Department of Civil Aviation
Fiji

Aircraft Accident Report

Collision with Terrain
Cessna 172R, DQ-FTR
Near Mt Delaikoro
Vanua Levu
26 February 2018
EXECUTIVE SUMMARY

The accident aircraft, a Cessna 172R registered as DQ-FTR and operated by the Pacific Flying School (PFS) departed Nadi at 7:03 am on the morning of Monday the 26th of February 2018 with a flight instructor and student on board. Its flight plan showed it flying on Visual Flight Rules (VFR) to Labasa, Savusavu and Nausori before returning to Nadi. The flight was a 300 nautical mile cross country training flight as part of the student’s Commercial Pilot Licence (CPL). After landing at Labasa at 8:40 am, the weather deteriorated and it began to rain. The pilots waited for the weather to improve before departing for Savusavu at 11:37 am.

Cloud satellite and rain radar imagery showed that as or shortly after the aircraft departed Labasa, the weather deteriorated and closed in on the accident aircraft, entrapping it without any escape route. This together with ADS-B surveillance data showed that in likely poor visibility and in Instrument Meteorological Conditions (IMC) for which the pilots had only received limited training, the aircraft entered a mountain valley before impacting steep mountainous terrain at an altitude of 2,600 feet near Mt Delaikoro, killing both occupants. The crash occurred shortly after 12:00 o’clock midday.

At the time of departing Labasa, it is likely that the weather was sufficiently adequate to comply with that required for flight under VFR. The pilots had probably complied with all the procedures and requirements specifically required of them by PFS.

The weather system that covered Vanua Levu that day was a tropical low-pressure trough system that progressed in a combination of bands and patches and probably originated from the South Pacific Convergence Zone (SPCZ) to the North of Vanua Levu. These systems are difficult to properly characterise using formal aviation weather systems and are also difficult to forecast. Moreover, they are not fully understood by the international aviation community. In these circumstances rapid changes in visibility can occur over relatively large areas and this is difficult for pilots to manage. The aviation safety risk of these conditions is magnified by mountainous terrain which can not only generate high turbulence including strong downdrafts, but can also further reduce visibility by causing condensation in the form of dense cloud, mist and heavy rain. The pilots did not fully understand how to manage these risks.

Because these types of weather systems are difficult to characterise and predict and are likely to intensify with global warming, this report recommends several improvements to the weather information that Fiji pilots are required to assess and use in their decision-making. Some training in mountain flying is also recommended.

Several recommendations have been addressed to the regulator, the Civil Aviation Authority of Fiji (CAAF), the ATM services of Fiji Airports (FA), the Fiji Meteorological Service (FMS) and the Pacific Flying School (PFS).
SUMMARISED DETAILS

Aircraft type: Cessna 172R
Serial number: 17280169
Registration: DQ-FTR
Engine type: Lycoming IO-360-L2A
Year of manufacture: 1997
Date and time of accident: 26 February 2018 1200 hours, midday (approx)
Location: Near Mt Delaikoro, Vanua Levu
Type of flight: Training Flight
Persons on board: Crew: 2
Injuries: 2 fatal
Nature of damage: Aircraft destroyed by impact forces.
Type of licence of Pilot in Command (PIC): Commercial Pilot Licence and Instructor Rating (Aeroplane)
Age of PIC: 32 years
Flying experience of PIC: Total: 1257 hours
Investigator in Charge: Andrew McGregor
Pro solve Ltd
Auckland
New Zealand

1All times in this report are expressed in Fiji Daylight Time (FDT) (UTC +12 hrs)
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<td>Airworthiness Directives</td>
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<td>ADF</td>
<td>Automatic Direction Finder</td>
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<td>ADS-B</td>
<td>Automatic Dependent Surveillance-Broadcast</td>
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<td>AIP</td>
<td>Aeronautical Information Publication</td>
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<td>AIRMET</td>
<td>Airmen’s Meteorological Information; a concise description of weather phenomena as it may affect aircraft safety.</td>
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<td>AMSL</td>
<td>Above Mean Sea Level</td>
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<td>ANR</td>
<td>Fiji Air Navigation Regulations 1981</td>
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<td>AOC</td>
<td>Air Operator Certificate</td>
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<td>ARA</td>
<td>Annual Review of Airworthiness</td>
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<td>ASB’s</td>
<td>Air Safety Bulletins</td>
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<td>ATC</td>
<td>Air Traffic Control</td>
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<td>ATIC</td>
<td>Aviation Training Institute Certificate</td>
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<td>ATM</td>
<td>Air Traffic Management services of Fiji Airports</td>
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<td>ATPL</td>
<td>Airline Transport Pilot Licence</td>
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<td>ATS</td>
<td>Air Traffic Service</td>
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<td>ATIS</td>
<td>Automatic Terminal Information Service</td>
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<td>AWR</td>
<td>Airborne Weather Radar</td>
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<td>AWS</td>
<td>Automatic Weather Station</td>
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<td>CAAF</td>
<td>Civil Aviation Authority of Fiji</td>
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<td>CASA</td>
<td>Civil Aviation Safety Authority of Australia</td>
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<td>CAST</td>
<td>Causal Analysis using System Theory</td>
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<td>Cb</td>
<td>Cumulonimbus thunderstorm cloud</td>
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<td>CFI</td>
<td>Chief Flying Instructor</td>
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<td>CFIT</td>
<td>Controlled Flight Into Terrain</td>
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<td>CPL(A)</td>
<td>Commercial Pilot Licence (Aeroplane)</td>
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<td>CRM</td>
<td>Crew Resource Management</td>
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<td>CVR</td>
<td>Cockpit Voice Recorder</td>
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<td>DME</td>
<td>Distance Measuring Equipment</td>
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<td>E</td>
<td>East</td>
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<tr>
<td>ELT</td>
<td>Emergency Locator Transmitter</td>
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<tr>
<td>ETA</td>
<td>Estimated Time of Arrival</td>
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<td>FA</td>
<td>Fiji Airports</td>
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<td>FAA</td>
<td>Federal Aviation Administration</td>
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<td>FDR</td>
<td>Flight Data Recorder</td>
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<td>Abbreviation</td>
<td>Full Form</td>
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<td>---------------------------------------------------------------------------</td>
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<td>FDT</td>
<td>Fiji Daily Time</td>
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<td>FIR</td>
<td>Flight Information Region</td>
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<td>FIS</td>
<td>Flight Information Service</td>
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<td>FISO</td>
<td>Flight Information Service Officer</td>
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<td>FMS</td>
<td>Fiji Meteorological Service</td>
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<td>ft</td>
<td>Foot or Feet</td>
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<tr>
<td>General area</td>
<td>An aviation weather forecast relating to a general area forecast</td>
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<td>GPS</td>
<td>Global Positioning System</td>
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<td>hp</td>
<td>Horsepower</td>
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<td>hPa</td>
<td>HectoPascals</td>
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<td>IATA</td>
<td>International Air Transport Association</td>
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<td>ICAO</td>
<td>International Civil Aviation Organisation</td>
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<td>IFR</td>
<td>Instrument Flight Rules</td>
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<td>IIC</td>
<td>Investigator in Charge of an Air Accident Investigation</td>
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<td>IMC</td>
<td>Instrument Meteorological Conditions</td>
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<tr>
<td>ITCZ</td>
<td>Intertropical Convergence Zone</td>
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<tr>
<td>kg</td>
<td>Kilogram(s)</td>
</tr>
<tr>
<td>km</td>
<td>Kilometre(s)</td>
</tr>
<tr>
<td>Kt</td>
<td>Knot(s) - nautical mile per hour</td>
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<tr>
<td>m</td>
<td>Metre(s)</td>
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<tr>
<td>M</td>
<td>Magnetic</td>
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<tr>
<td>METAR</td>
<td>A description of weather at an aerodrome at a certain time, issued in ICAO compliant code</td>
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<tr>
<td>MIT</td>
<td>Massachusetts Institute of Technology</td>
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<td>MSA</td>
<td>Minimum Safe Altitude</td>
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<tr>
<td>Mountain Flying</td>
<td>Any technique involving the manoeuvring of an aircraft through, over, or around terrain that could be perceived as an obstacle to the aircraft or weather path</td>
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<tr>
<td>NTSB</td>
<td>National Transportation Service Board</td>
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<td>PFS</td>
<td>Pacific Flying School</td>
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<td>PIC</td>
<td>Pilot in Command</td>
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<td>PIREPS</td>
<td>Pilot reports</td>
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<td>PPL(A)</td>
<td>Private Pilot Licence (Aeroplane)</td>
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<td>PQ’s</td>
<td>Protocol Questions</td>
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<td>RPM</td>
<td>Revolutions per Minute</td>
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<td>RTF</td>
<td>Radiotelephony</td>
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<td>S</td>
<td>South</td>
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<td>Abbreviation</td>
<td>Full Form</td>
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<tr>
<td>SARTIME</td>
<td>Search and Rescue notification time</td>
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<td>SIGMET</td>
<td>Significant weather information critical to aircraft safety</td>
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<td>SMS</td>
<td>Safety Management System</td>
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<td>SO</td>
<td>Safety Officer</td>
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<tr>
<td>SPCZ</td>
<td>South Pacific Convergence Zone</td>
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<td>SPECI</td>
<td>An aviation weather report issued when certain weather conditions change adversely or improve by certain criteria.</td>
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<td>SSP</td>
<td>State Safety Programme</td>
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<td>STAMP</td>
<td>Systems-Theoretic Accident Model and Process</td>
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<tr>
<td>TAF</td>
<td>Terminal Area Forecast, and is the weather forecast at an aerodrome, issued in ICAO compliant code</td>
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<td>TAIC</td>
<td>Transport Accident Investigation Commission</td>
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<td>TAWS</td>
<td>Terrain Alert Warning System</td>
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<tr>
<td>Tech Log</td>
<td>A log of aircraft defects and aircraft operating hours that is kept in the aircraft</td>
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<td>TCAS</td>
<td>Traffic Collision Advisory System</td>
</tr>
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<td>USOAP</td>
<td>Universal Safety Oversight Audit Programme</td>
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<tr>
<td>UTC</td>
<td>Coordinated Universal Time</td>
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<tr>
<td>VFR</td>
<td>Visual Flight Rules</td>
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<td>VMC</td>
<td>Visual Meteorological Conditions</td>
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<td>VNC</td>
<td>Visual Navigational Chart</td>
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<tr>
<td>VOR</td>
<td>Very High Frequency Omni-Directional Radio Range</td>
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<tr>
<td>WGS</td>
<td>World Geodetic System. This refers to a system of geographic coordinates used in cartography.</td>
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INTRODUCTION

Fiji is a Member State of the International Civil Aviation Organisation (ICAO). It therefore agrees to abide by the rules of the Convention on International Civil Aviation.

Annex 13 to the Convention on International Civil Aviation, states that the sole objective of any aircraft accident investigation and its final report is to prevent future accidents and incidents; it is not to apportion blame or liability. Fiji’s Civil Aviation (Occurrence Reporting and Investigation) Regulations 2009 together with the Civil Aviation Authority of Fiji’s (CAAF) Manual of Occurrence Reporting and Investigation supports and embodies the requirements of Annex 13 of ICAO. The reader is cautioned from drawing any inferences from the text of this report that could imply or suggest blame or responsibility, as it is not the purpose of the report to clarify or confirm possible references to attributions of responsibility or liability.

However, the investigation report must include factual material which is relevant and supports the conclusions reached. This material may contain information which at times could reflect on the performance of individuals and organisations, and how their actions may have contributed to the outcomes under investigation. ICAO recommends that a cause be reported even though blame or liability may be inferred from the statement of that cause. It is therefore necessary 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.

Furthermore, it is important to bear in mind that accident investigations do not always identify one dominant or ‘proximate’ cause. Often, an aviation accident is the last event in a chain of several events or factors, each of which may contribute to a greater or lesser degree, to the final outcome.

Fijian legislation prevents the use of information gathered throughout the course of this investigation for anything other than the prevention of accidents and incidents. Moreover, in order to encourage the flow of information to facilitate future investigations and accident prevention, it allows sources of information collected under this process, to remain confidential.

Conduct of the Investigation

The accident occurred on the 26th of February 2018. The Investigator in Charge (IIC) was appointed two days later, after the wreckage was found on the morning of the 28th of February 2018. He travelled to Fiji the next day, arriving in Labasa late on Thursday the 1st of March 2018. An inspection of the crash site by helicopter on the 2nd of March was prevented by bad weather. The earliest that ground search parties could methodically identify and prepare the wreckage for recovery by helicopter was the 7th of March 2018. A helicopter recovered the wreckage the next day.

The wreckage was transported to a location that remained under the guard of the Fijian Military for the duration of the investigation. Here it was inspected with the assistance of a New Zealand Aircraft Maintenance Engineer, who was qualified to both New Zealand and Fijian requirements and experienced in servicing aircraft similar to the accident aircraft. A New Zealand metallurgist experienced in assessing metallurgical failures in the aviation industry was also engaged to assess some detailed aspects of the wreckage.
The international company that helped to implement the ADS-B\(^1\) aircraft surveillance system in Fiji was engaged to help interpret the information provided by the ADS-B system, so that the whole flight path, including its final phase, could be comprehensively analysed.

This investigation was carried out by a company specialising and experienced in Air Accident Investigation and Forensic Engineering and which is based in Auckland, New Zealand. The investigation process and report were carried out in accordance with ICAO requirements and the Fiji regulations mentioned above.

Andrew McGregor, Prosolve Ltd
Investigator in Charge
October 2018

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\(^1\) ADS-B stands for Automatic Dependent Surveillance-Broadcast. It logged the flight path of the aircraft in terms of altitude, position, ground speed and track, and broadcast this information to the ATM centre at Nadi, which was later interrogated.
1 FACTUAL INFORMATION

1.1 History of the flight

1.1.1 The accident flight was flown as a training flight, with an instructor as Pilot in Command (PIC), and a student. The student’s training was being provided by the Pacific Flying School (PFS) at Nadi.

1.1.2 The aircraft departed from Nadi at 7:03 am on the 26th of February and arrived at Labasa at 8:40 am. This was the first leg of a four-leg cross country flight training exercise. The other destinations planned were Savusavu and Nausori, before returning to Nadi as the final destination.

1.1.3 It is likely that the accident student pilot downloaded the aviation general area forecast from the Fiji Meteorological Service aviation website and printed it out on the Pacific Flying School’s printer, as was common practice. At that time of the day, there were no Terminal Aerodrome Forecasts (TAF’s)\(^2\) yet published for Labasa or Savusavu. Nor were there any actual weather reports (METARS)\(^3\) from Labasa or Savusavu. Instead only a General Area Forecast\(^4\) had been published by the Fiji Meteorological Service.

1.1.4 The general area forecast showed isolated heavy showers with the greatest deterioration forecast in the afternoon and evening.

1.1.5 The accident flight was training preparation for a 300 nautical mile cross country flight that the accident student pilot was required to undertake as Pilot in Command (PIC)\(^5\) for her Commercial Pilot Licence (CPL). Although she had already flown this exercise with the same accident flight instructor the previous year in November 2017, she elected to fly it again with this accident flight instructor, as it had been some time since she had flown it previously. As she was not yet qualified to carry passengers, the accident flight instructor’s presence as PIC allowed her to bring a close friend for part of the journey who alighted at Labasa and did not continue with the rest of the flight. For these reasons, this report refers to the accident flight instructor as PIC and not the accident student pilot, even though the accident student pilot was named as PIC on the flight plan.

