Australian Government
Australian Transport Safety Bureau

Fuel starvation and forced landing involving Pilatus Britten-Norman Islander BN2A, registration VH-WQA

Moa Island, Queensland on 3 October 2022

ATSB Transport Safety Report
Aviation Occurrence Investigation (Short)
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Addendum

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Executive summary

What happened

On the afternoon of 3 October 2022, a Pilatus Britten-Norman Islander BN2A-21, registered VH-WQA and operated by Torres Strait Air, was conducting a non-scheduled passenger air transport flight from Saibai Island Airport, Queensland (QLD) to Horn Island Airport, QLD. There was 1 pilot and 6 passengers on board.

About 19 km NE of Moa Island both engines began to surge. The pilot diverted towards Kubin Airport on Moa Island. As the aircraft passed to the south of the township of Saint Pauls, the pilot determined there was insufficient altitude remaining to reach the airport. As a result, the pilot conducted a forced landing on a road 7 km ENE of Kubin Airport. There were no reported injuries to the pilot or the passengers. The aircraft was substantially damaged.

What the ATSB found

The ATSB found that the dual engine speed fluctuations and associated power loss was probably the result of fuel starvation.

The mechanism was not conclusively determined, however it was identified that the pilot did not operate the aircraft's fuel system in accordance with the aircraft flight manual, and that the configuration and location of the aircraft's fuel controls and tank quantity gauges were probably not conducive to rapid and accurate interpretation. The aircraft manufacturer released a service letter in June 2022 that detailed an optional modification to centralise the fuel system controls and gauges, however this modification was not fitted to VH-WQA. The ATSB considered that these factors increased the risk of inadvertent fuel tank selection.

Safety message

Accidents involving fuel mismanagement are an ongoing aviation safety concern. Pilots are reminded of the importance of understanding an aircraft's fuel supply system and being familiar and proficient in its use. Adhering to procedures, maintaining an accurate fuel record, and ensuring appropriate tank selections are made for the phase of flight will lessen the likelihood of fuel starvation.

The investigation

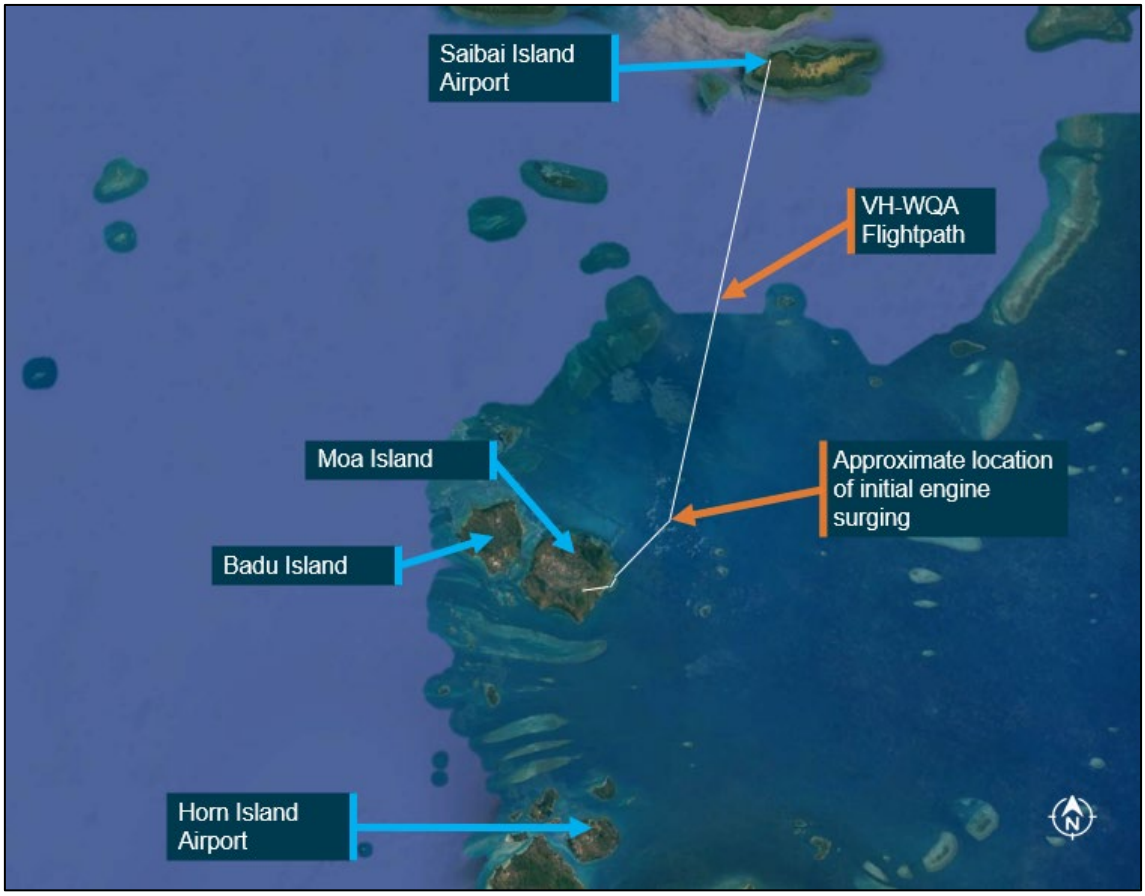
Decisions regarding the scope of an investigation are based on many factors, including the level of safety benefit likely to be obtained from an investigation and the associated resources required. For this occurrence, a limited-scope investigation was conducted in order to produce a short investigation report, and allow for greater industry awareness of findings that affect safety and potential learning opportunities.

