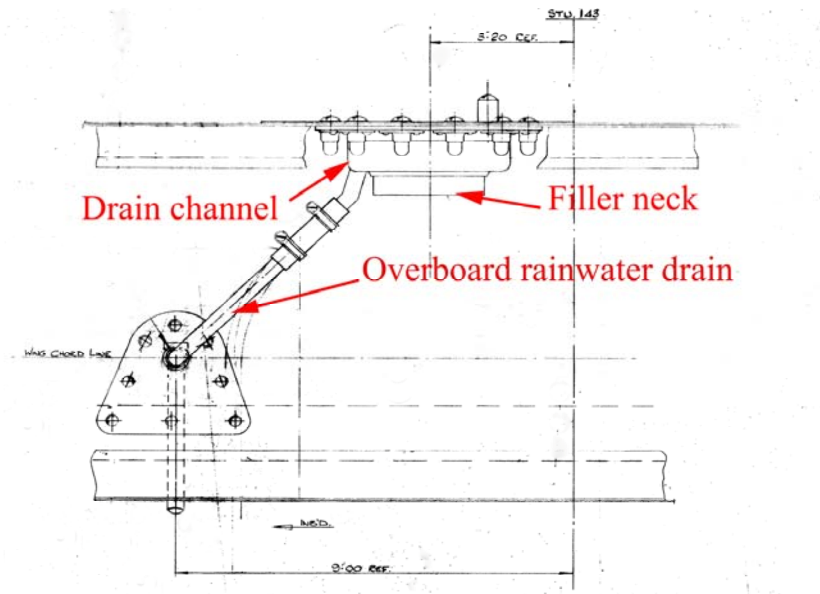

Figure 5

Drawing of fuel tank section showing rainwater drain details

March 1971 saw the introduction of Modification NB/M/477. This was a simplified design, manufactured by Shaw Aero Devices, which incorporated a shallower cap that fitted into an 'adapter ring' in the wing skin. The design deleted the rainwater drain and relied on an 'O' ring seal close to the top of the cap to keep rainwater out. A recessed tab in the top of the cap, when rotated, operated three tangs that extended beneath the attachment ring at the base of the filler neck, thus securing the cap in position. The spindle on which the tab rotated incorporated an adjustable spring mechanism that governed the tension of the cap when in position, such that a higher tension caused a higher contact pressure between the seal and the adapter plate. Figure 6, from the Illustrated Parts Catalogue (IPC) shows the salient details of both filler cap types, with Figure 7 showing the modified cap in greater detail. Both filler cap types were attached to the filler necks by a chain or lanyard.