1.1.6 The friend of the accident student pilot was also a student pilot of the Pacific Flying School, who had not yet flown solo.

1.1.7 After departing Nadi, the aircraft followed the Northwest coast of Viti

\(^2\) A TAF stands for ‘Terminal Area Forecast’ and is the weather forecast at an aerodrome, issued in ICAO compliant code.

\(^3\) A METAR is the actual weather at an aerodrome at a certain time, issued in ICAO compliant code.

\(^4\) A General Area Forecast is weather forecast for a particular area, written in ICAO compliant code.

\(^5\) As required by para 3.5.2 of the CAAF Standards Document relating to Flight Crew Licensing.
Levu before flying over the stretch of ocean between Viti Levu and Vanua Levu. The weather was fine, with high cloud cover and some lower cloud close to the sea surface.  

1.1.8 The friend of the accident student pilot advised that on approaching Labasa aerodrome\(^7\), a band of rain was seen at Labasa township, and that the cloud base was approximately 2,000\(^8\) feet. The aircraft landed at Labasa aerodrome at 8:40 am in dry conditions.

1.1.9 After landing, the friend of the accident student pilot observed the two pilots check the contents of the fuel tank of the aircraft and declare that the contents were sufficient for the aircraft to return to Nadi.

1.1.10 Soon after this, mobile phone photos were taken of each other\(^9\). It then started to rain heavily.

1.1.11 The accident student pilot asked her friend if she could borrow her mobile phone to post some of the photographs on Instagram, as the accident student pilot did not have sufficient data to do that with her phone. The friend of the accident student pilot obliged, and several photos were posted on Instagram. One of the photos that the accident student pilot posted on Instagram may be referred to in Fig C1 of Appendix C of this report.

1.1.12 At 9:18 am, the accident flight instructor’s mobile phone received a call from the manager at the Pacific Flying School (PFS). When interviewed in relation to this investigation, the manager stated that a prospective student had requested an introductory flight at Nausori. The manager phoned the accident flight instructor to ask if it was possible for the accident student pilot to relieve the accident flight instructor briefly while he carried out this introductory flight, if and when they arrived at Nausori.

1.1.13 According to the manager at the Pacific Flying School, the introductory flight was never confirmed to the prospective student, as it depended on the weather at Labasa and whether or not it would improve sufficiently to allow the aircraft to depart. It would also require the accident student pilot to approve this interruption to her flight schedule at Nausori. According to the manager, this approval was never received from the accident student pilot.

1.1.14 The manager also stated that the accident student pilot was encouraged to wait at Labasa until the weather improved, even though

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\(^6\) From photos taken by the friend of the student pilot who flew as a passenger on the flight from Nadi to Labasa.

\(^7\) Labasa aerodrome is also named Waigele Airport. The name for Labasa aerodrome in this report will be referred to as ‘Labasa’ as that is the name referred to in Fiji aviation terminology.

\(^8\) Unless stated otherwise, all heights in this report are stated above sea level.

\(^9\) Some of these photos were recovered on the mobile phone of the student pilot’s friend.
the aircraft and the accident flight instructor were due back in Nadi for another flight training lesson at 12:00 midday.

1.1.15 At 9:47 am the accident flight instructor phoned a colleague of his who was based at Nausori. This colleague was also a flying instructor. When interviewed in relation to this accident, the colleague stated that he provided a weather report of Nausori’s weather to the accident flight instructor, which at the time indicated a visibility of at least 10km and a cloud base of 2,500 feet. The colleague cautioned his friend about the weather at Vanua Levu as he knew that a trough had been forecast at Vanua Levu and pilots of another commercial flying organisation had advised that the weather there was deteriorating from the North.

1.1.16 The accident flight instructor advised his colleague that he was aware that a trough was approaching from the North and that the weather near Labasa was ‘closing in’. When the colleague asked him what height he would choose to fly over the mountains of Vanua Levu, the accident flight instructor replied 7,500 feet.\(^{10}\)

1.1.17 At approximately 10 am the friend of the accident student pilot left Labasa aerodrome to catch a bus to visit her friends. When interviewed in relation to this investigation, the friend stated that the accident flight instructor’s intentions were to wait for the weather to clear over the mountains, and if it didn’t clear, they would depart via the coast. The friend also stated that she did not hear or see the accident pilots review updated weather information.

1.1.18 Between 10 am and 11 am the mobile phone of the accident student pilot received two calls from her mother. When interviewed in relation to this investigation, the mother of the accident student pilot explained that the purpose of the call was to advise weather information that had been received from the family’s relatives at Savusavu. They reported that it was raining heavily at Savusavu.

1.1.19 The mother confirmed that the purpose of the flight to Savusavu was for flight training purposes and not to visit relatives. The accident flight instructor advised the Savusavu Flight Information Service Officer (FISO)\(^{11}\) in radio communications that their attentions at Savusavu were to ‘touch and go’ implying that they were not intending to disembark at Savusavu\(^{12}\).

\(^{10}\) The colleague advised that this height of 7,500 feet is typically chosen to enable an aircraft with only one engine glide to a forced landing site on either side of the mountain range, should the engine fail.

\(^{11}\) An FISO provides flight information to arriving and departing flights from an aerodrome. Unlike an Air Traffic Controller at Nadi or Nausori which is required to control the movement of aircraft, the role of an FISO is to provide information only. This abbreviation may also be used to indicate a Flight Information Service Office.

\(^{12}\) The term ‘touch and go’ landing refers to a landing in which the aircraft does not stop, but immediately takes off again, in this case to its next destination.
1.1.20  Shortly before 11 am as per normal practice, the Labasa FISO issued a weather report to the Fiji Meteorological Service (FMS) to enable the FMS to issue an 11 am METAR for Labasa. The Labasa 11 am METAR stated that visibility was 30km in rain, some cloud was scattered with a base at 2,000 feet, some cloud was broken with a base at 4,000 feet and other cloud was overcast at 8,000 feet. It also stated that there was a light wind from the north west of 8 knots.

1.1.21  At approximately 11:10 am a Fiji Link Twin Otter aircraft landed. It departed at approximately 11:27 am.

1.1.22  After approximately three hours of waiting for the weather to improve at Labasa, the pilots departed Labasa for Savusavu at 11:37 am, reporting to the Labasa FISO after take-off, an estimated time of arrival at Savusavu of 12:00 midday.

1.1.23  At this time, the FISO at Labasa did not consider that the weather had deteriorated to a level that required a SPECI to be issued. The FISO also stated that even though the weather was deteriorating at the time that the accident aircraft departed, conditions had not reduced to below the minimum required for Visual Flight Rules (VFR) flight.

1.1.24  The ADS-B data shows that the accident aircraft climbed to a maximum height of 6,000 feet while carrying out several orbits and part turns. In doing so its speed varied from 55 knots to 145 knots. Additional technical data derived from the ADS-B signals and radio transmissions that the accident aircraft transmitted may be found in Section 1.9 of this report, titled ‘Communications and Aircraft Tracking (ADS-B) Information’. Some of this information is stated in summary form below in order to complete this narrative.

1.1.25  At 11:43 am, the Fiji Link Twin Otter that departed Labasa just before the accident aircraft and was flying to Nausori, contacted Savusavu FISO and relayed the weather at Savusavu to the accident aircraft.

1.1.26  Five minutes later at 11:50 am the accident flight instructor obtained a similar report direct from Savusavu FISO.

1.1.27  At 11:54 am, after changing his mind once, the accident flight instructor reported that he had decided to return to Labasa.

1.1.28  Approximately 10 seconds before the decision was made to turn back to Labasa, the accident aircraft began to descend below 6,000 feet.

1.1.29  At 11:55 am the Labasa FISO contacted a Fiji Link commercial flight that was planning to land at Labasa in order to advise the intentions of the accident aircraft which was to return to Labasa, the estimated time of arrival of the accident aircraft being 12:15 pm.

1.1.30  At 11:56 am, the Fiji Link commercial flight advised Labasa that its estimated time of arrival at Labasa was 12:07 pm. Shortly after this time, the accident aircraft advised that its altitude was 3,200 feet.

1.1.31  Shortly after these communications, the Labasa FISO relayed the
inbound estimated time of arrival of the commercial aircraft to the accident aircraft and advised that the visibility at Labasa had reduced to 5,000 metres.  

1.1.32 At approximately 11:57 am, the accident flight instructor briefly acknowledged receipt of this information. This was the last communication from the accident aircraft. At this time the ground speed\textsuperscript{14} of the aircraft had increased to 130 knots and the aircraft was below 3,000 feet and descending.

1.1.33 The Labasa and Savusavu FISO’s attempted to contact the accident aircraft after its last communication but it continued to fly for approximately three and a half minutes after this last call.

1.1.34 After the aircraft’s last communication, its height reduced to 2,000 feet. Between 2,000 and 3,000 feet, the ground speed of the aircraft varied between 130 knots and 65 knots. The speed variation was greater below 3,000 feet than above 3,000 feet.

1.1.35 The likely time of impact according to the ADS-B information was 28 seconds past 12:00 pm midday.

1.1.36 The pilots flying the Fiji Link commercial flight approaching Labasa observed the presence of the accident aircraft on their TCAS instrument and saw its height trend indication change momentarily from descending to climbing and back to descending before it disappeared\textsuperscript{15}.

1.1.37 At 12:00 pm midday the Labasa FISO advised the Fiji Link commercial flight approaching Labasa that visibility there had reduced to 3,000 metres.

1.1.38 At the time of the accident, two Doguru villagers were tending to their crops in an area near the crash site; one was working in the valley below and the other on a ridge to the West of the crash site. They both stated that they could not see the tower at Delaikoro because of heavy rain and mist. Both witnesses heard the sound of the accident aircraft engine noise change, as if it’s RPM\textsuperscript{16} or ‘engine revs’ were changing. They both also heard a loud bang soon after that, around midday.

1.1.39 The village witness who was working in the valley below the crash site saw the aircraft circle three to four times before disappearing into fog

\textsuperscript{13} Visibility of 5,000 meters is the minimum visibility required for flight under Visual Flight Rules in the class of airspace that relates to Labasa aerodrome and the mountainous region of Vanua Levu.

\textsuperscript{14} The term ‘ground speed’ indicates the speed of the aircraft to a stationary observer located on the ground.

\textsuperscript{15} TCAS stands for Traffic Collision Advisory System and is an instrument that advises pilots the movement of other traffic. The accident aircraft did not have this instrument, and nor would it be usual for it to be required on that type of aircraft.

\textsuperscript{16} RPM – Revolutions per Minute
or cloud. This witness heard the loud bang one to two minutes after it disappeared behind cloud or fog. The other witness could hear the aircraft but did not see it because of fog or cloud.

1.1.40 Fiji newspapers documented other similar eye witness accounts.

1.1.41 Maps of Vanua Levu showing both the planned flight path and the ADS-B plot of the aircraft flight path from Labasa to the crash site are shown pictorially below.

![Map of Vanua Levu showing the planned flight from Labasa airport to Savusavu airport and the crash site](image)

**Fig 1:** Map of Vanua Levu showing the planned flight from Labasa airport to Savusavu airport and the crash site
**Fig 2:** A Google Earth perspective view of the accident flight path and accident site provided by ADS-B data
1.1.42 More details of the accident flight path as provided by the ADS-B data are introduced in Section 1.9 ‘Communications and Aircraft Tracking (ADS-B) Information’. ADS-B technical data may be found in Appendix B.

1.2 Injuries to persons
The injuries to the occupants of the aircraft are summarised in the following table.

<table>
<thead>
<tr>
<th>Injuries</th>
<th>Crew</th>
<th>Passengers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal</td>
<td>2 (Fijian)</td>
<td>0</td>
</tr>
<tr>
<td>Serious or</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>minor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2 (Fijian)</td>
<td>0</td>
</tr>
</tbody>
</table>

1.3 Damage to the aircraft
1.3.1 The aircraft collided with a near vertical rock cliff face and was completely destroyed. The impact was not survivable. A detailed description of damage to relevant aircraft components and systems is included in Section 1.12 - Wreckage and Impact information.

1.4 Other damage
1.4.1 No other significant damage was caused.

1.5 Personnel information
1.5.1 The Pilot in Command (PIC), aged 32, held a current Commercial Pilot’s Licence (CPL) and a Flight Instructor’s rating. He obtained an Assistant Flight Instructor Rating on the 12th of November 2016. He successfully passed a Flight Instructor Rating Test on the 1st of September 2017 following which his qualification status was upgraded from an instructor under supervision to a full instructor without supervision. This enabled him to authorise students on solo cross-country training flights without first clearing it with the Chief Flying Instructor (CFI). His Flight Instructor Rating was current to the 31st of August 2018. He did not possess an Instrument Flight Rating (IFR)\footnote{An IFR rating allows a pilot to fly in cloud without reference to a visual horizon.} and was not qualified to fly by sole reference to an aircraft’s flight instruments.

1.5.2 In addition to the minimum of 10 hours of instrument flight time that was required for his Commercial Pilot Licence, the PIC gained instrument flight time experience in the Pacific Flying School’s synthetic trainer. His log book shows 24 hours as an instructor and 10
hours as a student at the synthetic trainer. He had also flown 4 real flight hours as instructor for other students who were undertaking basic instrument flying skills on a basic panel while ‘under the hood’.

1.5.3 The PIC held a Class 1 medical certificate which was valid until the 4th of September 2018.

1.5.4 The PIC began his flight training in December 2009 and this was with Pacific Flying School (PFS). His total experience at the time of the accident was 1,257 hours. All of his commercial flying consisted of flight instruction. His experience over the past 90 days amounted to 273 hours. He had flown 16 ½ hours over the past 7 days, and 3 hours over the past 24 hours. All his flight training and flight instruction had been undertaken with PFS.

1.5.5 The duty time report for the PIC between the 12th and 25th of February (14 days) indicated that he had been on duty a total of 108.8 hours in that time. Paragraph 5.3.3 of the PFS Operations Manual states that the maximum duty time for an instructor is 100 hours in any 14 consecutive days. The maximum flight time in any consecutive 28 days is 100 hours. The pilots log book showed that during this time he had flown 46 ½ hours.

1.5.6 When interviewed in relation to this investigation, the Pacific Flying School manager advised that the PIC often appeared to enjoy being at the flying school and at times had to be encouraged to leave the school and go home. A close relative of the PIC concurred, stating that he enjoyed working at the flying school and assisting students, and did not mind being there for long hours each day.

1.5.7 The duty time report showed that the PIC was not on duty at the Pacific Flying School on the 23rd and 24th of February.

1.5.8 The PIC had previously flown the accident route, which is also likely to have included a flight over the mountains near Delaikoro for the Labasa to Savusavu leg, on the 4th of October 2017, 15th of November 2017, 29th of December 2017, and the 9th of January 2017.