The occurrence

On the afternoon of 3 October 2022, a Pilatus Britten-Norman Islander BN2A-21 (Islander), registered VH-WQA and operated by Torres Strait Air, was conducting a non-scheduled passenger air transport flight from Saibai Island Airport, Queensland (QLD) to Horn Island Airport, QLD. There was 1 pilot and 6 passengers on board.

At about 1333, when the aircraft was at a cruise altitude of 6,000 ft and approximately19 km NE of Moa Island (Figure 1), the pilot recalled that the right engine began to surge. The pilot observed the right engine speed fluctuate, accompanied by yawing[1] of the aircraft.

Figure 1: VH-WQA Torres Strait flightpath



Source: Google Earth annotated by the ATSB

About 40–50 seconds later, the left engine also began to surge. The pilot recalled disconnecting the autopilot, selecting auxiliary fuel pumps on and placing the left and right engine mixture, pitch

[1] Yawing: the motion of an aircraft about its vertical or normal axis.

and power levers in the full forward position. The pilot then varied the throttle and mixture levers in an attempt to resolve the issue, but the surging continued. The pilot reported that they did not check the fuel contents indicators at the time, as they believed the main tanks were supplying fuel to the engines and there was sufficient fuel within those tanks to complete the flight.

As a result of the engine issues, the pilot was unable to maintain level flight and recalled descending at 800–1,100 ft per minute to maintain an airspeed of about 75–85 knots. When the engine issues commenced, the closest land to the aircraft was Moa Island. However, the pilot initially elected to divert to Badu Island, as there was cloud along the track[2] to Moa Island. The pilot commenced a right turn towards Badu Island and recalled advising Brisbane Centre air traffic control of the diversion.

A short time later, the pilot revised their diversion plans and set a course for Kubin Airport on Moa Island. As the aircraft passed to the south of the township of Saint Pauls, the pilot determined there was insufficient altitude remaining to reach Kubin Airport (Figure 2). The pilot considered the available options and chose to land on a road that ran east–west. At an altitude of about 600–700 ft, the pilot recalled switching the fuel supply from main tanks to wing tip tanks but noticed no improvement in engine performance.

Figure 2: VH-WQA Moa Island flightpath

Source: Google Earth annotated by the ATSB

About 15 seconds prior to touchdown, the pilot recalled the right engine stopped. They then shut down the left engine and recalled setting both mixtures to cut-off, closing the throttles, and selecting the main fuel cocks to off. The pilot positioned the aircraft to land on the road, before noticing a power line in the intended touchdown area, which they manoeuvred to avoid. The pilot continued to fly the aircraft above the road and as the road traversed a hill and made a left turn, the pilot followed with the aircraft. At this point the pilot recalled that the stall warning system[3] sounded and that they called for the passengers to 'brace'.

[2] Track: the path of the aircraft across the earth's surface.

[3] Stall warning system: activates an audible alert at a desired point above the stall.

At about 1339, the aircraft impacted the ground heavily, with the rear fuselage and tail breaking away from the aircraft. The aircraft came to rest in an area of vegetation on the northern side of the road. The pilot reported instructing the passengers to evacuate, which they did through the emergency window hatches. The pilot then then exited through the pilot door.

There were no reported injuries to the pilot or the passengers. The aircraft sustained substantial damage.