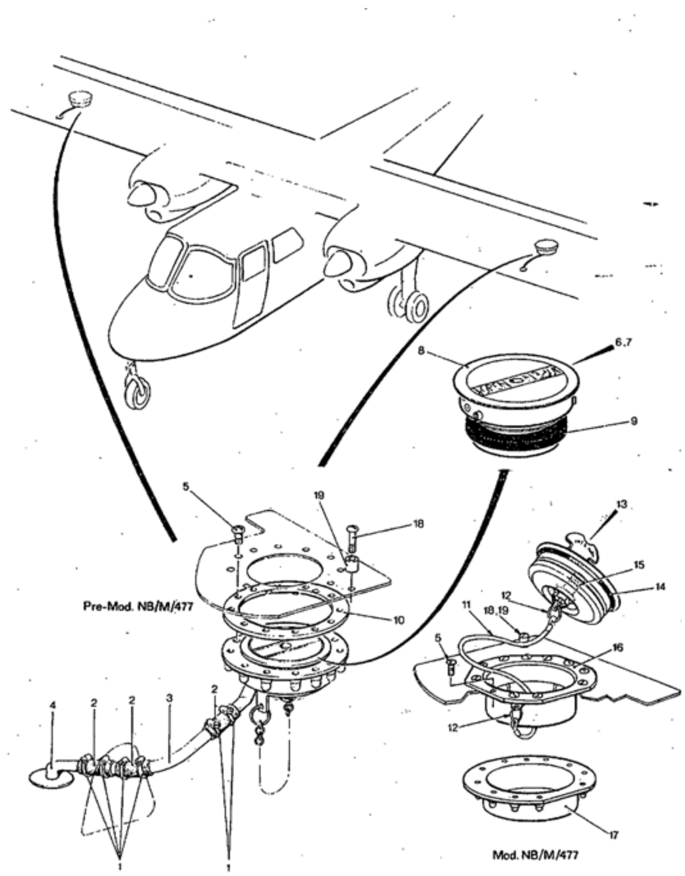

Figure 6
Fuel filler cap details

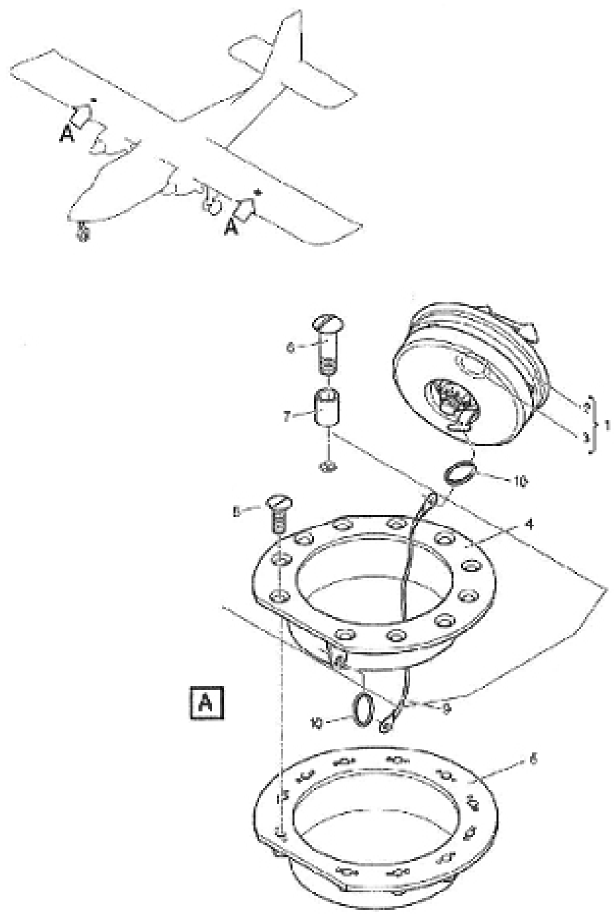

Figure 7

Additional details of Modification NB/M/477

The modification was offered as a customer option but was not installed at build until the introduction of the BN-2B Islander series in 1978. This production change may have been influenced by the fact that the King Aircraft components were no longer available. On those aircraft that were modified in service it was not necessary to physically remove the circular channel at the base of the filler neck. However, it was necessary to blank off the pipe that drained the channel at the point where it passed through the tank wall.

Examination of the wreckage of VP-MON revealed that both filler caps were the Shaw Aero Devices component (see the example shown in Figure 8), although the filler necks were of the pre-modification standard. This is covered in more detail on page 24 of this report**.**

Figure 8
Example of post-modification NB/M/477 fuel filler cap as found on VP-MON

AFM limitations

The Aircraft Flight Manual contained takeoff performance data for tailwinds up to and including five knots. Therefore, in the absence of data for greater tailwinds, five knots was the maximum permitted tailwind for takeoff in commercial operations.

Meteorological information

Meteorological observations were made and recorded each hour by observers at the airport. Following the accident, a special observation was made at 2032 hrs.

The observations at 2000 hrs and 2032 hrs were as follows:

	2000 hrs	2032 hrs
Surface wind	190/12 kts	260/9 kts
Visibility	6 km	10 km or more
Weather	Slight thunderstorm with rain	None
Lowest cloud	1-2 oktas Cumulonimbus, base 1,200 ft aal	1-2 oktas Cumulonimbus, base 1,200 ft aal
Next lowest cloud	3-4 oktas, base 1,300 ft aal	3-4 oktas, base 3,400 ft aal
Temperature and dew point	24/22 °C	24/22 °C
QFF (= QNH within 1 HPa)	1,013 HPa	1,012 HPa
Remarks		Thunderstorm with rain ended at 2012 hrs

Rainfall was measured using a calibrated rain gauge at the airport.

Rainfall in the hours before the accident was as follows:

Time period (hrs)	Rainfall (mm)
1700-1800	0
1800-1900	10.3
1900-2000	31.6

Thus, the aggregate rainfall in the two hours before departure was 41.9 mm

Aids to navigation

The aircraft was operating under visual flight rules (VFR); no aids to navigation were relevant.

Communications

Communications between the aircraft and air traffic control were by VHF aeronautical radio. Recordings of the transmissions were obtained. No communication difficulties were apparent.

Aerodrome information

No information relevant to the aerodrome was pertinent to the investigation.

Flight Recorders

The aircraft was not fitted with flight recorders; regulations did not require their fitment on this class of aircraft.