1.5.9 The PIC had also been a company Safety Officer (SO) for PFS. He received Safety Management System (SMS) training from CAAF in September 2015 and worked as a SO for PFS until September 2017, following which PFS appointed a Safety Manager. His SO duties required him to attend operational meetings twice a week and address any safety concerns that arose during the meetings. It also required him to investigate any minor incidents and raise any concerns to the attention of the Chief Flying Instructor and the Pacific Flying School Manager as

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18 ‘Under the Hood’ refers to simulated IFR flight generated by a portable hood being placed above and over a trainee pilot’s eyes, preventing the pilot from seeing the horizon.

19 Duty time is defined in the PFS Operations Manual as the undertaking on behalf of the operator of the aircraft, of any flight thereon (whether as passenger or crew) or of any function (whether or not inflight) on or in connection therein.
appropriate. He was also required to help prepare the flying school for the annual SMS audit undertaken by the regulator, the Civil Aviation Authority of Fiji (CAAF). The responsibilities of a Pacific Flying School Safety Officer are discussed more fully in Section 1.17 of this report titled, ‘Organisational and Management Information’.

1.5.10 In addition to the theory subjects for the Commercial Pilot Licence (CPL) qualification, the PIC of the accident aircraft had passed all the ground course subjects required for an Airline Transport Pilot Licence (ATPL) and an Instrument Flight Rules (IFR) rating. These included Meteorology, IFR ‘Instruments and Navigational Aids’ and IFR Law. The PIC had also worked as a ground instructor for the Pacific Flying School. Duties in this role included providing ad hoc individual tuition for the flying school’s students who were studying CPL and ATPL ground course subjects.

1.5.11 The Pacific Flying School manager stated that the PIC was well liked by the students of the flying school, as he would often go out of his way to help them, in whatever way he could. The management of the flying school considered him hard working and conscientious.

The Student Pilot

1.5.12 The student pilot who was 20 years old, began her training with Pacific Flying School in May 2016. At the time of the accident she had acquired 150 hours of flight training. In the last 90 days before the accident she had flown 14 hours, and in the last 7 days, had flown 1 hr.

1.5.13 She had last flown the accident route on the 15th of November 2017 and had undertaken this flight with the same instructor. However, her student lesson book did not have any instructor comments for this lesson, and nor were there instructor comments for other lessons she had completed.

1.5.14 She had completed all the courses required for her Commercial Pilot Licence, including Meteorology.

1.5.15 The student pilot possessed a Class I pilots medical which expired in November 2018. She also possessed a valid Flying Training Permit which allowed her to fly solo at an instructor’s discretion, and this was valid to the 25th of April 2018.

1.6 Aircraft information

1.6.1 The model designation of the accident aircraft DQ-FTR was a Cessna 172R and its serial number 17280169. It was manufactured in the United States in 1997 and first registered in Fiji in 2007. It held a current certificate of registration. It also possessed a valid Certificate of Airworthiness which was current to the 1st of May 2018.

1.6.2 The aircraft documentation included a current Certificate of Maintenance which was issued on the 29th of January 2018 and remained valid until the 29th of May 2018. It also included a Certificate of Release
to Service relating to the avionics equipment on the aircraft which verified that the aircraft avionics had been maintained appropriately.

1.6.3 The aircraft was subject to a heavy landing on the 2nd of October 2017. Following this, extensive repairs were required, and some components had to be replaced. A new firewall behind the engine was fitted and the engine was exchanged for an overhauled engine. Many engine accessories were replaced. These included both magnetos, the starter motor, the alternator, the ignition harness, the fuel pump, the fuel control unit and the manifold valve.

1.6.4 The aircraft flew again on the 2nd of February 2018 after four months of repairs and maintenance and after the overhauled engine had been installed. The last maintenance logbook entry on the 22nd of February 2018 indicated that the aircraft had flown 28.3 hours since the repairs were completed, and the overhauled engine was fitted. The number of flying hours between this time and the accident are unknown, as the flight Tech Log, which is normally kept in the aircraft, was not able to be recovered from the wreckage. However, based on the average number of flying hours per day that had already been logged, the unlogged additional time would be expected to be less than 15 hours.

1.6.5 The total recorded number of hours and landings that the aircraft had flown on the 22nd of February 2018 was 14,339.5 hours and 22,199 landings.

1.6.6 The engine had been overhauled by Aeromotive Ltd, an aviation engineering company based in Hamilton New Zealand. The model of the overhauled engine was a Lycoming IO-360-L2A, and serial number L-28144-51A. The engine overhaul documentation showed that the engine manufacturer’s instructions and all relevant Airworthiness Directives (AD’s) had been complied with. The aircraft propeller was manufactured by McCauley, model IC235/LFA7570 and serial number SD036.

1.6.7 According to Pacific Flying School fuel records that were logged on the day preceding the accident and the morning of the accident, the aircraft fuel tanks were full of fuel when the aircraft departed Nadi. This would have provided in excess of 5 hours total fuel endurance, based on a conservative fuel consumption rate.

Aircraft speed limitations and related information

1.6.8 The aircraft speed information below relates to the interpretation of aircraft ground speeds that the ADS-B data provided. The information in the Table 1 below is from the Pilot’s operating handbook and FAA\(^{20}\) approved airplane flight manual that was found in the wreckage of the aircraft and was also approved by the Civil Aviation Authority of Fiji.

\(^{20}\) FAA – Federal Aviation Administration
<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>SPEED (Knots indicated)</th>
<th>TERM</th>
<th>MEANING</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{NE}$</td>
<td>163</td>
<td>Never Exceed Speed</td>
<td>This must not be exceeded under any circumstances</td>
</tr>
<tr>
<td>$V_{NO}$</td>
<td>129</td>
<td>Maximum Structural Cruising Speed</td>
<td>This must not be exceeded except in smooth air and only with caution</td>
</tr>
<tr>
<td>$V_A$</td>
<td>99</td>
<td>Maximum manoeuvring speed at Maximum all up weight</td>
<td>The maximum speed at which full or abrupt control movements may be used without overstressing the airframe</td>
</tr>
<tr>
<td>$V_A$</td>
<td>92</td>
<td>Maximum Manoeuvring speed at Maximum all up weight</td>
<td>The maximum speed at which full or abrupt control movements may be used without overstressing the airframe</td>
</tr>
<tr>
<td>$V_{FE}$</td>
<td>110</td>
<td>Maximum flap extended speed, 10</td>
<td>The maximum airspeed at which the flaps may be lowered by 10 degrees</td>
</tr>
<tr>
<td>$V_Y$</td>
<td>79</td>
<td>Best rate of climb at sea level</td>
<td>The speed at which the aircraft will climb at its best rate</td>
</tr>
<tr>
<td>$V_X$</td>
<td>60</td>
<td>Best angle of climb at sea level</td>
<td>The speed at which the aircraft will climb at its best angle</td>
</tr>
<tr>
<td>$V_S$</td>
<td>44</td>
<td>Stall speed</td>
<td>The speed below which the aircraft will stall, or the minimum steady flight speed at which the aircraft is controllable</td>
</tr>
</tbody>
</table>

Table 1: Speed information for the accident aircraft

1.6.9 The PFS document that stipulates operating procedures for the Cessna 172 states that the normal climb speed for the aircraft is 85 knots and the normal descent speed is 100 knots.

1.6.10 The cruise speed of the aircraft depends on the power setting and atmospheric conditions. The PFS operating procedures specify a cruise
airspeed of 115 knots\textsuperscript{21} (True Airspeed\textsuperscript{22}) with the engine set at 2300 RPM. This relates to a power setting of approximately 75\% to 80\% of the engine’s maximum output.

1.7 Meteorological information

Weather information available on the day of the accident

1.7.1 The weather that was available on the day of the accident may be found in Appendix A. Included here are the ICAO compliant General Area Forecast\textsuperscript{23}, TAF\textsuperscript{24} and METARS\textsuperscript{25} as well as SPECIS\textsuperscript{26} and SIGMETS\textsuperscript{27}. This weather information is specifically required by ICAO and provided by the Fiji Meteorological Service (FMS) for aviators. These are discussed in the paragraphs to follow and are referenced in full in Appendix A.

1.7.2 Also available on the day were satellite cloud images, rain radar images and mean sea level synoptic charts. These are not specifically required by ICAO. The mean sea level synoptic chart is published for mariners. These are also discussed in the paragraphs to follow and are referenced in Appendix A.

1.7.3 At 7:03 am in the morning, when the accident aircraft departed, a general area forecast was available to the pilots. While there is no evidence that they downloaded it from the website of the Fiji Meteorological Website (FMS) and reviewed it, they probably did, since this was normal practice for pilots trained at PFS.

1.7.4 The general area weather forecast stated that a trough of low pressure lay over the Eastern part of the country. Isolated and occasional cumulonimbus (Cb) clouds, (thunderstorm showers) were predicted, with visibility at times less than 5,000 metres.

1.7.5 The General Area Forecast stated cloud cover would be scattered (1/8

\textsuperscript{21} Knots = nautical mile per hour

\textsuperscript{22} At sea level, the True Airspeed of an aircraft is approximately equal to the airspeed indicated on the aircraft airspeed indicator. As the aircraft climbs and the air becomes less dense, the value shown on the airspeed indicator will become less than the True Airspeed of the aircraft.

\textsuperscript{23} A General Area Forecast is a weather forecast for a general area, written in ICAO compliant code.

\textsuperscript{24} A TAF stands for ‘Terminal Area Forecast’ and is the forecast of weather at an aerodrome, issued in ICAO compliant code.

\textsuperscript{25} A METAR is the actual weather at an aerodrome at a certain time, issued in ICAO compliant code.

\textsuperscript{26} A SPECI is report is issued by the FISO or Air Traffic Controller when certain weather conditions change adversely or improve by certain criteria. This is an ICAO requirement.

\textsuperscript{27} A SIGMET is a significant meteorological advisory and in this context indicates the presence of embedded thunderstorms.
The General Area Forecast did not normally include separate mention of mountainous areas distinct from other parts of Fiji, and specific mention of mountainous areas was not included in this General Area Forecast.

Below the General Area Forecast statement, SIGMET 06 was issued. This stated the latitude and longitude co-ordinates of the boundary of embedded thunderstorm clouds forecast for between 10 am in the morning and 2 pm in the afternoon on the accident day, the 26th of February 2018. These were located to the North East of Vanua Levu and a plot of the SIGMET 06 area may be found in Appendix A. This plot shows that SIGMET 06 did not apply to Vanua Levu. It was located to the North East of the line of the low-pressure trough.

A Mean Sea Level Synoptic Chart was also available before the accident pilots departed at 6 am. This showed the islands of Fiji sandwiched between two low pressure troughs; one to the South West of Viti Levu and the other orientated North West to South East over the Northern part of Vanua Levu. According to the normal weather review practices at PFS, this synoptic chart was probably not reviewed by the accident pilots.

One PFS staff member involved in arranging weather for student pilots at the time of the investigation advised that it was normal practice at PFS to copy TAFS, METARS and General Area Forecasts from the Fiji Meteorological Service’s website into an MS WORD document so that it could be printed separately and carried with the pilot. The need to refer to other parts of the Fiji Meteorological Service website containing satellite cloud imagery and rain radar was optional, as these were not considered mandatory. Moreover, other commercial weather websites were considered more user friendly than the website hosted by the Fiji Meteorological Service.

A senior PFS staff member advised that it was not normal for pilots embarking on cross country training flights to review satellite cloud and rain radar images.

Satellite images of cloud build-up over Fiji would have been available at the time of departure, but due to the reasons explained above, it is unlikely that the accident pilots would have viewed these images, as this was not normally required at PFS.

No TAF’s or METARS of Labasa or Savusavu would have been available when the aircraft departed Nadi. This is because ICAO does not allow TAF’s to be generated unless these are able to be supported by real observations in the form of a METAR and/or Automatic Weather Station (AWS). There is no functional AWS at Labasa and a weather observation needed for a METAR could not have been recorded and sent to the FMS by the Labasa Flight Information Service Officers until after they had begun work at 8 am.
1.7.13 The first Terminal Aerodrome Forecast (TAF) that FMS published for Labasa was published at 8:12 am and was valid from 9 am until 6 pm that day. It forecast at least 10km visibility in rain showers with up to 2/8 of cloud cover at 700 feet, 3/8 to 4/8 of cloud cover at 1,700 feet and 5/8 to 7/8 cloud cover at 4,000 ft.

1.7.14 Between 10 am and 1 pm, there was a forecast 40% probability that thunderstorm rain showers would occur which would reduce visibility down to 4,000 metres. It is important to note that flight based on Visual Flight Rules requires at least 5,000 metres of visibility. However, the thunderstorm clouds from which the heavy rain would be falling, were forecast to only cover up to 2/8 of the sky at 1,600 feet, again implying that the thunderstorm cloud would be isolated.

1.7.15 The Labasa Flight Information Service Office issued METARS at 8 am, 9 am and 11 am. Of these, the 11 am METAR described the worst weather that Labasa experienced that morning. It stated that the visibility was 30km in rain, the cloud base was scattered (between 3/8 to 4/8 cloud cover) at 2,000 feet and broken (5/8 to 7/8 cloud cover) at 4,000 ft and overcast at 8,000 ft. These METARS, which may be found in Appendix A1, reflected better weather than the TAF’s predicted.

1.7.16 However, notwithstanding the reasonable weather that the Labasa METARS depicted, the accident pilots, after landing at 8:40 am, judged that the weather was too bad to continue and decided to wait for it to improve.

1.7.17 The rain radar images and the satellite cloud cover images may be viewed in Appendices A2 to A4. They reflect a different perspective to the Labasa METARS. However, it is unlikely that the accident pilots viewed these. They were waiting in the Labasa terminal building with limited facilities and did not have access to a computer. To view these, they would have needed to visit the Flight Information Service (FIS) tower and request access to the computer used by the Flight Information Service Officers (FISO’s). The rain radar and cloud cover satellite images are discussed in the Analysis section of this report.

1.7.18 In order to visit the FIS tower, they would have needed to ask to be transported there by the fire tender vehicle, as there is no other access to the FISO tower, which is located some distance away to the South of the terminal.

1.7.19 When interviewed in relation to this investigation, a Labasa FISO on duty at the time advised that such a request was not received from the accident pilots. The FISO advised that had such a request been issued, access to the FIS facilities would have been provided.

1.7.20 The Savusavu FISO on duty at the time of the accident was also interviewed in relation to this accident. That FISO did not receive any phone calls from either the accident flight instructor or the accident

28 This requirement is stated in Paragraph 111, Part VI of Fiji’s Air Navigation Regulations 1981
student pilot requesting updated weather information at Savusavu.

1.7.21 The call logs of the mobile phones of both the accident flight instructor and the accident student pilot were tracked with the help of a national call provider to determine the extent of any attempts to access meteorological weather reports. Neither pilot attempted to call the Fiji Meteorological Service or any Flight Information Service (FIS) or an ATM Flight Control Centre. Nor did the mobile phone of the accident flight instructor download satellite imagery and rain radar images from the website of the Fiji Meteorological Service.

1.7.22 The accident student pilot took a photo of a Fiji Link Twin Otter aircraft stationed on the tarmac adjacent to the Labasa terminal and posted this on Instagram while waiting for the weather to improve. The photograph may be viewed in Fig C1 of Appendix C. RTF\textsuperscript{29} transcripts (ref Appendix B2) indicate that it landed at approximately 11:09 am and departed at approximately 11:27 am. Other records show that the photograph was probably taken between 11:11 am and 11:20 am.