Context

Pilot information

The pilot held a commercial pilot licence (aeroplane), issued in January 2018 with single and multi-engine aircraft class ratings, multi-engine instrument rating, and a valid Class 1 medical. The pilot had accrued a total flight time of about 2,400 flying hours, including about 200–250 hours flying the Islander, and commenced employment with Torres Strait Air in April 2022.

The pilot reported they were well rested and the ATSB found no risk indicators of the pilot experiencing a level of fatigue known to affect performance.

Aircraft information

VH-WQA was a Pilatus Britten-Norman Islander BN2A-21; a twin-engine, high-wing, unpressurised aircraft, with fixed landing gear and seating for up to 9 passengers. It was fitted with Textron Lycoming IO-540-K1B5 piston engines and Hartzell HC-C2YK-2CUF propellers. The aircraft was manufactured in 1975 and first registered in Australia on 5 October 1978. Torres Strait Air became the registered operator of the aircraft on 14 August 2018.

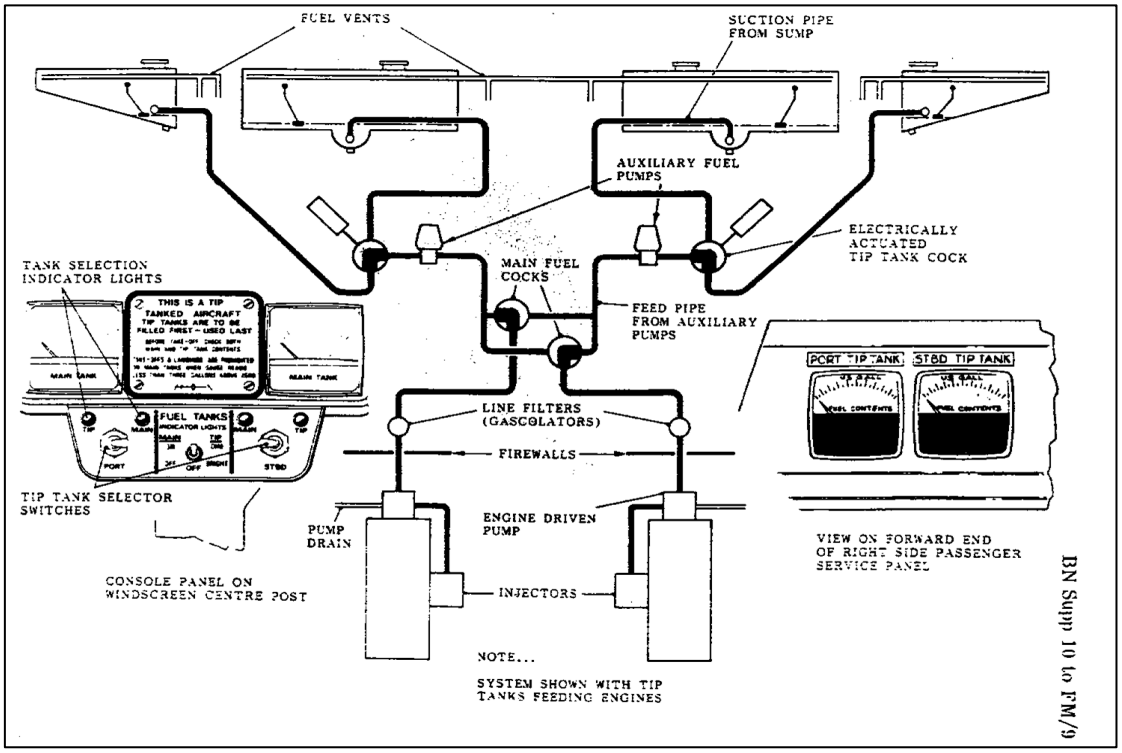
The last periodic inspection was carried out on 21 September 2022. There were no defects recorded on the aircraft's maintenance release. At the time of the accident, the aircraft had accumulated 14,081.92 hours total time in service, and the left and right engines had accumulated 294.15 and 2,185.36 hours since overhaul respectively.

Fuel system

The fuel system in VH-WQA was specification Mod NB/M/364 that consisted of a tip tank and main fuel tank within each wing. The usable capacity of each main tank was about 65 US gallons (246.1 l), and 27.5 US gallons (104.1 l) for each wing tip tank.

Fuel was fed from either the main or wing tip tanks (but not simultaneously) to the auxiliary fuel pumps, and then supplied to either engine via the main fuel cocks (Figure 3).