Wreckage and impact information

Accident site

The aircraft had struck the ground approximately 140 m from the right hand edge of Runway 07, close to an old service road that ran to the north of, and parallel to, the disused east-west runway. The ground marks and the disposition of the wreckage indicated that the impact track was around 230º M. The first mark on the ground had been made by the right wing tip; subsequent marks were found to have been made by respectively the right engine propeller spinner, the aircraft nose and the left engine/propeller. These marks were almost aligned with the impact track, which suggested that the aircraft was banked steeply to the right, perhaps in excess of 80º, at impact, such that a cart-wheeling motion ensued. The left wingtip was heavily damaged in the process, although the area of ground that it struck was difficult to discern on the concrete surface of the service road. The aircraft came to rest in an upright position on a heading of 083º, in a severely damaged condition. It was clear that the main impact had been borne by the nose, with considerable compression of the cockpit and forward cabin. The wing-to-fuselage structural attachments had mostly failed, leaving the wing attached by little more than secondary structure and cables. This had resulted in the fuselage and main landing gear resting on the ground, causing the wing to adopt a leading edge-down attitude.

The main wreckage lay approximately 25 m from the initial impact mark which, together with the relatively low degree of fragmentation, suggested a low speed impact.

Detailed examination of the wreckage

General

An inspection of the airframe indicated that there had been no pre-impact structural failure, the flaps had been at the takeoff setting and the rudder and elevator trim settings had been approximately neutral.

The cockpit could not be inspected until access was gained by removing the forward cabin roof. It was established that the fuel tank selections were at their normal tank-to-engine configuration and the electric boost pump switches were in their ON positions. The engine and propeller control levers, together with the pedestal in which they were located, had been crushed in the impact with the result that their absolute positions in the quadrant could not be determined. However, it was observed that all the levers were approximately in line across the quadrant.

The stall warning indicator light, on the right hand side of the instrument panel, was removed and subsequently inspected using a microscope. It was found that the filament was considerably distended within the glass envelope, which is consistent with the bulb being illuminated at impact[1].

Note: When bulbs are illuminated, the heated filaments become extremely ductile and an impact can result in extensive filament stretching within the glass envelope. This feature can thus provide evidence that the bulb was lit at impact.

Power plants

The engines had sustained little physical damage during the impact and were not examined in detail. As noted earlier, the right propeller blades were not in the feathered position and were undamaged, showing no evidence of rotation at impact. The left propeller blades had sustained considerable damage during the impact, indicating that the engine was developing significant power at the time. It was also apparent that some of the damage had arisen as a result of the blades striking the left side of the cockpit structure during the impact.

The pressure dome charging valve on the right hand propeller was found to have broken off during the impact; thus the internal pressure had dissipated. The pressure provides assistance in moving the blades to the feathered position. A loss of pressure in service would manifest itself in sluggish operation during feathering checks.

Fuel system

The first-arriving members of the investigation team took a fuel sample from the gascolator on the right hand side within a short time of the accident; it was noted to consist entirely of water, which had a light brown colour. Subsequently, the carburettor fuel bowl was removed from the right hand engine and was also found to contain water. A fine mesh filter within the carburettor was found to be free of debris, although water contamination was evident.

The two boost pump filters in the right wing were found to be contaminated with water and additionally contained a rust-coloured residue. It was not possible to quantify the amount of water that had been present in the fuel system, although Britten-Norman stated that the pipe work between the fuel tank exit and the carburettor would contain approximately 0.5 lbs of fuel.

The fuel system supplying the left engine was examined, with no evidence of water contamination being found. The boost pump filters did not contain any residue. A fuel sample taken from the left gascolator conformed to the normal appearance and smell of Avgas, as did another sample taken from the refuelling bowser shortly after the accident.

All the samples, which included the residue from the right hand boost pump filters and a sample of tank sealant, were analysed by a specialist company in the UK.

The right fuel tank was found to be empty due to a hole in the underside caused as a result of the impact. The left tank had remained intact and had retained its contents. However the wing had come to rest in a leading edge down attitude and it was evident that some fuel had leaked out via the overboard rainwater drain and vent lines. During the on-site investigation it became necessary to separate wing from the fuselage. Before this could be accomplished, the wing was levelled in order to facilitate the draining of the remaining fuel via the normal tank drain. Approximately 150 lb of fuel was recovered, which equates to around 25 US gallons.

Fuel filler necks and caps

As stated on page 19 of this report, both filler caps were of the post-modification NB/M/477 standard, although the filler necks were the original, pre-modification type, which retained the rainwater drain channels. However, reference to Figure 9 shows that the left tank filler cap fitted into a stainless steel surround. It was subsequently found that this was a locally manufactured component that was installed when the aircraft was refurbished in British Columbia in the autumn of 2009, although the task was not listed in the airframe log book. The company that conducted this work stated that the repair was necessary due to corrosion pitting on the original component, with the replacement being manufactured from stainless steel "*in accordance with [the] Shaw Aero Devices drawing*". The relevant drawing was entitled 'Adapter Filler Cap Class 1 Tank' and was dated 7 October 1952, some 15 years before the Islander aircraft was certificated. The company additionally stated that, due to the non-availability of the 'ordinary' fuel cap surrounds, they had had a die made for pressing the stainless steel surrounds, which were then tested for correct sealing. A few were sold to various operators, and some were used on operators' aircraft that the company was re-furbishing. It was thus apparent that the modification was not one that had been approved by the aircraft manufacturer, nor was it the subject of a Supplemental Type Certificate (STC).