1.7.23 The Analysis Section 2.4 later in this report discusses this photograph as well as the satellite images and the rain radar, and relates these to the TAF’s and METARS and other weather information available at the time. It presents a hypothesis that possibly explains the decisions and actions of the accident Pilot in Command.

1.7.24 When interviewed in relation to this investigation, the Pilot in Command of the Fiji Link Twin Otter Aircraft advised that during his aircraft’s turnaround at Labasa, neither of the accident pilots consulted him about the weather that he had observed while flying to Labasa that morning. He stated that he had to carry out a full instrument approach to land at Labasa.

1.7.25 The weather report given to the pilots of the Fiji Link Twin Otter aircraft on approach to Labasa differs significantly from the Labasa METAR. The weather report that the Labasa FISO advised to the Twin Otter Link at 10:59 am on approach to Labasa was 15 kms visibility in light showers and with a scattered cloud base (3/8 to 4/8 cover) at 800 feet. The visibility of 15kms was confirmed at approximately 11:06 am. The RTF transcripts relating to this communication may be referred to in Appendix B1 of this report.

1.7.26 A Flight Information Service Officer who was on duty at the time the accident aircraft departed, advised that although weather conditions had not deteriorated to the extent that required the FISO to publish a SPECI weather report, they began to deteriorate after 11:30 am. That FISO confirmed that despite the deterioration that was observed at the time the accident aircraft departed, meteorological minima at Labasa aerodrome still satisfied that required for flight under Visual Flight Rules (VFR).

\textsuperscript{29} RTF = Radiotelephony
1.7.27 The Savusavu TAF was issued at 8:13 am and was valid from 9 am to 6 pm. It forecast the cloud to be scattered (3/8 to 4/8 cover) at 2,000 feet, with a 40% probability that between midday and 3 pm in the afternoon, visibility would reduce to 5,000 metres in thunderstorm rain showers, with few (1/8 to 2/8 cover) Cb’s\(^{30}\) at 1,700 feet. A similar TAF was issued for Savusavu at 11:23 am.

1.7.28 A SPECI was issued for Savusavu at 11 am. The 11 am SPECI stated visibility of 500 metres in heavy rain with cloud overcast at 700 feet.

1.7.29 There is no evidence that the accident pilots reviewed the Labasa and Savusavu TAF’s, METARs and the Savusavu SPECI that were issued that morning.

1.7.30 Helicopter pilots who were searching for the wreckage of the accident aircraft experienced significant turbulence, at times severe, on the afternoon of the accident day and also the following day.

1.8 Aids to navigation

1.8.1 The flight was conducted under Visual Flight Rules (VFR) without sole reliance on navigational aids and aircraft instruments alone. However, the aircraft was sufficiently equipped with avionics instrumentation to fly in accordance with Instrument Flight Rules, if required. The aircraft had two radios, two VOR\(^{31}\)’s one ADF\(^{32}\), one DME\(^{33}\) and one GPS.\(^{34}\) This equipment was covered by a telecommunications service licence which was valid from the 1\(^{st}\) of January 2018 until the 31\(^{st}\) of December 2018.

1.8.2 IFR approach and en route charts were found in the wreckage of the aircraft along with other documentation. The Minimum Safe Altitude (MSA) for an IFR flight from Nausori to Labasa is 4,200 feet. This track passes close to the crash site. For this track, 4,200 feet is the lowest altitude that an aircraft is able to fly IFR, below which it risks colliding with terrain.

1.8.3 The navigational aids at Labasa include a VOR and DME beacon. An instrument approach utilising the VOR and DME beacons is provided. At

\(^{30}\) Cb’s means cumulonimbus or thunderstorm clouds

\(^{31}\) VOR stands for Very high frequency Omnidirectional Radio Range and is emitted from a VOR Beacon near an aerodrome to allow an aircraft to approach an aerodrome in Instrument Meteorological Conditions (IMC). An aircraft’s VOR instrument detects the VOR signal and guides the aircraft towards the Beacon.

\(^{32}\) ADF stands for Automatic Direction Finder and is an instrument that detects a radio signal and guides the aircraft towards the signal.

\(^{33}\) DME stands for Distance Measuring Equipment and provides a digital readout of the distance between the aircraft and a DME beacon, which at Labasa is co-sited with the VOR beacon.

\(^{34}\) GPS stands for Global Positioning System and advises the position of the aircraft utilizing satellite technology.
the time of writing, an instrument departure procedure was not available at Labasa.

1.9 Communications and Aircraft tracking (ADS-B) Information

1.9.1 This section relates to the flight details from time that the accident aircraft departed Labasa to when it crashed. It summarises information derived from the ADS-B data and Radiotelephony communications (RTF) between the accident PIC and the Flight Information Service Officers at Labasa and Savusavu. Both sets of this information are data rich and may be referred to in Appendix B of this report. The paragraphs to follow in this section set out significant information that has been derived from this data. Before reviewing this data, it is necessary to consider how the ADS-B system works.

The ADS-B aircraft tracking system.

1.9.2 Automatic Dependent Surveillance — Broadcast (ADS-B) is a surveillance technology in which an aircraft determines its position via satellite navigation and periodically broadcasts it, enabling it to be tracked. The information can be received by air traffic control ground stations as a replacement for secondary surveillance radar, as no interrogation signal is needed from the ground. It can also be received by other aircraft to provide situational awareness and allow self-separation. ADS-B is “automatic” in that it requires no pilot or external input. It is “dependent” in that it depends on data from the aircraft’s navigation system.

1.9.3 ADS-B is becoming increasingly common in international airspace. ADS-B is an element of the United States Next Generation Air Transportation System and is currently mandatory in portions of Australian airspace. ADS-B equipment will become mandatory for some aircraft in Europe from 2017.

1.9.4 ADS-B enhances safety by making an aircraft visible in real time, to Air Traffic Control (ATC) and other appropriately equipped ADS-B aircraft with position and velocity data transmitted every second. ADS-B data can be recorded and downloaded for post-flight analysis as it has been in this investigation.

Relevant ADS-B and RTF information

1.9.5 The following information has been derived from RTF communication transcripts that may be found in Appendix B1 and ADS-B information that may be found in Appendix B2.

1.9.6 The ADS-B information has been derived from aircraft transponder data that was transmitted to the ADS-B computer facilities at the Nadi ATM Centre. Data interrogation and manipulation was undertaken by ERA, the company that assisted with the installation of the ADS-B system.

1.9.7 The aircraft ADS-B data density that was transmitted was two data
points per second.

1.9.8 The RTF transcripts show that at 23:31:15 UTC time or at 11:31:15 am FDT, the Labasa FISO advised the accident aircraft that at the airfield, wind was calm.

1.9.9 At 23:31:43 or 11:31:43 FDT, the accident aircraft advised the Labasa FISO that its intentions were to track to Savusavu and that it would not be climbing above 6,500 feet.

1.9.10 At 23:36:03 or 11:36:03 FDT, the accident aircraft advised the FISO at Labasa that it was rolling on runway 31. This means that it was taking off in a North-westerly direction. The prevailing wind at the time was from the North West at 8 knots.

1.9.11 The ADS-B data represented in DQ-FTR Altitude chart shown in Fig B7 shows that the aircraft became airborne at approximately 11:37 am, FDT.

1.9.12 The ADS-B electronic data shows that the aircraft commenced its first turn at 23:40:07 UTC or 11:40:07 am FDT while at 1,500 feet and at a speed of 111 knots. This speed later reduced to a minimum of 55 knots after it had reached a height of 1,925 feet. Interrogation of ADS-B data shows that it completed this turn at 11:41:08 am FDT, one minute after the turn began. By this time its height had increased to 2100 feet and its speed had increased to 102 knots, before continuing to climb.

1.9.13 The RTF transcript shows that during this first turn, at 11:40:46 am FDT, the aircraft advised the Labasa FISO that it’s Estimated Time of Arrival (ETA) at Savusavu was 12:00 midday.

1.9.14 Fig B3 shows the location on the ADS-B track plot where these two speeds of 111 knots (Tag 1) and 55 knots (Tag 2) were recorded. Fig B7 titled ‘DQ-FTR Altitude Chart’ shows the altitudes that the accident aircraft reached at the time that these speeds were recorded.

1.9.15 Interrogation of ADS-B data shows that at 11:41:50 am FDT the accident aircraft commenced several turns. During these turns, the speed ranged from 53 knots (Tag 3) to 147 knots (Tag 4). Fig B3 shows the location on the ADS-B track plot where these speeds were recorded. Fig B7 shows the altitudes of the aircraft that were recorded at these speeds. At 11:47:02 am FDT the aircraft stopped turning and continued to climb.

1.9.16 At 11:44:54 am FDT, a commercial flight that had just departed Labasa for Nausori, relayed to the accident aircraft the latest weather information at Savusavu.

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35 UTC means Coordinated Universal Time and is the international time reference system which Fiji refers to in weather forecasts. FDT is Fiji Daily Time and is exactly 12 hours ahead of UTC. 11:31:15 means 15 seconds after 11:31 am. Time expressed in this report is to Fiji Daily Time.
1.9.17 At 11:49:31, the accident aircraft contacted the Savusavu FISO who provided the accident pilots with the latest Savusavu weather. At 11:51:01 am FDT, the accident aircraft advised the Savusavu FISO that its intentions at Savusavu were to ‘touch and go and then proceed to Nausori’.

1.9.18 The ADS-B data shows that at 11:54:02 am FDT, the accident aircraft began to descend after reaching 6,025 feet. This is identified as Tag A on the figures and graphs in Appendix B2.

1.9.19 The RTF transcript shows that at 11:54:09 am FDT, after receiving additional weather information from Savusavu FISO relating to Labasa and Namena weather, the Pilot in Command of the accident aircraft decided to return to Labasa. This is identified as Tag B on the figures and graphs in Appendix B2.

1.9.20 The RTF transcript shows that at 11:55:40 am FDT, the Labasa FISO advised a Fiji Link flight FJ 81 inbound to Labasa, that the accident aircraft was returning to Labasa and that its estimate for Labasa was 12:15:00 pm FDT.

1.9.21 Soon after this, at 11:56:16 pm FDT, the accident aircraft advised the Labasa FISO that its altitude was 3,200 feet. (At this time the ADS-B data shows that the aircraft was at 3,550 feet).

1.9.22 At 11:56:22 pm FDT, the Labasa FISO advised the accident aircraft that the Fiji Link flight FJ 81 was estimating its arrival at Labasa aerodrome at 12:07 pm FDT and that the visibility at Labasa was 5,000 metres with a cloud base of 3,000 feet.

1.9.23 At 11:56:43 pm, the accident aircraft acknowledged receipt of this information. This was the last communication from the accident aircraft. This event is labelled Tag C on the figures and charts that may be found in Appendix B2.

1.9.24 Soon after this time at 11:57:09 pm FDT, the aircraft reached its greatest speed for this part of the flight. The speed reached was 133 knots at a height of 2,325 feet, and is labelled as Tag D in the figures and graphs that may be found in Appendix B2.

1.9.25 The aircraft continued to descend to 2,100 feet, and at this height its speed had reduced to 65 knots. This is the minimum speed for this part of the flight. This event is labelled as Tag E in the figures and graphs that may be found in Appendix B2.

1.9.26 Tags F, G and H relate to ADS-B data during the last minute of the flight. These are labelled on a track of the ADS-B plot in Fig B5. This information was not readily available during search and rescue activities immediately following the accident. The Google Earth ADS-B plot is not able to show the final descent into the cliff face. The final descent is shown graphically in figures B11 and B12.

1.9.27 Figs B11 to B13 show graphical data that highlights the variation of speed and altitude during the last minute of the flight that covers Tags
F, G and H. This will be discussed in detail later in the Analysis section of this report.

1.10 Aerodrome information

1.10.1 The Flight Information Service Office (FISO) at Labasa provides by radio communications, meteorological and other aviation information to pilots of aircraft arriving and departing Labasa. It is located in a small tower building on the Western side of the runway, and to the South of the terminal. It is not possible to access the Flight Information Service Office except by means of the fire crash tender vehicle.

1.10.2 The telephone number for the FISO is not listed specifically in the Fiji AIP manual, but a general phone number for Labasa aerodrome is provided which would after contacting, by means of a second action, allow a call to be put through to the Labasa FISO.

1.10.3 The Labasa section of the Fiji AIP manual includes a table that is titled ‘Meteorological Information Provided’. It is not clear whether this table indicates that at Labasa, a meteorological briefing is available.

1.10.4 A plan of the Labasa runway including an enlarged section of the Apron and terminal may be found in Appendix C; Figs C2 and C3.

1.11 Flight recorders

1.11.1 The aircraft did not have a Cockpit Voice Recorder (CVR) or Flight Data Recorder (FDR). In colloquial terms these comprise what is commonly known as the ‘black box’ of an aircraft. These devices are fitted for the purpose of air accident and incident investigation; a CVR records the last two hours of a conversation between the flight crew, the FDR records the last two hours of primary flight and instrumentation data. They are very useful aids in determining the cause of any crash or incident and the factors that contributed to the pilots’ decision making.

1.11.2 However, these investigation aids were not required by the Fiji Air Navigation Regulations for the accident aircraft, and nor would they be normally required in other countries.37

1.12 Wreckage and impact information

1.12.1 The aircraft crashed in mountainous terrain at 2,600 feet, less than one nautical mile North of Mt Delaikoro and close to the direct track between Labasa and Savusavu.

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36 AIP stands for Aeronautical Information Publication and is a manual of reference information for aviators.

1.12.2 The aircraft crashed into a near vertical rock face, while flying a Northerly heading. The crash site is shown Fig 3 below.

![Crash site](image1)

Fig 3: The crash site

1.12.3 After impacting the rock face, the aircraft broke up and fell into a tree which arrested the fall of the main fuselage, the fin, and both wings. Other items fell through the tree and were found wedged between rocks and trees some distance down the steep slope below the tree. A photograph of the wreckage in the tree is shown in Fig 4 below.

![Wreckage marker](image2)

Fig 4: Aircraft wreckage in a tree that was growing out of a cliff face.
1.12.4 Some of the items had partially separated at impact. To facilitate recovery, one wing was fully separated from the fuselage. During this process, the wing fell below the tree into vegetation below. It was later recovered.

1.12.5 The engine was found separated from the airframe and also separated from its propeller. Both the engine and propeller were found below the tree that had arrested the fall of most of the wreckage. Part of the engine crankshaft was found separately from the engine lying some distance below the engine on the steep slope.

1.12.6 Because of the precarious support of aircraft wreckage, it was not possible to inspect the wreckage in situ before it was disturbed by the helicopter recovery process.

1.12.7 In order to assist the helicopter recovery process, ground parties gathered main items such as the engine, propeller, a wing and a few other minor items together into two groups, which they marked with two blue plastic tarpaulins. One of the tarpaulins may be seen in Fig 3 above.

1.12.8 The wreckage was removed by helicopter to Doguru village where it was transported by truck to a location under the guard of the Fijian Military. Here the wreckage was inspected by a Licensed Aviation Maintenance Engineer (LAME) and a forensic engineer, both experienced in air accident investigation.