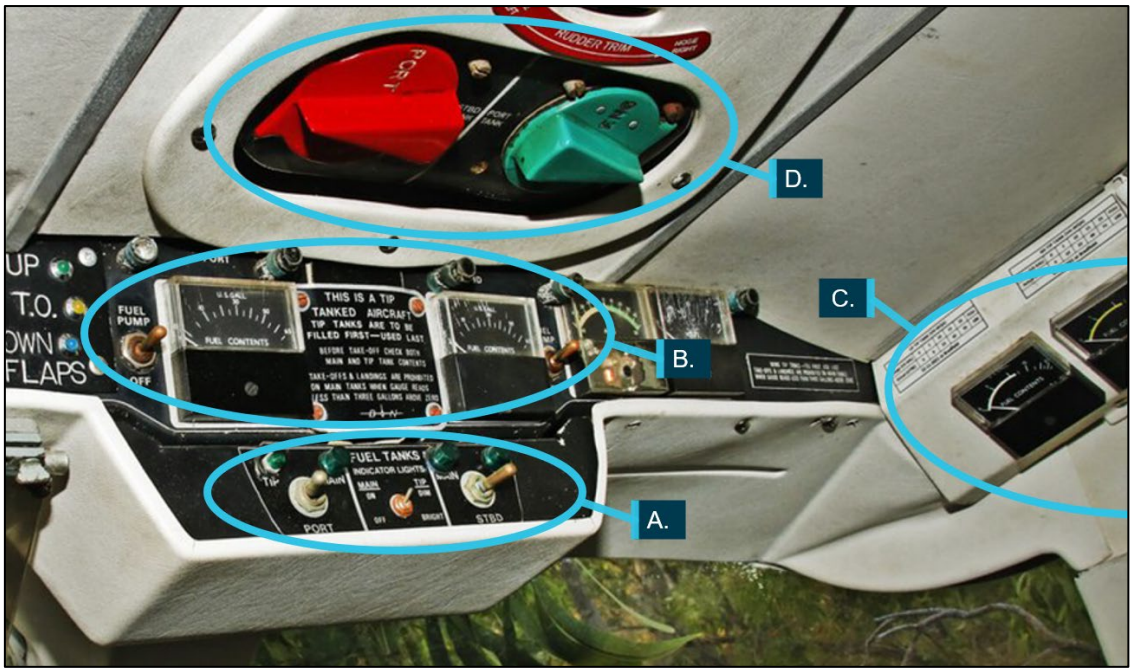
Figure 3: Fuel system



Source: Britten-Norman

The electrically-actuated tank cocks were controlled via an overhead panel, located above the windscreen central pillar. The panel consisted of port and starboard switches that selected either the wing tip tank or main tank. There was a corresponding indicator light for each selection. The panel also contained a switch that controlled the brightness of the tip tank indicator light when that tank was selected (dim or bright). The same switch also determined the main tank indicator light when that tank was selected, either on or off (for the tip tank light positions of dim or bright, respectively) (Figure 4, Label A).