Figure 9
Left fuel tank filler neck, showing stainless steel fitting

It can be seen in Figure 10 that the right tank filler neck displayed evidence of corrosion.

Figure 10
Right fuel tank filler neck showing corrosion and drain channel

In a simple experiment to discover if this had adversely affected the seal between the neck and the cap, water was poured onto the top of the wing around the filler cap. After gaining access to the filler cap underside via an adjacent access panel, water droplets could be observed dripping from the central spigot of the cap and falling into the body of the tank; they were not being directed into the rainwater drain channel. The experiment was repeated a number of times, each time removing and then reseating the filler cap. Leakage, at variable rates, was observed in most cases, although it was sometimes possible to achieve an effective seal.

When the same experiment was repeated on the left tank filler cap, no water leakage past the seal was observed; it was clear that the smooth surface of the stainless steel formed an effective seal against the 'O' ring on the cap.

Modification NB/M/477, or simply the use of the post-modification cap, as seen here, rendered the rainwater drain channel assemblies redundant. However, the sealing of the overboard drains, as required by NB/M477, had not been accomplished, with the result that fuel was able to slosh into the channel and drain overboard. In fact it was observed that the leading edge down attitude at which the aircraft had come to rest had resulted in some fuel being spilled overboard via the water drain from the intact left tank.

Propeller governor test

The governor was a Woodward Governor Inc unit, Part number G210659, Serial No 1758957. It had achieved approximately 1054 operating hours and was therefore around halfway through its overhaul life.

The governor was taken to an engine and accessories overhaul company in the UK, where it was subjected to a 'production test' on a test rig. This functioned all the operating features of the unit, including the over-speed function, fine-feather adjustment, relief valve operation and internal pump capacity. The unit performed satisfactorily in all respects.

Analysis of fuel and filter samples

The report from the fuel analysis company concluded that the bowser and left gascolator samples were identical. Both were typical of AVGAS 100LL although they did not conform to the specification in that some of the volatile components had been lost. However, it was considered that this was likely to have been the result of the storage conditions in which the sample were kept prior to the analysis.

The samples from the right gascolator and carburettor were found to be essentially water, with trace elements consistent with ferrous corrosion products. Other elements were consistent with seawater residues. Analysis of the tank sealant sample indicated that it was polymeric material, as expected, and was not consistent with any of the material found in the fuel or water samples. Thus the brownish colour of the latter was most likely due to the presence of rust type particles.

The solid debris from the filters element was analysed using scanning electron microscopy and found to consist mainly of ferrous corrosion products.

Medical and pathological information

Post-mortem examinations were carried out by a pathologist engaged by the Antiguan authorities. The post-mortem examination reports had not been released by the pathologist by the time of the production of this report, though information was received which indicated that neither the examinations, nor toxicological testing, had revealed any information likely to have been relevant to the investigation.

Fire

There was no fire.

Survival aspects

The aircraft impact attitude and the vertical speed had resulted in the nose and forward cabin area sustaining considerable crushing damage that had resulted in the occupants in this area receiving fatal injuries. The energy absorbed by the progressively collapsing fuselage structure had attenuated the impact experienced towards the rear of the aircraft such that the deformation was significantly less. This had resulted in the passenger in the rear seat to be subjected to reduced impact loads, which facilitated his survival.

Tests and research

No tests or research were necessary.

Organisational and management information

Regulatory supervision; maintenance

As noted on page 12 of this report, the aircraft maintenance was carried out by a company in Anguilla. ASSI's regulatory requirements were to ensure that the maintenance organisation had in place suitable arrangements for continued airworthiness management by reference to OTAR Part 39. This included ensuring that engineering personnel were licensed in accordance with the requirements laid out in OTAR Part 66. The relevant maintenance requirements were covered by OTAR Part 145. Following an initial audit the company was issued with a temporary ANG/OTAR Part 145-01 Approval Certificate in November 2007, with a full Approval Certificate, reference ANG/OTAR Part 39-01 in January 2008. Prior to ASSI's involvement, the company's Part 145 approvals were the subject of the ECCAA. Part 39 and Part 145 Audits. Since 2010, renewal has been conducted on a two-year basis.