1.12.9 The leading edges of the propeller were examined. One of the blades exhibited a bend without significant gouges or chips at its leading edge. The other was less bent and had significant chordwise gouges and chips at its leading edge, consistent propeller rotation as it struck the rock cliff face. A photograph below depicts some of the damage to the leading edge of this propeller blade.

1.12.10 The substantial damage along the leading edge of the propeller blade indicates that the propeller blade was being driven by the engine at the time of impact.
Strike evidence of the tip of one of the propeller blades, indicating that the engine was operating at the time of impact. Secondary damage in the form of the score marks parallel to the axis of the blade is likely to have been caused after the initial impact as the wreckage fell down the cliff face.

The engine internals were examined. The engine crankshaft had broken off at the crank closest to the front of the engine. The con rod had left a witness mark where it had been pushed against the side surfaces of the crank shaft crank, while the crank was still turning, providing further evidence that the engine was delivering power at the time of impact.
1.12.12 Both wings exhibited damage similar to each other, with multiple impact folds on the undersides, consistent with the wings having contacted the cliff symmetrically. A photo of both wings located adjacent to each other is shown below.

![Left and right wings placed side by side, leading edges facing each other and both showing undersides.](image)

**Fig 6:** Left and right wings placed side by side, leading edges facing each other and both showing undersides.

1.12.13 The wing fuel tanks were inspected thoroughly. No fuel was found in the tanks. The fuel filters and fuel lines of each wing were also inspected, and these were found clean without contamination or debris.

1.12.14 The cables responsible for actuating the flight control surfaces such as the ailerons, elevator and rudder were examined for possible fraying and pre-existing defects that may have contributed to loss of control of the aircraft. While several cables had been severed, all the damage could be attributed to crash trauma and not pre-existing defects.

1.12.15 Trim tabs are small control surfaces on other major control surfaces designed to alleviate control loads on the pilot. This Cessna aircraft has a trim tab on its elevator control surfaces. Lowering the elevator control surface raises the tail and causes the nose to fall, allowing the aircraft to descend. Raising the elevator trim tab reduces the force that the pilot needs to apply to lower the elevator if the aircraft is required to descend.
1.12.16 The elevator trim is actuated by the pilot by means of a control wheel at the base of the instrument panel. This control wheel by means of steel cables, actuates a worm drive installed in the body of the tail plane, which in turn actuates the elevator trim tab. The worm drive was found in the full nose down position. This means that at the time of impact, the elevator trim tab was configured to allow the aircraft to naturally fly with a nose down attitude in a descending flight path.

1.12.17 The position of the flap actuator lever was in the full up position. The significance of this is that in bad weather with poor visibility, pilots are taught to slow the aircraft down by reducing the throttle setting and lowering the flaps ten \(^{38}\) degrees. The flaps were found fully retracted.

1.12.18 The instrument panel of the aircraft was totally destroyed by crash trauma. Most of the instruments including the GPS\(^{39}\) unit could not be found.

1.12.19 The aircraft appeared to have been well maintained, with evidence of significant recent repairs, as discussed previously in section 1.6; Aircraft Information.

1.13 Medical and pathological information

1.13.1 Samples were taken from the bodies of the deceased occupants and analysed by the Fiji Police Forensic Chemistry Laboratory. The results of the chemical analysis were interpreted by a toxicologist who is employed by the New Zealand National Poisons Centre. This interpretation concluded that although alcohol (ethanol) was found in both samples, with a relatively high concentration in the sample from the PIC, this chemical was most likely to have formed during the extended period which elapsed between the accident and the time the samples were taken. For this reason it is unlikely that the pilots were under the influence of alcohol at the time of the accident.

1.13.2 With respect to possible influences of drugs such as Kava and Marijuana, although the chemical analysis undertaken by the Fiji Police Forensic Chemistry Laboratory did not specifically test for these substances, there was no evidence, either from witness accounts or from the circumstances leading up to the accident, to indicate that the pilots were under the influence of these drugs.

1.13.3 A search of the PIC’s medical records identified no chronic or mental health conditions or regular use of medications.

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\(^{38}\) Lowering the flaps increases the camber of the wing and lowers the stall speed of the aircraft, thus improving stall safety margins at a lower flight speed which is sometimes safer in poor visibility.

\(^{39}\) The GPS is a navigational instrument that operates similar to a hand-held GPS instrument, the latter which can be purchased in retail stores.
1.14 Fire

1.14.1 There was no evidence of fire in flight or after the impact.

1.15 Survival aspects

1.15.1 The last minute of ADS-B data was difficult to access. This factor in conjunction with bad weather on the day, resulted in delays to finding the aircraft. The delayed search may have compromised the rescue of the pilots if they had survived the crash.

1.15.2 The aircraft did not have an Emergency Locator Transmitter (ELT)\(^40\) fitted. ELTs were required in Fiji before the ADS-B infrastructure was implemented in late 2010, following which ELT’s were no longer considered necessary because the ADS-B system was considered capable of providing more comprehensive tracking information than an ELT.

1.15.3 While the ADS-B system in this incident was less successful than desired from a search and rescue perspective, it is unlikely that an ELT would have been better. This is because ELT’s have a reputation for being unreliable, particularly in severe impact cases as occurred in this accident. Appendix D includes a policy document on ELTs published by the New Zealand CAA\(^41\) which states that ELTs perform as expected for only 27 to 43 percent of the time. The reason is that crash trauma often breaks off the ELT transmitter aerial, preventing it from transmitting an effective homing signal for search and rescue operations.

1.15.4 Another difficulty experienced during the investigation is that the map grid reference of the Fijian topographical maps conforms to WGS-72\(^42\) whereas the grid reference system for the Fiji Aeronautical chart, Google Earth and the ADS-B system conforms to WGS-84. The aviation and Google earth maps do not contain as much topographical detail as the Fijian topographical map, which despite it conforming to the WGS-72 system, still had to be referred to for ground search activities. Regrettably, the ADS-B track plot could only be laid over Google Earth, which is referenced to WGS-84.

1.15.5 Co-ordinates near the wreckage site and other locations provided by hand-held GPS devices and some mobile smart phones could not be reconciled consistently and reliably with known locations and landmarks. This may have been due to poor satellite signals in mountainous terrain, atmospheric conditions, the limited accuracy of the GPS units themselves and different WGS mapping systems.

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\(^40\) An Emergency Locator Transmitter (ELT) is a small radio transmitter that is designed to activate a radio frequency alert on impact. This broadcasts a homing signal for search and rescue operations.

\(^41\) ‘Domestic Policy for the Emergency Location of Aircraft’ Published by the NZ CAA, Dec 2015

\(^42\) WGS-84 stands for World Geodetic System-84 and refers to the geographic coordinate system used for the global positioning system (GPS) and Google Earth map displays. WGS-72 is an earlier cartography system which is not fully compatible with GPS and Google Earth mapping systems.
1.16 Tests and research

Tropical weather systems and low-pressure troughs

1.16.1 Because of the significance of adverse weather in this accident the investigation carried out research to gauge the current level of understanding of low-pressure weather troughs which are characteristic of tropical weather systems.

1.16.2 Information was readily available about temperate frontal systems and meteorological hazards such as ice, thunderstorms, tornadoes, mountain waves and tropical cyclones. However, although tropical low-pressure troughs are mentioned in several contexts, they were not discussed or explained to the same extent as other meteorological phenomena. For example the study guide for the Commercial Pilot Licence and Airline Transport Pilot Licence meteorology exams set by the Civil Aviation Safety Authority of Australia (CASA) introduced the concept of low pressure troughs within the context of Australia’s topography and adjacent continental features but they did not include an oceanic environment in the South Pacific.

1.16.3 There are indications that tropical low-pressure troughs are considered to be unpredictable, hard to characterise and difficult to forecast. Although these factors have adverse implications for aviation safety in the tropics, they have not been documented in a manner that could relay a warning for pilots in a way that could have prevented this accident. Only the paper by Kodama & Businger43 mentions the significance of the South Pacific Convergence Zone (SPCZ) on weather patterns in the South Pacific. The paper notes:

“Forecasting deep convection for the tropical Pacific presents a considerable challenge to the Pacific Region’s meteorologists. Large regions of the tropical Pacific are conditionally unstable on any given day and the use of traditional stability indices, such as convective available potential energy (CAPE) and the lifted index, often fail to provide meaningful assistance. In addition, the lack of sufficient surface and upper-air observations hinders attempts to define the stability or the potential trigger mechanisms such as mesoscale convergence zones and vortices”.

1.16.4 The Fiji Meteorological Service advised that low-pressure troughs and the early stages of tropical cyclones form by similar convection mechanisms. They too confirmed that it is well known and accepted within meteorological circles that convection mechanisms in the tropics are difficult to model and therefore difficult to forecast.

1.16.5 A paper published by the International Air Transport Association (IATA)

\[43\] Kodama & S Businger ‘Weather and Forecasting Challenges in the Pacific Region of the National Weather Service’ © American Meteorological Society
in 2016 identified the risks that these types of weather systems pose to international jet transport aircraft at their cruising levels which are typically 30,000 to 40,000 feet. The main risks discussed relate to turbulence and icing. Severe icing contributed to the crash of Air France 447 off the coast of Brazil in June 2009. The paper introduces and explains the weather phenomena of the Intertropical Convergence Zone (ITCZ) which is a general form of the South Pacific Convergence Zone (SPCZ) located to the North of Vanua Levu.

1.16.6 The IATA paper advises that convective weather cells in these types of weather systems responsible for severe turbulence and icing can be difficult to detect using conventional means. SIGMET weather reports are not included in the range of mitigation strategies discussed and Airborne Weather Radar (AWR) may not always be able to detect cells generating strong convective turbulence and icing.

1.16.7 A copy of the paper may be found in Appendix G of this report.

1.17 Organisational and management information

Introduction

1.17.1 This section presents information about the organisations that provided services in relation to the accident. These organisations are the Civil Aviation Organisation of Fiji (CAAF) as the regulator; the Air Traffic Management (ATM) services of Fiji Airports (FA) which manage air traffic co-ordination and control within Fiji including Flight Information Services at Labasa and Savusavu; the Fiji Meteorological Service (FMS); and the Pacific Flying School. As the International Civil Aviation Organisation (ICAO) promulgates requirements, procedures and safety systems which Fiji has agreed to comply with, ICAO’s contribution will also be discussed.

1.17.2 The way that some of these organisations relate to each other is illustrated and discussed in a document titled ‘Proposed improvements to Fiji Aviation Weather Information’ in Appendix F of this report.

The International Civil Aviation Organisation (ICAO)

1.17.3 The following paragraphs detail the role and purpose of the International Civil Aviation Organisation (ICAO).

1.17.4 ICAO is an international body set up to regulate the safety of international air travel. It formed in December 1944 during an event known as the Chicago Convention. The Convention recorded that “The undersigned governments having agreed on certain principles and arrangements in order that international civil aviation may be developed in a safe and orderly manner and that international air

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transport services may be established on the basis of equal opportunity and operated soundly and efficiently.” Over time a total of 191 countries have acceded to the Convention.

1.17.5 A copy of the Convention is included in Appendix G. It includes 96 articles, all of which prescribe how countries are required to relate to each other harmoniously and safely in International Civil Aviation affairs. In the years following the Convention, many technical annexes have been written to provide further support to these articles. One of these relates to the supply of meteorological services, and is discussed in the context of the Fiji Meteorological Service (FMS) below.

1.17.6 While the ICAO technical annexes specify in detail aspects such as the information required from a meteorological service provider, and also what is required of a Safety Management System, they do not specifically identify the detailed risks inherent in mountain flying and bad weather.

1.17.7 However, Annex 6; ’Operation of Aircraft’ recognises the importance of good weather for flight under Visual Flight Rules (VFR). Paragraph 4.3.5.1 of Annex 6 Part I states:

‘A flight to be conducted in accordance with the Visual Flight Rules shall not be commenced unless current meteorological reports or a combination of current reports and forecasts indicate that the meteorological conditions along the route or that part of the route to be flown under the visual flight rules will, at the appropriate time, be such as to enable compliance with these rules.’

1.17.8 With regards to the provision of meteorological services, Paragraph 9.2.1 of Annex 3 states that:

‘Briefing and/or consultation shall be provided, on request, to flight crew members and/or other flight operations personnel. Its purpose shall be to supply the latest available information on existing and expected meteorological conditions along the route to be flown, at the aerodrome or intended landing, alternate aerodromes as relevant, either to explain and amplify the information contained in the flight documentation or, if so agreed between the meteorological authority and the operator, in lieu of flight documentation.’

Annex 19; Safety Management System (SMS) and the State Safety Programme (SSP)

1.17.9 Annex 19 outlines the requirements of a State Safety Programme (SSP) and Safety Management System (SMS). Annex 19 became applicable in November 2013.

1.17.10 An ICAO set of presentation slides defines SSP as an integrated set of

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45 From the Preamble of the Convention on International Civil Aviation on the 7th Day of December 1944

46 An introduction to SSP and SMS by Hernandez and Chacin; SSP/SMS implementation Go Team workshop 30 June – 4 July 2014.
regulations and activities aimed at improving safety in an ICAO state\textsuperscript{47}. The slides explain that the SSP is made up of these three elements:

- Safety rulemaking - based on comprehensive analyses of the State’s aviation system;
- Safety policy development - developed based on hazard identification and safety risk management;
- Safety oversight - focused towards areas of significant safety concerns of higher safety risks.

1.17.11 The ICAO requirements of a Safety Management System (SMS) are explained in paragraphs below, in relation to the regulator, the Civil Aviation Authority of Fiji.

1.17.12 From time to time, ICAO conducts onsite audits of ICAO states such as Fiji, against the requirements and recommended practices outlined in the ICAO annexes. ICAO also subjects ICAO states to a continuous monitoring programme called Universal Safety Oversight Audit Programme (USOAP). The results of the USAOP continuous monitoring programme are promulgated on the ICAO website and are visible to other ICAO states. The results of the onsite audits are confidential to the regulator of each ICAO state. Both audit programs review the SSP and SMS activities of each state.

1.17.13 The USOAP audit process includes subjecting each state to a set of questions called ‘Protocol Questions’ or PQ’s. The questions address the following critical areas:

1. Primary aviation legislation and civil aviation regulations (LEG);
2. Civil Aviation Organisation (ORG);
3. Personnel Licensing and Training (PEL);
4. Aircraft Operations (OPS);
5. Airworthiness of Aircraft (AIR);
6. Aircraft accident and incident investigation (AIG);
7. Air Navigation Services (ANS);
8. Aerodromes and ground aids.

1.17.14 The last ICAO onsite audit of Fiji was undertaken in 2006. The results of this audit as they may relate to this investigation are reviewed in the Analysis Section 2.8.

1.17.15 The results of the USOAP and the relevance of the USOAP Protocol

\textsuperscript{47} In relation to this accident investigation, the ICAO state is Fiji.
Questions are also discussed in the Analysis Section 2.8

The Regulator, the Civil Aviation Authority of Fiji (CAAF)

1.17.16 Before 1970, Fiji was ruled as a UK colony and aviation in Fiji was governed by the UK Territorial Air Navigation Order. In 1970, Fiji received independence and aviation in Fiji was governed by the Ministry of Civil Aviation. In 1973 Fiji acceded to the Chicago Convention which is administered by the International Civil Aviation Organisation (ICAO). The Civil Aviation Authority of Fiji (CAAF) was formed in 1979 under the Civil Aviation Authority Act 1979.