Figure 4: VH-WQA cockpit fuel system configuration

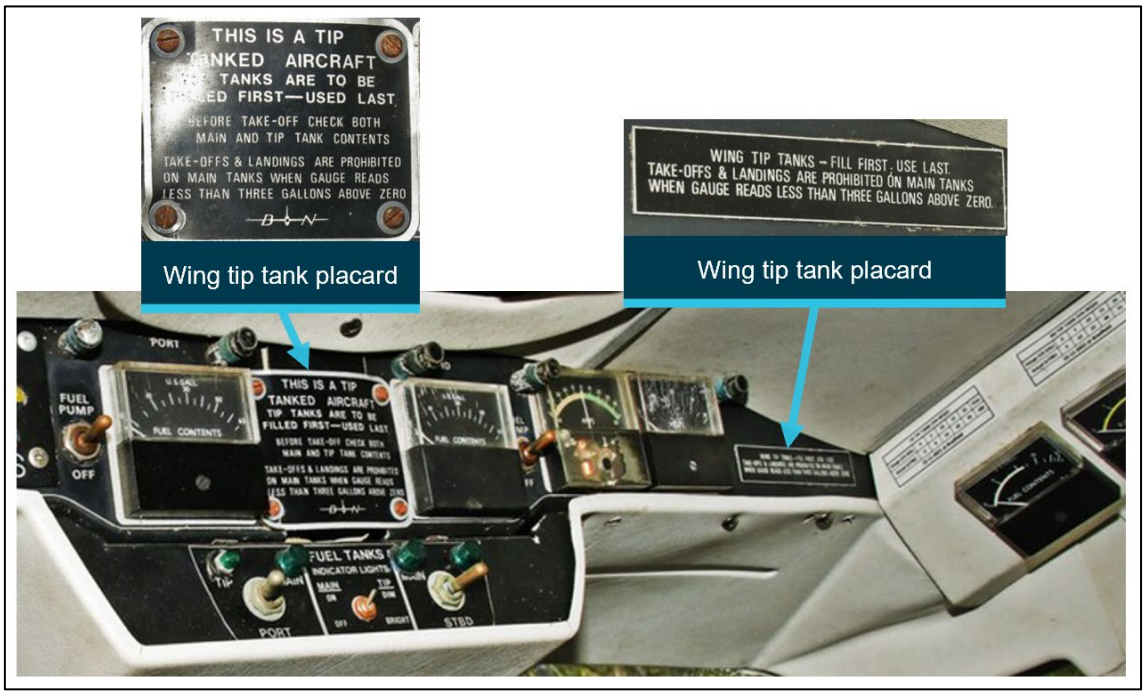


Source: Queensland Police annotated by the ATSB

The main tank contents indicators were located above the fuel tank section panel, with corresponding auxiliary fuel pump switches located either side (Label B). The wing tip tank contents indicators were located on the right side of the cockpit above the side window (Label C). The main fuel cock rotary selectors were located above the main tank contents indicators (Label D).

Fuel system placards,[4] highlighting the configuration and usage of the fuel tanks, were located between the main fuel contents indicators and to the left of the wing tip tank contents indicators (Figure 5).The placards indicated that wing tip tanks were to be used last (after main tanks), and that main tanks were not to be used for landings when the gauge reads less then 3 gallons.

Figure 5: VH-WQA fuel system placards



Source: Queensland Police annotated by the ATSB

Service letter SL 145

On 1 June 2022, Britten-Norman released service letter (SL) 145 applicable to all BN2 series Islander aircraft with Mod NB/M/364 wing tip tanks. The service letter detailed an optional modification to provide an alternative pilot interface that centralised the fuel system controls, specifically relocating the wing tip tank indicators to the overhead panel adjacent to the main tank fuel indicators, with the fuel selection switches mounted between the indicators. VH-WQA did not have this modification fitted.

Aircraft flight manual

The aircraft flight manual[5] for VH-WQA contained a supplement that detailed procedures, limitations, and information for the operation of the modified fuel system. This supplement stated that 13.5 US gallons (51 l) of fuel was to be retained in each wing tip tank at all times for structural reasons, except that this fuel could be used as reserve for holding or diversion to an alternate

[4] Placard: a notice affixed to an aircraft that my contain warnings, limitation or reference information.

[5] Aircraft flight manual: a document produced by the aircraft manufacturer that contains information on the specifications and operation of the aircraft.

airfield. The wing tip tanks were required to be refuelled before the main tanks and used in flight after the main tanks were exhausted. The supplement stated:

> The fuel in the main tanks may be used below the zero marking in cruise flight until the tanks are empty. Between 40 and 50 seconds of warning are given before engine malfunction occurs due to fuel exhaustion of the main tanks. The warning is characterised first by a drop-off of fuel pressure followed by a gentle hunting of the propeller.

Fuel

The flight time records indicated that VH-WQA flew 6 sectors on the day of the occurrence, prior to the accident flight. The occurrence pilot flew all of those sectors (Table 1).

Table 1: VH-WQA flight time records 3 October 2023

Sector	Start time	Block time[6] (min)	Fuel on board (l)	Recorded tank contents (l) (left tip, left main, right main, right tip)	Fuel burn (l)	Fuel remaining (l)
Horn I. – Murray I.	0650	70	440	LT 40, LM 175, RM 190, RT 35 (after refuelling and before sector)	123	317
Murray I. – Yorke I.	0810	28	317	-	44	273
Yorke I. – Horn I.	0843	48	273	LT 40, LM 55, RM 75, RT 35 (after sector)	87	186
Horn I. – Moa I.	1026	19	186	-	27	159
Moa I. – Horn I.	1113	22	159	LT 30, LM 30, RM 45, LT 25 (after sector)	29	130
Horn I. – Saibai I.	1200	49	350	LT 55, LM 120, RM 120, RT 55 (after refuelling and before sector)	83	267
Saibai I. – Horn I.	1308	-	267	-	-	-