In common with ASSI normal procedures, the maintenance organisation was audited at least annually, with additional visits being arranged to cover renewal of Certificates of Airworthiness. Any findings from an audit are recorded in a Regulatory Non-conformity Report (RNR). Each finding is graded Level 1, 2 or 3. Level 1 is defined as any non-conformity which lowers safety standards and seriously hazards flight safety and which requires urgent attention and satisfactory corrective action within an agreed period of not more than seven days. Level 2 is any non-conformity which could lower safety standards and possibly hazard flight safety, satisfactory correction of which is to be completed within an agreed period of 90 days. Level 3 is any other minor non-conformity, satisfactory correction of which is to be completed within an agreed period which may be more than 90 days.

Following the accident to VP-MON, ASSI conducted an additional audit of the maintenance organisation. Four Level 2 and one Level 3 findings were recorded on the RNR. One of the Level 2 findings concerned the failure to record Part Nos/Serial Nos of components removed from aircraft, although the relevant data for components being installed was recorded. Another referred to the fact that a copy of "each applicable and completed sector record page is not retained at the departure location". A third finding concerned the fact that aircraft defects were being entered and cleared on Maintenance Defect and rectifications worksheets without being recorded in the Technical Logs. Finally, the missing Check 'A' signatures on the Technical Log from VP-MON, as detailed in on page 13 of this report, was also noted.

There were no Level 1 non-conformities resulting from this, or any other audit conducted in recent years.

Finally, as noted on page 13 of this report, VP-MON was the subject of an ASSI survey after its maintenance in Canada prior to being delivered to Fly Montserrat. The stainless steel adapter plate on the left filler receptacle was not noticed either then or at subsequent audits.

The operator's operations manual

Examination of the operator's operations manual showed that it contained some information and instructions (for example, to do with loading, operational procedures, and performance), which were not appropriate to the aircraft type. No equivalent information, applicable to the type, was published.

In the course of the investigation, the regulator (ASSI), reported that action had been taken to ensure that suitable material had been published in a revised version of the manual.

Additional information

Similar event

During the course of the investigation a previous accident came to light which appeared to have many circumstantial similarities to those of VP-MON.

On August 2, 1984, a Britten-Norman BN-2A-6 Islander, registration N589SA, crashed into the ocean shortly after takeoff from Vieques, Puerto Rico. The pilot and all eight passengers were killed and the aircraft was destroyed on impact with the water. The United States National Transportation Safety Board's investigation[1] revealed that the left engine lost power shortly after takeoff and that the pilot lost control of the aircraft.

The investigation determined that the probable cause of the accident was:

"…the failure of the pilot to execute the emergency engine-out procedure properly shortly after takeoff following a loss of power in the left engine because of water in the airplane's fuel system and the failure…..to remove excess water known to be in the airport's in-ground fuel tank before conducting fuelling operations. The pilot's failure to execute the engine-out procedure properly was due to his inexperience in multi-engine airplanes. Contributing to the accident were: (1) the air carrier's use of a pilot not certificated for the flight; (2) the air carrier's failure to train the pilot adequately; (3) the pilot's

[1] NTSB Report Reference: NTSB/AAR-85/08

failure to follow proper practices to detect water in the airplane's fuel tanks; (4) the out of weight and balance condition of the airplane; (5) the Federal Aviation's (FAA) incorrect application of 14 CFR Part 135 Rules to commuter air carriers, and (6) the FAA's genera1ly inadequate surveillance of the air carrier.

The NTSB noted that the water contamination check had either not been conducted, was conducted too soon after refuelling, or was made with the aircraft not in a level attitude. The report noted the potential of Modification NB/M/350, as described on page 15 of this report, to provide improved protection against loss of engine power due to water contamination and went on to recommend that the Federal Aviation Administration:

> *"Issue an Airworthiness Directive applicable to Pilatus Britten-Norman BN-2, BN-2A, BN-2B, BN-2T, and BN-2A Mk **111** model airplanes requiring the incorporation of Britten Norman modification NB/M/350 to provide increased protection from fuel contamination."*

The FAA response included the following:

> *"The modification NB/M/350 was introduced at the factory at the request Australian government. there* (sic) *are about 68 airplanes flying without the modification, 15 of which may be in the U.S. "In view of the satisfactory worldwide experience with these airplanes, the CAA-UK is of the opinion that, although modification NB/M/350 might be thought to yield enhanced protection, the evidence indicates that the required sump capacity is adequate if water drain checks are performed. A review of the CAA-UK mandatory occurrence reports data, the FAA's service difficulty reports, and accident/incident reports has revealed no evidence of incidents due to water in the fuel other than the subject accident."*

Safety action

Following the accident to VP-MON, Britten-Norman issued Service Bulletin (SB) 332 on 6 December 2012. This called for a one-off check of the fuel filler caps to ensure that they were of the same modification state as the receptacle (filler neck). In the event of a miss-match, the SB required that the correct type of fuel cap be fitted before the next flight.