1.17.17 With respect to the goals and objectives of Fiji’s aviation regulator, the Civil Aviation Authority of Fiji, Section 14 of the Civil Aviation Reform Act 1999 states that:

“(2) The authority... has the following safety-related functions:

(a) encouraging a greater acceptance by the aviation industry of the industry’s obligation to maintain high standards of aviation safety, through:

(i) comprehensive safety education programmes;
(ii) accurate and timely aviation safety advice; and
(iii) fostering an awareness in industry management, and within the community generally, of the importance of aviation safety and compliance with relevant legislation.

(b) promoting full and effective consultation and communication with all interested parties on aviation safety issues.

1.17.18 An example of the regulator’s efforts to foster an awareness of aviation risks and issue safety advice are the promulgation of Aviation Safety Bulletins (ASB’s). ASB’s that the regulator issued between the last quarter of 2012 and the first quarter of 2018 were reviewed for relevance to low pressure trough weather systems and mountain flying risks. Although there were articles about the risks of microbursts and thunderstorms which are a facet of low-pressure troughs, there were no articles that mentioned specifically the risks associated with mountain flying, or the unpredictability of low pressure trough weather systems, or when mountain flying occurs in a low-pressure trough weather system.

1.17.19 The Aviation Safety Bulletin dated the 30th of September 2014 identified the need to address the following risks in relation to bad weather:

- The dangers of taking off and landing when Cb activity is in close proximity to an airport;
- The meaning of a micro burst (Cb’s) and the dangers associated with it;
- Taking off and landing in marginal weather conditions at airports that do not have let down aids, i.e. low visibility and cloud base;
• The importance of having a back-up plan or escape route in the event of a sudden mechanical failure at a critical time or when operating in marginal weather conditions;

• The need to address possible safety hazards when assessing weather reports.

1.17.20 However, the ASB of 30 September 2014 did not mention the risks of tropical low-pressure trough weather systems or mountain flying.

1.17.21 The ASB dated February 2015 identified the following items as the focus of the regulator’s Safety Oversight Program:

• Bird strikes

• System/component failure or malfunction

• ATM/CNS (Air Traffic Management)

1.17.22 In general, the focus of the regulator’s Safety Oversight Program did not include the risks of tropical low-pressure weather trough systems or mountain flying.

The Air Navigation Regulation 1981 (ANR’s)

1.17.23 CAAF relies on the Air Navigation Regulation 1981 to prescribe fundamental rules and responsibilities for pilots and aviation organisations.

1.17.24 Regulation 31, in relation to the authority and duties of the Pilot in Command, with regards to flight planning and assessment of en route weather, states:

‘The pilot in command of an aircraft registered in Fiji shall ensure before the aircraft takes off- (a) that the flight can safely be made, taking into account the latest information available as to the route and aerodromes to be used, the weather reports and forecasts available, and any alternative course of action which can be adopted in case the flight cannot be completed as planned’

1.17.25 Regulation 69 of the ANR’s also states:

‘Subject to the provisions of regulation 31, (1) the pilot in command of an aircraft shall, whether manipulating the controls or not, be responsible for the operation of the aircraft in accordance with the provisions of these Regulations. (2) The pilot in command of an aircraft shall, before beginning a flight, familiarize himself with all available information appropriate to the intended operation. Pre-flight action for flights away from the vicinity of an aerodrome, and for all IFR flights, shall include a careful study of available current weather reports and forecasts, taking into consideration fuel requirements and an alternative course of action if the flight cannot be completed as planned.’
Minimum Weather Requirements for flights conducted under Visual Flight Rules (VFR).

1.17.26 Regulation 111 of the ANR’s states the meteorological minima required for Class G airspace, which includes the Labasa airport and the mountainous area of Vanua Levu, for the altitudes that the accident aircraft was flying. These are summarised as follows:

- For flight at or below 3,000 ft above sea level, or 1,000 ft above land, (whichever is the higher) the aircraft must stay clear of cloud and the pilots must be in sight of land or water. The pilots must also have 5,000 metres of visibility.

- For flight conducted higher than 3000 ft above sea level or 1,000 ft above land, (whichever is the higher) the aircraft must not fly less than 1,500 metres from cloud or be less than 1,000 feet vertically from cloud. The pilots must also have 5,000 metres of visibility.

Safety Management Systems (SMS)

1.17.27 The following paragraphs reproduce relevant excerpts from the standards document that CAAF have promulgated on their website, in order to provide guidance in relation to Safety Management Systems.

1.17.28 The preface of the CAAF standard on Safety Management Systems refers to the ICAO document 9859, 2006 amendment, as the basis for its promulgation. This document is freely available on the World Wide Web.

1.17.29 The CAAF standard defines a Safety Management System as ‘an organised approach to managing safety, including the necessary organisational structures, accountabilities, policies and procedures’.

1.17.30 The CAAF standard defines ‘Safety’ as ‘The state in which the risk of harm to persons or of property damage is reduced to, and maintained at or below, an acceptable level through a continuing process of hazard identification and risk management’.

1.17.31 The CAAF standard defines relevant terms. Three significant terms to this investigation are the terms: ‘Predictive, Proactive and Reactive’. They are defined in the CAAF standard as follows:

‘Predictive. Identify changes from trend analysis of risks being reported, safe work practices being updated, or additions to the Safety Program. Risk management is predictive and provides foresight. Monitoring is proactive and provides oversight, and safety reporting and investigation is reactive and provides hindsight.’

‘Proactive. Means the adoption of an approach which emphasises prevention, through the identification of hazards and the introduction of risk mitigation measures before the risk-bearing event occurs and adversely affects safety performance.’
‘Reactive means the organisation’s processes which are brought into play when an incident report or investigation is required. Safety reporting and investigation is reactive and provides hindsight.’

1.17.32 The CAAF standard in Paragraph 2.2.1 states that ‘a service provider shall have in place a Safety Management System (SMS) that is acceptable to the Civil Aviation Authority of Fiji, that, as a minimum:

- Identifies hazards and assesses and mitigates risks;
- Ensures the implementation of remedial action necessary to maintain agreed safety performance;
- Provides for continuous monitoring and regular assessment of the safety performance; and
- Aims at a continuous improvement of the overall performance of the safety management system.”

1.17.33 Paragraph 5.1 of the CAAF SMS standards states: ‘the service provider shall establish, maintain, and adhere to a Safety Management System (SMS) that is appropriate to the size, nature and complexity of the operations authorised, to be conducted under its operations certificate and the safety hazards and risks related to the operations’.

1.17.34 CAAF audits the Safety Management System of PFS annually. The results of the last PFS SMS audit before the accident are discussed later in this section under the title heading that relates to the Pacific Flying School.

State Safety Programme (SSP)

1.17.35 The Safety Management System (SMS) of each aviation service provider is part of Fiji’s State Safety Programme (SSP).

1.17.36 There are two documents that introduce the SSP. Both are available from CAAF’s website. One is titled ‘State’s Safety Programme Fiji’, the other is a Fiji Aeronautical Information Circular numbered AIC 05/13.

1.17.37 The executive summary of the document titled ‘State’s Safety Programme Fiji’ includes the following paragraphs.48

Paragraph (a) ‘the State Safety Programme includes a regulatory framework and activities within the State to ensure the discharge of the State’s obligations under the Chicago Convention.’

Paragraph (d) ‘In legal terms, the Standards Documents are the means by which compliance with the legislation may be demonstrated.’

Paragraph (f) ‘There shall be a Civil Aviation Authority of Fiji Safety Plan which shall include any variations to cover local needs.’

48 Not all the paragraphs in the executive summary are quoted here.
Paragraph (g) ‘By these means Fiji government can be assured, and
demonstrate as required, that Fiji aviation industry is meeting the agreed
international standards and that the regulatory oversight of the industry is
adequate.’

1.17.38 Under the title heading ‘safety policy’ of section 2.1 is stated in
paragraph (k):

‘Fiji’s commitment is to establish provisions for the protection of safety data,
collection and processing systems (SDCPS) so that people are encouraged to
provide essential safety-related information on hazards, and there is continuous
flow and exchange of safety management data between CAAF and
operators/service providers.’

1.17.39 A similar paragraph is stated in para 7.1.4(k) of AIC 05/13.

1.17.40 Under para 4.1 of the document titled ‘States Safety Programme Fiji’ is
stated:

‘The CAAF has established mechanisms to ensure that the identification of
operational hazards and management of safety risks by service providers follow
established regulatory controls (requirements, specific operating regulations
and guidance materials). These mechanisms include inspections, audits and
surveys to ensure that regulatory safety risk controls are appropriately
integrated into the service providers’ SMS, that they are being practiced as
designed, and that the regulatory controls have the intended effect on safety
risks’.

Certification of Aviation Training Organisations

1.17.41 The following paragraphs relate to requirements of Aviation Training
Institutions in Fiji, as they may relate to this investigation. These
requirements are stipulated by the Standards Document titled
‘Certification of Aviation Training Institutions’ which may be found on
the CAAF website.

1.17.42 Annex A relates to a Commercial Pilot Licence (Aeroplane) CPL(A)
consolidated training course that is completed in 150 hours of flight
training. Annex B relates to a CPL(A) training course that is completed
in 200 hours of flight training. Both annexes refer to the CASA day VFR
syllabus and require this to be followed in Fiji.

1.17.43 CASA is the Civil Aviation Safety Authority of Australia. This organisation
is Australia’s civil aviation regulator.

1.17.44 Paragraph 43.6 of Annex A and Paragraph 44.3 of Annex B specify the
minimum aeronautical experience requirements for a Commercial Pilot
Licence (Aeroplane) for both 150 hour and 200-hour courses
respectively. There are no requirements for mountain flying training or
experience. Nor are there training requirements stipulated for
addressing the risks of Fiji’s unpredictable tropical weather systems.

1.17.45 The requirements relating to accountable manager may be found in
section 9 of the standard. In this regard, Paragraph 9.1 states:
Para 9.1: ‘The Authority requires each applicant for the issue of a standard Aviation Training Certificate to engage, employ or contract a senior person identified as the Accountable Manager. He or she is to have the overall authority within the organisation, including financial authority, to ensure that the necessary resources are available to provide the training courses and assessments conducted by the organisation. The Accountable Manager is required to ensure that the organisation’s activities are carried out in accordance with their Aviation Training Certificate and to the standard required by the Authority.’

1.17.46 In addition to the Safety Management System, CAAF also audits the requirements of an Aviation Training Institute Certificate. (ATIC audit). The results of the last PFS ATIC audit before the accident are discussed later in this section under the title heading that relates to the Pacific Flying School.

1.17.47 The application for the issue of a Commercial Pilot Licence promulgated by CAAF stipulates the flying exercises that the student will be tested on. One of the subjects nominated is ‘weather interpretation’ however the various weather information instruments available to a pilot when evaluating weather are not identified in the list of items to be assessed. A cross country navigation exercise is not listed in the list of test exercises, nor is mountain flying. However low flying and poor visibility simulation are included in the list of flying exercises to be evaluated during the Commercial Pilot Licence flight test.

Harmonisation

1.17.48 The term “Harmonisation” relates to the aligning of rules and regulations to neighbouring ICAO States with a similar operational context. Harmonisation may be of interest to Fijian operators who have an interest in minimising the costs incurred when importing into Fiji, aircraft parts and operational and maintenance personnel from neighbouring ICAO States such as Australia and New Zealand.

1.17.49 Harmonisation may also be of interest to the regulator in harmonising with other ICAO states that have similar risks to Fiji, and have already developed guidelines and rules to address these risks. One such ICAO state is New Zealand which has similar risks to Fiji in the area of mountain flying.

1.17.50 For many years, CAAF has been considering the harmonisation with some, but not all parts of New Zealand aviation regulations. Areas that have been proposed for harmonisation with New Zealand include Part 61 of New Zealand regulations relating to Pilot licences, permits, approvals and ratings, and Part 135 relating to Air Transport Operations of small aircraft. Parts 61 and 135 of the New Zealand regulations require mountain flying training as outlined in the NZ CAA advisory circulars AC 061-3, AC 061-5 and AC 119-3 which may be found in Appendix D of this report.
Air Traffic Management (ATM) services of Fiji Airports (FA), previously Airports Fiji Ltd (AFL).

1.17.51 Fiji Airports is a Government owned commercial company established on the 12th of April 1999 under the Public Enterprise Act, 1996. It operates 15 airports in the Fiji Islands including Nadi and Nausori International airports and 13 other domestic airports which are located on islands distributed over Fiji’s maritime zone. Fiji Airports also provides Air Traffic Management (ATM) services within the Nadi Flight Information Region (Nadi FIR) and this includes the sovereign air spaces of Tuvalu, New Caledonia, Kiribati, Vanuatu, and Wallis and Futuna.

1.17.52 ATM services include the provision of Air Traffic Control Services at international airports of Nadi and Nausori, and Flight Information Services (FIS) at outer lying aerodromes such as at Labasa, Rotuma, Matei and Savusavu. FIS Officers (FISO’s) do not control aircraft but provide traffic and meteorological information to arriving and departing aircraft, as well as weather observations to the Fiji Meteorological Service. The meteorological services that the FISO’s provide are stated in paragraphs below.

1.17.53 FISO’s advise estimated cloud height and extent of cover as well as visibility to arriving aircraft. FISO’s have reference landmarks that they use to assess this information. Some commercial operators’ telephone FISO’s for the most up to date weather before they depart.

1.17.54 FISO’s do not normally advise departing aircraft cloud height, extent of cover and visibility, unless specifically requested. This and other weather information is provided at Nadi and Nausori International airports by way of a pre-recorded message that is available on a dedicated radio frequency. This information is referred to as an ‘ATIS’ report.

1.17.55 FISO’s provide weather observations to the FMS to enable the FMS to issue METARS and SPECIS every hour between 8 am and 4 pm, 7 days a week. Based on these observations, the FMS updates TAF’s as and when required.

1.17.56 FISO’s provide temperature and rainfall data in the form of ‘Synops’ to the FMS at 9 am, 12 pm and 3 pm.

1.17.57 The ATM centre at Nadi receives HF, CPDLC & ADS-C satellite position data from international commercial jet aircraft identifying aircraft positions. This information also includes meteorological data such as wind speed, wind direction and atmospheric temperature, which is communicated electronically to the FMS.

1.17.58 Air traffic controllers and FISO’s relay significant weather reports provided by pilots (PIREPS) to the FMS, as and when received.
1.17.59 The AIP⁴⁹ manual identifies that at Labasa, a personal meteorological briefing service is available, but only Nadi and Nausori Air Traffic Services (ATS) units are provided with meteorological information. (see NFNL AD 2.11)

1.17.60 A Flight Information Service Officer at Labasa advised that the Flight Information Service Office does have computer facilities and is able to access the Fiji Meteorological Service website and it is possible to view satellite cloud and rain radar images, though this is not done regularly and the FISO procedures do not require this information to be reviewed regularly by FISO’s.