Source: Torres Strait Air

The aircraft was refuelled with avgas[7] at Horn Island Airport at 0626 (300.3 l) and again at 1150 (200.3 l). The pilot recalled using a fuel dipstick[8] to check the contents of the 2 main tanks and 2 wing tip tanks following refuelling, as well as checking drained fuel for water contamination. The flight time records contained a fuel discrepancy following the 1150 refuelling (the aircraft had an additional 20 l) and recorded tank contents on the Yorke Island – Horn Island sector (which is 19 l more than the recorded fuel remaining). Despite these discrepancies, the aircraft departed Horn Island Airport with a recorded 350 l of fuel on board, which was sufficient for the round trip to Saibai Island Airport. This was composed of 120 l in each of the main tanks and 55 l in each of the wing tip tanks.

The aircraft was recorded to have used 83 l on the flight to Sabai Island Airport, but the pilot did not record the individual levels of each tank in the flight time records on arrival at Saibai Island Airport. The ATSB calculated that 81 l of fuel was required to complete the intended flight from Saibai Island Airport to Horn Island Airport. About 44 l fuel would likely have been used for the flight from Saibai Island Airport to the vicinity where the pilot recalled that the engine surging commenced.

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6 Block time: elapsed period from when an aircraft starts to move at the beginning of the flight, to the time it comes to rest at the conclusion of the flight.

7 Avgas: a type of aviation fuel used in aircraft with a spark-ignited internal combustion engine.

8 Dipstick: a graduated tool that is inserted into a fuel tank and used to determine the level of fuel within the tank.

Pilot fuel management

The pilot was familiar with VH-WQA's modified fuel system and during interview, recalled the correct use of the tip tanks. Despite this, flight time records indicated that the pilot had, on occasion, operated VH-WQA without the required 51 l of fuel in the wing tip tanks and had also used these tanks when fuel remained in the main tanks. The pilot did not give a reason for this usage of the tip tanks.

Site and wreckage

The ATSB did not examine the accident site or wreckage. The site was attended on 6 October 2023 by representatives from the aircraft operator, insurance provider, independent maintenance provider, and Queensland Police. The site inspection was recorded by Queensland Police and the video footage was provided to the ATSB along with forensic photographs taken on the day of the accident. The aircraft wreckage was not guarded during the period between the accident occurring and the on-site examination.

The wreckage was located a short distance from the road in an area of low foliage approximately 6.5 km ENE of Kubin Airport. The undercarriage and empennage were separated from the aircraft and the fuselage was resting right wing low (Figure 6 and Figure 7). No obvious airframe or engine defects were reported by those that attended the site.

Figure 6: Accident site from road

Source: Queensland Police

Figure 7: Accident site

Source: Queensland Police

The right main tank and wing tip tank were ruptured during the accident sequence. The left main fuel tank and wing tip tank were reported as being intact and found to contain approximately 60 l, and less than 500 ml of fuel respectively. No fuel contamination was apparent and the fuel selectors were found to work correctly when electrical power was applied to the aircraft. Table 1 depicts the positions of the fuel controls as documented in forensic photographs taken shortly after the accident. The wing tip tanks were selected for use, the auxiliary pumps were on and the main fuel cocks were selected 'off', which was consistent with the pilot's recollection of the occurrence.

Table 2: Fuel system cockpit control positions

Control	Position
Left electrically actuated tip fuel cock	Wing TIP tank
Right electrically actuated tip fuel cock	Wing TIP tank
Tank indicator light setting	Wing tip tanks DIM
Left auxiliary fuel pump	ON
Right auxiliary fuel pump	ON
Left main fuel cock	OFF
Right main fuel cock	OFF

Source: Queensland Police

Related occurrences

Collision with terrain, Pilatus Britten–Norman aircraft BN2B-27 near Marcel Marchant Aerodrome, Chile on 16 April 2019, 1895SP (Directorate General of Civil Aviation Chile)

On 16 April 2019, a Pilatus Britten–Norman aircraft BN2B-27 with modified fuel system (Mod NB/M/364) collided with terrain shortly after take-off from Marcel Marchant Aerodrome, Chile. The pilot and 5 passengers on board were fatally injured and the aircraft was destroyed. The final

investigation report concluded the near-empty wing tip tanks were likely selected to supply fuel to the engines, resulting in fuel starvation.