On 20 December 2012 the EASA issued Airworthiness Directive (AD) 2012-0270. This required a one-time inspection of the fuel filler caps and their receptacles, in accordance with SB 332, to be carried out within 30 days of the AD's effective date of 03 January 2013. If a miss-match was found, the AD required the correct cap/receptacle combination to be fitted to the aircraft within three months of the effective date. Until this was achieved, a water contamination check was required to be conducted prior to every flight. This included checking the tank drains, the gascolators and tip tanks, if installed.

The AD was subsequently re-issued with a minor amendment intended to address a potential ambiguity in the wording.

ANALYSIS

The fuel system

The fuel filler necks (receptacles) and caps

The examination of the aircraft wreckage revealed that the fuel filler caps in use on the aircraft were of the type designed to be used with Modification NB/M/477. However the filler necks were of the pre-modification standard and retained the original adapter plates (on the right tank, at least) and rainwater drain channels. During the course of the investigation no examples of the earlier type of fuel cap were seen, which probably reflected the fact that these components had been out of production for many years. Although the caps appeared to fit satisfactorily, it was found that the right tank cap did not always seal properly, with corrosion on the adapter plate possibly contributing to this condition. A simple experiment indicated that water could leak past the cap seal and into the tank, although the leakage rate tended to vary each time the cap was re-seated such that it was sometimes possible to achieve an effective seal. On the left tank, a non-approved modification had been conducted in which the adapter plate had been fashioned from stainless steel; however the smooth surface had resulted in an effective seal.

Although the modification, when incorporated at initial build, represented a simplification in that it deleted the rainwater drain channel, the original design at least accommodated the possibility of rain leaking past the cap. When an aircraft is modified in service the drain channel is left in place but the overboard drain tube is sealed where it passes through the wing leading edge. As this had not been accomplished on VP-MON it would have been possible, especially when the tanks were full, for small quantities of fuel to slosh into the rainwater drain channels and be lost overboard.

Water contamination of the fuel

The examination of the aircraft fuel system confirmed that the right engine had stopped due to the presence of a significant quantity of water. Earlier in the day of the accident the aircraft had arrived from Montserrat and had been refuelled from a bowser. It had then been parked outside during a period of heavy rain, with the airport rain gauge recording 42 mm of rainfall in two hours.

A sample from the refuelling bowser was found to be free from water contamination; furthermore there were no reports of problems occurring on other piston engine aircraft operating out of Antigua. It is thus reasonable to conclude that the water entered the fuel tank during the period the aircraft was parked in heavy rain. However, such conditions are not unusual in the Caribbean, where, in addition, high humidity levels can generate condensation within the fuel tanks, further contributing to water contamination. In the case of VP-MON, the variable efficacy of the fuel right tank fuel cap seal would have led to water periodically entering the tank, although it is likely that this could have been removed by the daily water drain checks. The fact that the Technical Log page for the day of the accident did not display a signature for the daily Check 'A' (which would have included the water drain check) raises the possibility of the check being omitted. However, the aircraft flew without problem from Montserrat to Antigua earlier in the day, indicating that either there was no water or there was insufficient quantity to be drawn into the fuel system. It was therefore concluded that a combination of the heavy rainfall and a relatively high leakage rate past the fuel cap resulted in a significant quantity of water entering the right fuel tank.

Fuel tank sump and suction filter

The design of the fuel tank sump would allow an amount of water to accumulate below the level of the fuel off-take suction filter which, in the absence of longitudinal acceleration or positive pitch attitude, would not be drawn into the fuel system. When the water level reaches the suction filter, it would enter the fuel system as soon as the engine was started, reaching the engine itself after a period that would vary according to the engine power setting.

The aircraft manufacturer indicated that the length of fuel line between the suction filter and carburettor inlet was likely to contain approximately 0.5 lbs of fuel. Had the filter been covered with water prior to engine start, it is likely that the engine would have stopped before the aircraft reached the runway from its parked position. The witness information indicates that a power check was not conducted, but the engines were observed to have been set at full power shortly before the aircraft commenced its takeoff run. If a typical full power fuel flow value of 25 US gals/hr is assumed for the engine, it would take approximately

12 seconds to consume 0.5 lbs of fuel. Thus, if the water in the sump had started to flow into the fuel line as a result of longitudinal acceleration caused by the aircraft starting to accelerate, the engine may have begun faltering around 12 seconds later. Although an accurate timeline for the accident sequence was not established, this figure seems too short to place the aircraft in the air when the engine stopped. This suggests that it is more probable that the water was drawn into the fuel line as the aircraft rotated to the takeoff attitude.