1.17.61 A comprehensive summary of the interactions between ATM personnel and other aviation organisations and entities in Fiji, as they relate to the dissemination and feedback of weather information may be found in Appendix F of this report.

The Fiji Meteorological Service (FMS)

1.17.62 The Fiji Meteorological Service (FMS) is a Department of the Ministry of Disaster Management and Hydrological and Meteorological services of the government of Fiji. It is responsible for providing weather forecasts to Fiji and surrounding regions. The headquarters of the FMS is located in Nadi within walking distance of the Nadi control tower, the CAAF offices and the Pacific Flying School.

1.17.63 Since June 1995, the headquarters of the FMS in Nadi, has been one of six regional specialized meteorological centres within the World Weather Watch program of the World Meteorological Organization. The specialty of the FMS is forecasting tropical cyclones.

1.17.64 The FMS issues public and marine weather bulletins for Kiribati, Northern Cooks, Southern Cooks, Tuvalu, Tokelau, Niue, Nauru and Fiji.

1.17.65 The Fiji Meteorological Services, as per its agreement with the International Civil Aviation Organization, (ICAO) functions as the Meteorological Watch Office for the Nadi Flight Information Region (FIR), which extends from Western Kiribati to Tuvalu, Fiji, Vanuatu, Wallis and Futuna, and New Caledonia. It also provides certain aviation forecast services to Cook Islands, Christmas Island (Line Islands), Samoa, Niue and Tonga which are situated outside the Nadi FIR boundary.

1.17.66 FMS provides the following services to the Fijian aviation industry; TAFS, METARS, SIGMETS and SPECI weather reports as well as General Area Forecasts for pilots, in accordance with ICAO requirements. It also provides Mean Sea Level Synoptic Charts as well as satellite images of cloud movements every 30 minutes, and rain radar images every 10 minutes. It displays this information on its website and on TV sized

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⁴⁹ AIP stands for Aeronautical Information Publication and is a reference manual advising information and services available to aviators.
screens in its briefing offices.

1.17.67 FMS provides two weather briefing offices specifically for pilots. These are located at Nadi and Nausori International airports. It is also possible to provide weather briefings at the forecasting centre of FMS’ head office in Nadi.

1.17.68 When interviewed in relation to this investigation, an FMS representative advised that before 2012, weather briefings were provided in person to pilots at these briefing offices, during which hard paper copies of the weather information were also provided. Attendance at these briefings were logged by FMS.

1.17.69 However, after 2012, flying organisations and airlines requested soft copies of the weather forecasts from the FMS and these were provided. At the same time, the FMS posted weather information on its website. Since then, attendance to these briefing offices has become less frequent, to the extent that some briefing offices are no longer attended by pilots. Many pilots, when interviewed in relation to this investigation, were not aware that comprehensive weather briefings are available from the headquarters of the FMS 24 hours a day, seven days a week.

1.17.70 The headquarters of the FMS is located within walking distance of the Pacific Flying School (PFS) which operated the accident aircraft. As with many aviation operators in Fiji, this flying school has not required its instructors or student pilots to receive face to face briefings from FMS in recent times, including on the day of the accident.

1.17.71 The FMS representative stated that the advantage of face to face weather briefings, is that uncertain and intense systems such as low-pressure troughs can be explained and discussed more comprehensively than in emails and website images. The satellite cloud images and rain radar images provide a more comprehensive indication of weather trends when several images are looped together electronically on a large screen than when conveyed individually by email. Face to face weather briefings also provide an opportunity for weather forecasters to understand the concerns and interests of pilots and pilots are able to understand the uncertainties of some types of weather patterns, such as low-pressure trough systems.

1.17.72 A flight testing officer who was interviewed in relation to this investigation noted that most students prior to their flight test, when briefing him on the weather forecast applicable to the flight test, did not refer to satellite imagery of cloud or Mean Sea Level Synoptic Charts or rain radar images when describing the weather situation and assessing possible weather risks prior to the flight test.

1.17.73 Some pilots were interviewed to determine their preferred weather forecasting website. Five weather websites were identified that were being regularly referred to by pilots at the time of the accident, although different pilots preferred different websites for different reasons. Of these, the website of the Fiji Meteorological website was considered to be the least popular. Typical comments were that it was
not considered user friendly and, in some cases, its forecasts were perceived to be less accurate than those provided in other websites.

1.17.74 In relation to this investigation, one IT professional attempted to download aviation forecasts in the form of TAF’s and METARS from the FMS website using a modern smartphone. The TAF’s and METARS were unable to be downloaded reliably and consistently with ease. That IT professional therefore considered that the FMS website was not ‘mobile friendly’.

1.17.75 In response to some of these comments, a representative of the FMS stated that the FMS is required to comply with the requirements of ICAO which have strict requirements for the processes used to derive weather forecasts. One of these requirements prevents the FMS from relying on mathematical models without validation in the form of ‘ground-truthing’ which requires real field observations. Other commercial weather forecasting websites may not be so constrained.

1.17.76 That representative also stated that he considered that a face to face weather briefing was more essential than a user-friendly website that did not necessarily ‘ground truth’ all of its forecast modelling.

The Operator: The Pacific Flying School (PFS)

Background and History

1.17.77 The Pacific Flying School is one of four companies managed and operated by Joyce Aviation. The other three companies that Joyce Aviation manages are Heli Tours Fiji Ltd, Skydive Fiji Ltd, and Sunflower Aviation Ltd.

1.17.78 The Pacific Flying School (PFS) began in 1996 and was previously owned by Sunflower Aviation Ltd. PFS and Sunflower Aviation were taken over by Joyce Aviation in 2014.

1.17.79 At the time of the accident, the school operated 7 training aircraft and a synthetic flight simulator used for IFR training. It had 40 enrolled students and 5 instructors.

1.17.80 During December 2017, the manager of the Pacific Flying School was promoted to General Manager of Joyce Aviation.

1.17.81 At the end of January 2018, the person who was the administration manager for Pacific Flying School, was promoted to Flying School manager and became the accountable manager for PFS.

1.17.82 This person has worked for the flying school since 2002 and stated that since 2014, the school had grown in numbers and had been able to provide a higher level of flight instruction and professionalism. The accountable manager advised that the accident flight instructor

50 The process by which forecasts and the models that derived them are validated by real observations
contributed to that improvement as he was well liked by the students and often ‘went the extra mile’ to help them.

1.17.83 At the time of the accident, the organisational hierarchy was as depicted in the Pacific Flying School SMS manual, as described above.

Guidelines, procedures and documentation of PFS.

1.17.84 The operation of Pacific Flying School is controlled by procedures and guidelines set out in several documents which were reviewed as part of this investigation. The relevant documents are:

- Safety Management System (SMS) Manual;
- VFR (day) Aeroplane Training Manual;
- Pacific Flying School Operations Manual;


1.17.85 The paragraphs to follow outline significant sections of the manual as they may relate to this accident.

1.17.86 The manual includes a section that lists definitions, reflecting the definitions in the CAAF standards document. The definitions of ‘Predictive’, ‘Proactive’ and ‘Reactive’ are identical to those included in the CAAF standards document.

1.17.87 Under ‘Definitions’, The SMS manual defines ‘Accountable Executive’ as

‘the single, identifiable person who has the full responsibility for an organisation’s SMS, the full authority for human resources issues, the authority for major financial issues, direct responsibility for the conduct of the organisation’s affairs, final authority over operations under the certificate and final responsibility for all safety issues. The accountable Executive for Pacific Flying School is the Accountable Manager’.

1.17.88 The SMS manual defines ‘Safety Officer’(SO) as follows: ‘is the focal point for the development and maintenance of an effective SMS. Having the SO report directly to the CEO demonstrates that safety has equivalent level of importance in the decision making process as other major organisational functions. Regardless of the size of the organisation, a formal statement of the responsibilities and accountabilities is advisable. This statement clarifies the formal and informal reporting lines of the organisational chart and specifies accountabilities for particular activities.

1.17.89 Section 1.11 of the SMS manual sets out the Organisational Structure and Responsibilities and includes a diagram to represent the organisational structure. The term ‘Acting accountable manager’ is located at the top of the structure, to whom reports the Chief Flying Instructor, the Quality Assurance Officer, the Safety Officer and the administration officer.

1.17.90 Section 5 of the manual is titled ‘Management Forum and Review’. 
Section 5.1 sets out seven items of risk management responsibilities. These include aspects such as the monitoring and review of trends, incidents, ensuring corrective actions are implemented, review of significant changes to the organisation, and ensuring effective communication and feedback to employees.

1.17.91 Section 5.2 of the manual states the members of the Safety Management Review Committee as: Accountable Manager (Chairman), Chief flying Instructor and Safety Officer.

1.17.92 Section 5.3 of the SMS manual states that the committee will participate in a PFS meeting once a month, and that part of that meeting will involve SMS related issues. It infers that the SMS matters will be recorded in a meeting report template. The SMS manual includes a copy of that report template.

1.17.93 Section 8 of the manual sets out the Risk and Hazard management procedures for PFS, the details of which are explained in section 8.2 ‘Hazard Identification and Risk Management Process’.

1.17.94 Section 8.2.1 states that

‘Hazards may be identified by one of the following ways: (a) Records and trend analysis, (b) Systems analysis identifying gaps, (c) staff meetings and brainstorming, (d) work processes flow charts.'

1.17.95 Section 8.2 discusses various Risk management processes. These include a risk probability/consequence assessment table and the ‘SHEL’ model.

1.17.96 Paragraph 8.2.2.6 titled ‘Risk Mitigation’ includes an example from industrial engineering to explain what risk mitigation means. No reference is given to an example from the aviation industry.

1.17.97 Section 9 of the SMS manual sets out the type of monitoring required. Seven examples of monitoring actions are stated. These are: safety reporting, internal safety audits, external safety audits, safety surveys, safety reviews, safety studies and internal safety investigations.

1.17.98 Section 13 of the SMS Manual mentions internal audit processes. Paragraph 13.3.1 identifies 20 items that are to be subject to regular internal audits. Included in these are ‘flight safety’ and ‘training’. However, there is no specific mention of bad weather risk assessment and decision making in bad weather situations.

The Pacific Flying School VFR (day) Aeroplane Training Manual

1.17.99 The paragraphs to follow outline significant sections of the manual as they may relate to this accident

1.17.100 The Preamble of the Pacific Flying School VFR (day) Aeroplane Training Manual states in the preamble that it ‘has been compiled for the use and guidance of all the Instructors and Trainee Pilots in the execution of their duties and flying responsibilities.'
1.17.101 Under ‘Overview’ is stated ‘The day VFR syllabus is based on Australia CASA guidelines for flying and aeronautical training requirements relevant to Private Pilot Licence (PPL) and the Commercial Pilot Licence for aeroplanes.’ This complies with the CAAF standard in relation to Air Training Institutions in Fiji which requires compliance with the CASA Flight Training Syllabus.

1.17.102 Part 2, Section 2 Subsection 4 of the manual sets out the flying standards and assessment guides for each of the training elements relating to commercial pilot training at PFS.

1.17.103 Element 1.4.1 sets out the performance details that a trainee commercial pilot must demonstrate and how these are assessed, in relation to pre and post flight administration. The assessment guide of element 1.4.1 refers to the need to interpret and apply Area and Terminal meteorological forecasts. However, no mention is made of other meteorological information such as Mean Sea Level Synoptic Charts, SIGMETS, METARS, SPECIS, cloud satellite imagery and rain radar images.

1.17.104 Element 25.1 sets out performance details that a trainee commercial pilot must demonstrate and how these are assessed, in relation to flight navigation exercises. However, there are no details related to the interpretation of weather information and associated decision making. Element 25.1 also provides an assessment guide for navigation exercises and this refers to the need to obtain and interpret an aviation meteorological forecast. However, the type of aviation meteorological forecast is not specified and there is no requirement for a face to face weather briefing with a meteorological forecaster.

1.17.105 Element 25.4 relates to aircraft navigation and requires an awareness of en route and destination weather conditions to the extent that may require changes to the flight plan.

1.17.106 Element 25.8 refers to the need to utilise GPS and radar facilities as aids in navigation.

1.17.107 All the lessons for the CPL training syllabus have performance criteria that need to be graded by a flight instructor. Lessons 46 and 47 relate to the 300nm cross country training exercise. Both lessons have 53 performance criteria items to be graded. However, there are no items of performance criteria relating to how meteorological information is interpreted by the student.

1.17.108 The PFS training manual includes a set of VFR training notes. The set of notes relating to Navigation preparation states the need to properly assess the weather; but does not stipulate how this should be done and does not specify the type of meteorological information that should be utilised to do this.

1.17.109 The PFS training manual includes a copy of Part 61 ‘Manual of Standards’ promulgated by the Civil Aviation Safety Authority of Australia (CASA) which itemises the aeronautical knowledge standards required for a Commercial Pilot Licence (CPL) and Air Transport Pilot...
Licence (ATPL) to Australia requirements. This is identified as Schedule 3 in the PFS manual.

1.17.110 Section 1.8 of Schedule 3 relates to Meteorology. Unit 1.8.2 relates to meteorology applicable for a Private Pilot Licence (PPL). Unit 1.8.3 relates to meteorology applicable for a Commercial Pilot Licence (CPL). Units 1.8.4 and 1.8.5 relates to advanced meteorology for an Air Transport Pilot Licence (ATPL). All these units mention troughs, equatorial troughs, the Intertropical Convergence Zone (ITCZ), monsoonal weather conditions and tropical storms. However, the risk details are not stated. Also, the application of these concepts is required in relation to Australia and its neighbours, not the South Pacific or Fiji.

1.17.111 The South Pacific Convergence Zone is not mentioned, nor is its effect on Fiji weather.

1.17.112 The difficulty of forecasting tropical storms and low-pressure troughs compared to frontal systems, and the risk that this poses to aviation, is not mentioned.

1.17.113 Schedule 3 mentions meteorological weather information in the form of General Area Forecasts, Mean Sea Level Synoptic Charts, TAF’s, METARS, SPECIS and SIGMETS, but satellite cloud imagery, rain radar and the way they should be interpreted and applied to various types of weather contexts is not included.

1.17.114 The PFS VFR (Day) training manual includes no training items related to mountain flying, as New Zealand requires for its pilots.

The Pacific Flying School Operations Manual

1.17.115 In paragraphs to follow, key aspects of the PFS Operations Manual will be referred to, as they may relate to this accident. Some paragraphs relate to operational responsibilities of key staff members. Other paragraphs relate to management of weather related risks.

Staff responsibilities and organisational hierarchies

1.17.116 Paragraph 1.1.1 states the roles and responsibilities of the Accountable Manager similarly to what is stated in the Safety Management System Manual.

1.17.117 Paragraph 1.1.3 requires a Safety Officer to report to the Accountable Manager and defines the role of a Safety Officer in terms of the following responsibilities:

- Ensure pilot training and qualification is conducted in accordance with PFS Instructors manual;
- Conducts routine audits of PFS operational activities
- Maintain a corrective action register
• Ensure that records of qualifications and ratings for individual flying instructors are maintained;

• Provide routine reports to the Accountable Manager;

• Ensure the practice of open communication about safety issues;

• Ensure the provision of adequate resources to address safety concerns;

• Ensure a commitment to a non-punitive, confidential safety or hazard reporting system;

• Hold regular formal and informal meetings to discuss safety concerns.