Collision with terrain, Pilatus Britten–Norman aircraft BN2B-21 near Devil's Hole, approximately 2.5 nm north of Jersey Airport, Channel Islands on 3 November 2013, Air Accidents Investigation Branch United Kingdome Bulletin: 10/2014

During a search and rescue flight at night in poor weather conditions, one engine ceased producing power and eventually stopped. During the subsequent diversion towards Jersey Airport the other engine also stopped. The pilot was able to reach the Jersey coast and make a forced landing, in which the aircraft suffered significant damage. The aircraft had operated a previous flight with the fuel system configured so that tip tank fuel was being supplied to the engines. The aircraft departed on the accident flight in the same configuration and the engines stopped when the tip tank fuel became exhausted. The investigation also noted the layout of the fuel controls and tank quantity gauges as a source of complication with regard to the presentation of fuel source information to the pilot.

Australian occurrences

The ATSB has conducted a number of investigations that involved fuel management and fuel starvation. Examples include:

- Fuel starvation involving Cessna 310R, VH-JQK, Sunshine Coast Airport, QLD, on 18 August 2022 (AO-2022-040)
- Fuel starvation and forced landing involving Piper PA-28, VH-BDB, 15 km WSW of Bankstown Airport, NSW, on 19 September 2017 (AO-2017-094)
- Fuel starvation involving Cessna 206, 3.5 NM NE of Aldinga, SA, on 3 February 2019 (AB-2019-004)
- Cessna C310R, VH-HCP, 3km E Newman Aerodrome, WA, on 26 January 2001 (200100348)

The 2013 ATSB publication*, Avoidable Accidents No. 5: Starved and exhausted: Fuel management aviation accidents* (AR-2011-112) focused on accidents involving fuel starvation due to fuel management, stating:

> Keeping fuel supplied to the engines during flight relies on the pilot's knowledge of the aircraft's fuel supply system and being familiar and proficient in its use. Adhering to procedures, maintaining a record of the fuel selections during flight, and ensuring the appropriate tank selections are made before descending towards your destination will lessen the likelihood of fuel starvation at what may be a critical stage of the flight.

Safety analysis

At a cruise altitude of 6,000 ft the pilot reported that the right engine and, shortly after, the left engine began to surge. There were limited potential reasons for two fuel-injected engines to behave in this manner, and (almost) simultaneous dual technical failure of independent systems would be highly unlikely. The most probable contributing factor was a fuel-related issue, which was also consistent with the onset of surging described by the pilot.

The aircraft departed Horn Island Airport with sufficient total fuel for the round trip to Saibai Island Airport and a significant quantity of fuel remained in the left main tank after the accident. The aircraft therefore did not suffer fuel exhaustion. The aircraft was filled with the correct fuel type and no fuel contamination was apparent to those on site. Additionally, the aircraft had already flown for over an hour since refuelling, which suggested that an issue with fuel quality was unlikely.

The reported fuel burn from Horn Island to Saibai Island, and the ATSB's calculated fuel usage for the return flight, to the point of engine surging, totalled 127 l. Each of the main tanks were recorded as commencing the round trip with 120 l. This meant that the (approximately) 60 l of fuel

found on site in the left main tank was correct if the flights to that point had been flown entirely on the main tanks, and assuming the breached right main tank contained the same volume. This also supported the pilot's recollection of the occurrence, along with the fuel system cockpit control positions.

However, the calculated fuel usage was also close to the reported amount of fuel in the wing tip tanks (55 l each, 110 l total) upon refuelling at Horn Island. It was therefore considered whether the wing tip tanks had been selected for most or all of the flight duration and became exhausted. Previous occurrences have highlighted this as a possibility and it was also consistent with the small quantity of fuel found remaining within the reportedly unbreached left wing tip tank (<500 ml).

The pilot reported that they did not verify the fuel remaining in the aircraft's main or wing tip tanks when attempting to restore engine performance, following the onset of the engine surging. This oversight was possibly due to confirmation bias, as the pilot believed there was sufficient fuel in all 4 tanks at that time. The fuel controls and tank contents indicators were also probably not conducive to rapid and accurate interpretation due to the potentially confusing configuration of the fuel system panels, and the disparate location of the wing tip tank contents indicators on the right side of the cockpit. In addition, fuel records from earlier flights showed that the pilot was using the wing tip tanks when fuel remained in the aircraft's main tanks, which was not in accordance with the approved flight manual. The ATSB considered that both of these factors increased the likelihood of the wing tip tanks being inadvertently selected during part or all of the round trip, leading to the exhaustion of the wing tip tanks. However, it is noted that this scenario is inconsistent with the pilot's recollection of switching to the tip tanks in attempting to restore power – the position to which the tanks were found selected during the wreckage examination.