Safety action

Following the accident to VP-MON, Britten-Norman issued Service Bulletin 332 and the EASA issued the associated Airworthiness Directive 2012-0270. This was intended to address the problem of water entering the fuel tanks and will eventually result in the fleet being equipped with the modified fuel caps and receptacles. However, it is worth noting that the original design, although relatively complex to build, acknowledged that rainwater would inevitably leak past the cap itself, and thus provided a drain. Modification NB/M/477 relied on an improved seal between the cap and adaptor plate to keep rainwater out of the fuel tanks. It is possible that whilst this may be effective when the components are new, wear of the 'O' ring seal on the cap and corrosion on the adaptor plate could eventually result in leakage similar to that which actually occurred on VP-MON. (In fact the left filler cap had been replaced in November 2010 due to the discovery of water leakage into the tank; it is probable that this was due to a worn/faulty 'O' ring, as the stainless steel adaptor plate is unlikely to have corroded.) This emphasises the importance of conducting regular and effective checks for water contamination of fuel.

A 1984 accident to a BN-2A-6 Islander, registration N589SA, which occurred in Vieques, Puerto Rico, was investigated by the NTSB. The investigation found that an engine had stopped as a result of water contamination of the bulk fuel supply where the aircraft had refuelled. However the key similarity with the circumstances of the accident to VP-MON was that the water in the fuel tank sumps probably entered the engine fuel supply lines at the point where the aircraft rotated into the takeoff attitude. This suggested a maximum limit on the likely quantity of water that was in the sump prior to departure. There would be a point where the water level would enter the suction filter even with the aircraft parked in a level attitude. In this event, it is unlikely the engine would run for long enough for the engine to start up and the aircraft taxied to the start of the takeoff roll.

Both N589SA and VP-MON had the same design of fuel suction filters, which drew fuel from the rear of the fuel sump. These filters are particularly vulnerable to being submerged with water when the aircraft adopts a nose-up attitude. A modified suction filter was available which, being longer and slightly higher above the sump floor, would be drawing fuel from the forward end of the sump whilst the aircraft is in a climbing attitude and is thus more likely to be in clean fuel above the (heavier) water contamination. The modified design would therefore appear to offer an improved tolerance of water in the fuel system in comparison with the original design.

The fuel suction filter modification, NB/M/350, had been available since 1968 and had been mandated by the Australian authorities. In fact the associated Airworthiness Directive was cancelled in November 2008 on what appears to be a premature assumption that all aircraft would have been modified by this date.

In their report, the NTSB recommended that the FAA should mandate modification NB/M/350. However, the FAA, following consultation with the UK CAA, did not accept the recommendation.

In view of the fact that two fatal accidents have occurred in which the fuel suction filters became inundated with water during takeoff, the Safety Recommendation stated at the end of this report is made.

Operational matters

The pilot was appropriately qualified to conduct the flight, and was familiar with the aircraft and route. The flight itself was a routine one.

It was not possible to establish whether the pilot carried out a drain of the fuel system's water drain traps before departure, although in light of the quantity of water discovered in the right-hand fuel system, it is possible that such a check would have revealed the presence of water, and enabled the system to be drained until the water had been eradicated from the fuel tank.

The presence of a cumulonimbus cloud on the approach to Runway 07 had caused the air traffic controllers on duty to select Runway 07 for departures, although aircraft taking off would experience a tailwind.

Either windshear associated with the cumulonimbus cloud, or the wind gradient, may have caused the accident aircraft to experience performance-reducing shear in its climb, as it flew from relatively weaker westerly winds at the surface into relatively stronger winds aloft. The description, by some eyewitnesses, of the aircraft appearing to 'sink' before it rolled and yawed, would be consistent with a performance-reducing shear. An into-wind takeoff would have reduced the probability of performance-reducing windshear.

The witness accounts and evidence from the accident site combine to indicate that during the aircraft's initial climb, the right-hand engine ceased producing power. This may have occurred just after, or during, the effect of any windshear. No evidence suggested that the pilot had attempted to secure the failed engine or feather its propeller; if these actions had been completed and control of the aircraft retained, continued flight to a safe landing would have been a possibility.

The surviving passenger's account of the stall warning sounding and illuminating throughout the aircraft's final descent, and others' accounts of the yawing and rolling motion of the aircraft, identified that the final manoeuvre was an incipient spin which may have become a developed spin. For an aircraft to enter a spin, at least one wing must be stalled, with sufficient yaw present. Unintentional spin entry is often a consequence of inadequate control of airspeed and/or yaw.

The pilot's training records contained little narrative information about his progress, from which an assessment of ability might be made. Some evidence, such as the relatively short time he took to achieve his first solo flight, and the fact that he achieved his qualifications in little more than the statutory minimum times, suggest that he exhibited average or above-average ability. However, the written reports from his flight tests, and the account provided by his previous employer, noted that his control of altitude, airspeed, and heading, were associated with his lowest scores in tests, and the previous employer noted particularly that *'on departure and final approach… airspeed will bleed to critical levels without him noticing'*.

Some dialogue between the accident operator and the previous employer might have enabled the accident operator to make more informed decisions, for example around training and testing. In the event, the accident operator's accountable manager recalled nothing remarkable about the pilot's performance.

CONCLUSIONS

(a) Findings

(i) The pilot was properly licensed and qualified to conduct the flight and was reportedly well rested

(ii) The aircraft was certified and equipped in accordance with the existing regulations

(iii) The aircraft's mass and balance were within the applicable tolerances

(iv) The aircraft's fuel load was sufficient for the flight

(v) The meteorological conditions were suitable for flight from VC Bird to John A Osborne

(vi) At the time of takeoff the tailwind on the departure runway was 10 kts; the maximum permitted for the operation was 5 kts

(vii) The aircraft's fuel tank filler necks were of the original production standard incorporating a rainwater drain channel

(viii) Both fuel filler caps were to a design which corresponded to a later design standard of fuel tank filler neck

(ix) The right hand fuel tank filler neck showed evidence of corrosion (the filler neck on the left hand tank was of stainless steel)

(x) Neither the engineering inspections carried out by the maintenance organisation nor inspections by the regulator had identified the mis-match between the fuel filler caps and filler necks

(xi) Tests showed that with the right hand fuel filler cap in place, water falling or flowing on the upper wing surface could enter the right hand fuel tank

(xii) Heavy rain fell for a period whilst the aircraft was parked before departure

(xiii) A significant quantity of water was present in the right-hand fuel tank before the aircraft's departure

(xiv) The fuel suction filters fitted in the aircraft's fuel tanks were of the original production standard

(xv) The early-production-standard fuel suction filters were of a design which would, with a certain volume of water present in the sump, permit that water to enter the engine fuel supply under longitudinal acceleration and/or nose-up pitch attitude

(xvi) The fuel suction filters fitted to later aircraft appeared to be more tolerant of the presence of water in the fuel sumps

(xvii) Some evidence suggested that performance-reducing windshear may have caused a loss of airspeed shortly before control was lost

(xviii) At a low height after takeoff, the aircraft stalled and entered an incipient spin to the right

(xix) The aircraft struck the ground in an extreme nose-down, right-wing-low attitude
(xx) The accident was not survivable for those occupants seated in the forward part of the fuselage
(xxi) The crushing of the forward fuselage attenuated the forces experienced by the rear-most passenger
(xxii) There was no fire
(xxiii) The left-hand engine was running at impact
(xxiv) The right-hand engine was not running, and its propeller was not in the feathered position at impact
(xxv) The as-found positions of the engine and propeller controls suggested that no attempt had been made to shut down the right-hand engine or feather its propeller
(xxvi) The limited information available regarding the pilot's performance under training and test identified that weaknesses in his performance concerned control of the aircraft
(xxvii) The response of the emergency services was prompt and appropriate

(b) Causal factors

The investigation identified the following causal factors

1. Significant rainfall, and anomalies in the aircraft's fuel filler neck and cap, led to the presence of water in the right-hand fuel tank

2. Shortly after takeoff, the water in the right-hand fuel tank entered the engine fuel system causing the engine to stop running
3. Control of the aircraft was not retained after the right-hand engine stopped

The investigation identified the following contributory factors:

1. No pre-flight water drain check was carried out; such a check would have allowed the presence of water in the right-hand fuel tank to be detected and corrective action taken

2. It is possible that performance-reducing windshear, encountered during the downwind departure, contributed to a reduction in airspeed shortly before the aircraft stalled

Safety Recommendations

It is recommended that the European Aviation Safety Agency take the appropriate measures to ensure that all Britten-Norman Islander and Trislander series of aircraft are equipped with the latest standard of fuel suction filters.

It is further recommended that all authorities with Britten-Norman Islander and Trislander series of aircraft on their register take appropriate measures to ensure that all these aircraft are equipped with the latest standard of fuel suction filters.

It is recommended that in the future, dialogue between the accident operator and any previous employer should take place and that references be obtained. The accident operator should in the future examine the pilot's training records of low time pilots from their professional pilot training.