The ATSB was unable to account for the fuel tank content discrepancy for either scenario. However, the aircraft wreckage was not guarded during the period between the accident occurring on 3 October 2022 and the on-site examination on 6 October 2022. Consequently, while there was not evidence of tampering, it is possible that during this time fuel was removed (syphoned or pumped) from either tank or leaked from the fuel system, through a mechanism not obvious during the on-site examination. Ultimately the fuel discrepancies were unable to be resolved from the evidence available. However, on the balance of probabilities and in the absence of any other likely mechanical or fuel related issue, the dual engine speed fluctuations and associated power loss was most probably the result of fuel starvation.

Findings

ATSB investigation report findings focus on safety factors (that is, events and conditions that increase risk). Safety factors include 'contributing factors' and 'other factors that increased risk' (that is, factors that did not meet the definition of a contributing factor for this occurrence but were still considered important to include in the report for the purpose of increasing awareness and enhancing safety). In addition 'other findings' may be included to provide important information about topics other than safety factors.

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

From the evidence available, the following findings are made with respect to the Engine power loss and forced landing involving Pilatus Britten-Norman Islander BN-2A, registered VH-WQA, Moa Island, Queensland on 3 October 2022.

Contributing factors

- The engine power loss was likely the result of fuel starvation.

Other factors that increased risk

- The pilot did not use the aircraft's wing tip tanks in accordance with the flight manual. In addition to aircraft structural considerations, this also increased the likelihood of an inadvertent inappropriate fuel tank selection.
- For Britten-Norman Islander aircraft fitted with wing tip tanks, but without the alternative pilot interface per service letter number SL145, the configuration and location of the fuel controls and tank quantity gauges were probably not conducive to rapid and accurate interpretation.

General details

Occurrence details

Date and time:	03 October 2022 13:39	
Occurrence class:	Accident	
Occurrence categories:	Starvation, Forced / Precautionary landing, Diversion / Return	
Location:	6.5 km 70 degrees from Kubin	
	Latitude: 10.2065º S	Longitude: 142.2793º E

Aircraft details

Manufacturer and model:	PILATUS BRITTEN-NORMAN LTD BN2A-21	
Registration:	VH-WQA	
Operator:	TORRES STRAIT AIR PTY LTD	
Serial number:	494	
Type of operation:	Part 135 Australian air transport operations - Smaller aeroplanes-Standard Part 135	
Activity:	Commercial air transport-Non-scheduled-Passenger transport charters	
Departure:	Saibai Island Airport	
Destination:	Horn Island Airport	
Persons on board:	Crew – 1	Passengers – 6
Injuries:	Crew – 0	Passengers – 0
Aircraft damage:	Substantial	

Sources and submissions

Sources of information

The sources of information during the investigation included the:

- pilot of the accident flight
- aircraft operator
- UK Air Accident Investigation Branch
- Civil Aviation Safety Authority
- Queensland Police Service
- aircraft manufacturer
- Airservices Australia

Submissions

Under section 26 of the *Transport Safety Investigation Act 2003*, the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. That section allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the following directly involved parties:

- pilot of the accident flight
- aircraft operator
- Civil Aviation Safety Authority
- UK Air Accident Investigation Branch.

Submissions were received from:

- UK Air Accident Investigation Branch.

The submissions were reviewed and, where considered appropriate, the text of the report was amended accordingly.

Australian Transport Safety Bureau

About the ATSB

The ATSB is an independent Commonwealth Government statutory agency. It is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers.

The ATSB's purpose is to improve the safety of, and public confidence in, aviation, rail and marine transport through:

- independent investigation of transport accidents and other safety occurrences
- safety data recording, analysis and research
- fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia, as well as participating in overseas investigations involving Australian-registered aircraft and ships. It prioritises investigations that have the potential to deliver the greatest public benefit through improvements to transport safety.

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

Purpose of safety investigations

The objective of a safety investigation is to enhance transport safety. This is done through:

- identifying safety issues and facilitating safety action to address those issues
- providing information about occurrences and their associated safety factors to facilitate learning within the transport industry.

It is not a function of the ATSB to apportion blame or provide a means for determining liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner. The ATSB does not investigate for the purpose of taking administrative, regulatory or criminal action.

Terminology

An explanation of terminology used in ATSB investigation reports is available on the ATSB website. This includes terms such as occurrence, contributing factor, other factor that increased risk, and safety issue.