1.17.118 The PFS Operations Manual in Paragraph 1.1.6, defines the role of a Flight Operations Officer who is required to report to the Chief Flying Instructor (CFI) and PFS Office Manager. Amongst PFS staff, this person is known as an ‘Operations Controller’. The responsibilities for a person in this role are listed in para 1.1.6 and amount to approximately 30 detailed responsibilities. Many are safety related.

1.17.119 One of these safety related responsibilities relates to weather monitoring on the Fiji Meteorology website, which is only stated generally in the Operations Manual.

1.17.120 One PFS Flight Operations Officer or Operations Controller was interviewed in relation to the responsibility of weather monitoring. He stated that he regularly downloads from the Fiji Meteorological Service website the Aviation General Area Forecast, METARS and TAF’s, prints them out and fixes them to a clipboard in the PFS Operations room for all pilots to refer to. He advised that with regards to other types of Meteorology reports such as satellite cloud images, Mean Sea Level Synoptic Charts and rain radar images, reference to these were optional. Students were encouraged to refer to two other websites as these were considered more user friendly and accurate than the website of the Fiji Meteorological Service website.

1.17.121 Other responsibilities of the Flight Operations Officer include ensuring that flight instructors and charter pilots complete all necessary despatch documentation in order to help ensure smooth running of flight operations. Much of this documentation is also safety related.

1.17.122 Section 1.11 of the PFS manual portrays an organisation chart for the Pacific Flying School. This chart shows the CFI, the Administration Officer, the Quality Assurance Officer and the Safety Officer all reporting to the Accountable Manager and is similar to that shown in the PFS SMS manual discussed above. The Flight Operations officers report to the Administration Officer.

Operational guidelines relating to bad weather

1.17.123 The Operations Manual of the Pacific Flying School provides guidelines for pilots operating in bad weather in Part 3 titled ‘Flight Operations’. The paragraphs to follow cite relevant guidelines for decision making in
bad weather conditions.

1.17.124 Section 3.1 titled ‘Introduction’ refers to disciplinary action if pilots are observed flying outside permitted limits.

1.17.125 Under section 3.3 titled ‘VFR Operations’ the Operations Manual states that the pilot of the aircraft is responsible for operating the aircraft in such weather conditions ‘that permit safe separation from other aircraft, the ground, or any obstacles. Nothing, including an ATC clearance takes this responsibility away from the pilot’. This is consistent with pilot responsibilities stated in aviation regulations of most countries, including Fiji.

1.17.126 Paragraph 3.3.1 states that ‘weather forecasts must be obtained and understood before any cross-country flight is undertaken.’ This paragraph does not stipulate the type of weather forecasts that must be reviewed, nor does it advise how to obtain up to date forecasts at remote aerodromes with limited facilities.

1.17.127 Paragraph 3.3.3 titled ‘Visual Meteorological Minima’ reiterates the requirements stated in regulation 111 of Fiji’s ANR regulations and related paragraphs.

1.17.128 Section 3.7 is titled ‘Weather Restrictions’. Paragraph 3.7.1 states that ‘weather limitations have been established for PFS so that pilots do not find themselves in conditions beyond their own or their aircraft’s capabilities.’ It prohibits flying under several conditions, including these conditions:

- In the vicinity of active Cb’s (thunderstorms)
- In wind shear conditions known to be severe
- In areas of known severe turbulence at low levels.

1.17.129 It also states that ‘most of the above conditions will have current SIGMETS\textsuperscript{51} issued. Operation is prohibited when SIGMETS apply to an area of intended operation.’

1.17.130 Paragraph 3.7.2 titled ‘VFR Weather Limitations’ summarises weather limitations for circuit flying for instructors, student pilots, PPL and CPL pilots. No limitations are prescribed for cross-country flying apart from re-iterating what is stated in the Fiji Air Navigation Regulations, which have already been discussed above.

1.17.131 Paragraph 3.16.3 titled ‘Cross-Country Navigation’ refers to the need to check weather in the planning phase of the flight but stops short of specifying what type of weather information checks are required.

\textsuperscript{51} A SIGMET is a significant meteorological advisory and in this context indicates the presence of embedded thunderstorms
1.17.132 The Operations Manual does not require pilots to obtain briefings in person from the Fiji Meteorological Service, and nor does it encourage pilots to utilise the resources of Flight Information Service Officers at remote aerodromes when landing there during cross country training exercises.

1.17.133 The Operations Manual does not provide any guidance on mountain flying operations and does not identify any risks that can occur while flying over or near mountainous terrain, of the type that the New Zealand CAA has identified in documents which may be referred to in Appendix D of this report.

1.17.134 In Paragraph 5.3.3 the Operations Manual stipulates the maximum duty time for a flying instructor as 100 hours in any 14 consecutive days and 190 hours in any 28 consecutive days. Paragraph 5.12.2 states that the maximum flight time in any 28 consecutive days is 100 hours.

1.17.135 In Paragraph 3.2.5 the Operations Manual defines ‘duty’ as meaning ‘the undertaking on behalf of the operator of the aircraft, of any flight thereon (whether as passenger or crew) or of any function (whether or not inflight) on or in connection therein’.

CAAF’s audits of the requirements relating to the Aviation Training Institute Certificate (ATIC) and the Safety Management System (SMS) of Pacific Flying School.

1.17.136 In March and April 2017, CAAF undertook an audit of PFS’ SMS system, and also an audit of the requirements relating to PFS’ Aviation Training Institute Certificate (ATIC). The purpose of the ATIC audit was to ascertain whether PFS’ performance was sufficiently acceptable to justify the renewal of its Aviation Training Institute Certificate. The findings of both audit reports are similar and are summarised below:

- PFS had not obtained approval from CAAF with regards to its documented flight and duty time limitations.

- Shortfalls were identified in relation to the work of the CFI. This related to flight training, instructor competency checks and also monitoring and updating of the students’ flight training records.

- The Safety Management System was criticised. PFS had not undertaken any safety audits conducted since the previous CAAF audit, indicating a lack of internal monitoring and surveillance. The last CAAF audit findings stated that the accountable manager, who at that time was the owner of Joyce Aviation had not attended safety meetings regularly.

- The audit report named the accident flight instructor as the PFS Safety Officer, but implied that the payment allocated for that role was insufficient for the work required to effectively maintain the PFS Safety Management System. This was cited as one of the reasons for the SMS shortfalls.

- Notwithstanding the criticisms, the audit reports complimented
the internal hazard reporting procedures, stating ‘a good number of hazard/safety reports have been received for 2016 and 2017 which shows a good reporting culture.’ Regrettably most of the reports had not been closed out, indicating that safety actions remained outstanding.

1.17.137 The 2017 CAAF audits identified no findings and issued no comments relating to the risk assessment of cross-country flight training in bad weather and over mountainous terrain.

1.17.138 Following the 2017 audit, PFS received a new Aviation Training Institute Certificate that was valid to 29 April 2018.

Cessna 172 Route Guide of Sunflower Aviation Ltd;

1.17.139 The operations of Sunflower Aviation are not part of the Pacific Flying School. However, the Route Guide was reviewed for reference purposes, as Pacific Flying School has no Route Guide for any of its cross-country flight routes, including that of the accident flight.

1.17.140 The introduction of the Route Guide states:

The information provided in this route guide depicts the navigational requirements for the C-172M and C-172R. Sunflower Aviation main operations with the C-172 are general charters between Nadi Airport, Nausori airports and the outer island and inland air strips that are reachable taking into account ANR 98, that a single engine aircraft must operate within gliding distance of land when flown for the purpose of public transport. Flight crew should be familiar with the tracking requirements and aerodrome operation requirements and read and familiarise themselves with the important notes that are found in this route guide before flying as pilot in command.

1.17.141 The destination of Labasa is not included in the Route Guide, and nor is flight over the central mountain range of Vanua Levu. All the destinations in the Route Guide are effectively at sea level. There are no comments or guidelines relating to weather patterns that may occur at each of the destinations, which pilots should be aware of.

Legal matters between CAAF and Joyce Aviation

1.17.142 Many allegations have been issued by CAAF against Joyce Aviation, in relation to several alleged incidents that occurred between June 2005 and March 2017. Some of these allegations have been withdrawn and others relating to Mr Joyce flying on an expired license have resulted in convictions in the Nadi Magistrates court.

1.17.143 One of the decisions by CAAF against Joyce Aviation has been quashed on an application for Judicial Review by the High Court of Fiji. CAAF has lodged an appeal with the Fiji Court of Appeal. At the time of writing the outcome of the appeal remained pending.

1.17.144 Appendix H of this report includes copies of court judgements made in relation to these matters which were available at the time of writing.
1.18 Additional information

Similar accidents in other countries

1.18.1 Accidents in which an aircraft impacts with terrain while able to be fully controlled by the pilot are termed Controlled Flight Into Terrain (CFIT) accidents. CFIT accidents that occur to light aircraft while flying under Visual Flight Rules (VFR) often occur in mountainous terrain and in bad weather.

As part of background research for this investigation, CFIT accidents with similar circumstances that have occurred in New Zealand and Alaska were reviewed for reference purposes. Also reviewed were the recommendations that were implemented following these accidents.

Two mountain flying accidents in New Zealand

1.18.2 On the 19th of September 1981 a Cessna 172 crashed in a mountain valley near Lake Luna in Otago, South Island. The aircraft was taking part in an annual mountain flying experience course and had one instructor and three student pilots on board. The probable cause of the crash was that “a downdraught effect was encountered during an initial attempt to turn the aircraft to vacate the narrow valley, and in the course of a subsequent turn the instructor was unable to prevent the aircraft colliding with the terrain.”

On the 5th of September 2003, a Cessna 172 crashed in the same mountain valley. Again, the accident flight was part of a structured mountain flying training course. The cause of this air accident was very similar to that which occurred in the same valley 22 years previously; a downdraught in a mountain valley preventing the aircraft from turning and climbing out of it safely.

New Zealand’s Safety Actions

1.18.3 An official from the New Zealand Civil Aviation Authority, (NZ CAA) when interviewed in relation to these types of accidents, advised that as a result of several accidents resulting in 29 deaths over 15 years, involving light aircraft flying in mountainous areas and in bad weather, the New Zealand Transport Accident Investigation Commission (TAIC) and the Coronial Services of New Zealand strongly recommended to the New Zealand Civil Aviation Authority that it implement mandatory mountain flying training for the PPL and CPL flight training programmes, with respect to both fixed wing and rotary wing aircraft types.

52 Aircraft Accident Report No 81-077; Office of Air Accidents Investigation, Wellington New Zealand.

53 Aircraft Accident Report Occurrence No 03/3531, ZK-EOA; Investigated by the Civil Aviation Authority of New Zealand.
1.18.4 The New Zealand mountain flying training syllabus was implemented in the period from 2008 to 2011. The NZ CAA official advised that since the implementation of this mountain flying training, there has been a significant reduction in the types of accidents that are caused due to a combination of mountain flying and bad weather factors.

1.18.5 The NZ CAA Advisory Circulars and additional educational resources relating to mountain flying training may be found in Appendix D of this report. They include:

- The NZ CAA GAP booklet on mountain flying;
- A NZ CAA training video on mountain flying;
- Mountain Flying Training Standards Guide for the Private Pilot, Commercial Pilot, and Flight Instructor;
- Advisory Circular AC 61-3 relating to PPL training requirements, including Appendix IV—Aeroplane Terrain and Weather Awareness Syllabus;
- Advisory Circular AC 61-5 relating to CPL training requirements, including Appendix V - Aeroplane Basic Mountain Flying Training Syllabus;
- Advisory Circular AC 119.3 relating to Air Operator Certification—Part 135 Operations, Appendix V- Mountain Flying Training Fixed Wing.

1.18.6 This educational material addresses mountain flying hazards such as:

- Valley flying including the risk of flying up a valley with no exit route;
- Weather awareness and decision making;
- Dangers of downdraughts and turbulence, wind-shear, rotors, mountain waves;
- Ridge crossings and escape routes in closing weather;
- The value of local knowledge with respect to weather and terrain hazards;
- Optical illusions related to: blind valleys, false horizons, whiteout, scale issues and depth perception.

1.18.7 By way of explanation, NZ Advisory Circular 119.3 defines mountain flying as: ‘Any technique involving the manoeuvring of an aircraft between, over, or around terrain or resultant weather that is, or that could be perceived as being, an obstacle to the aircraft flight path’

1.18.8 It is also relevant to note that Advisory Circulars AC 61-3 and 61-5 include requirements for a cross country flight test, separate and
additional to a flight test to assess general aircraft handling. The Advisory Circulars permit the flight testing officer for the cross country flight test to be a senior ‘B’ Category instructor from the flying school that provided the training to the student being tested.

An Alaskan CFIT Accident

1.18.9 Alaska has extensive mountainous remote areas and adverse weather systems. Air traffic services provide the main transportation for much of Alaska. In Alaska, CFIT accidents are not uncommon. Its investigating authority is the National Transportation Service Board (NTSB) and its regulator is the Federal Aviation Administration (FAA).

1.18.10 On the 2nd of October 2016, a Cessna 208B Grand Caravan aircraft collided with steep mountainous terrain at an altitude of 2,300 feet, while flying under Visual Flight Rules on a scheduled commuter flight. The two commercial pilots and the passenger were killed, and the aircraft was destroyed. The Pilot in Command (PIC) had accumulated 5,800 hours of experience and was qualified to fly under Instrument Flight Rules. The aircraft was also equipped to fly under Instrument Flight Rules. However, the pilots chose to fly under Visual Flight Rules because of time delays that would likely occur before the IFR plan could be logged and accepted.

1.18.11 The NTSB report concluded that the aircraft had likely entered Instrument Meteorological Conditions (IMC) at the time of impact. The NTSB report also stated that the aircraft had a Terrain Alert Warning System (TAWS) that was inhibited by the pilots. This prevented it from providing ground proximity warnings as the aircraft approached its crash site.

Safety Recommendations from the Alaskan Accident

1.18.12 The NTSB report issued recommendations to address the need for improvements in the following areas:

- Crew Resource Management (CRM) training programmes
- CFIT avoidance training programs
- TAWS inhibit protections
- Safety Management Systems
- Flight Data Monitoring Programs and monitoring devices
- Better infrastructure to support low level IFR operations

54 For example, see appendices I and II of NZ CAA Advisory Circular AC 61-5

55 NTSB Accident Report Cessna 208B N208SD, NTSB/AAR-18/02 PB2018-100871
• Improved sharing of pilot weather reports (PIREPS)

1.18.13 In relation to the need for improved sharing of pilot weather reports, (PIREPS) the NTSB undertook a special investigation report56.

1.18.14 The NTSB report stated that:

‘Between March 2012 and December 2015, the NTSB investigated 16 accidents and incidents that exposed PIREP-related areas of concern. The NTSB determined that PIREP-dissemination deficiencies contributed to the cause of two incidents; in both cases, the flight crews were not provided PIREPs (submitted previously by other pilots) about hazardous weather before they encountered it. The PIREP information, if disseminated, would have increased the weather situational awareness of the incident flight crews, which could have helped them avoid the weather hazards and prevent the aircraft-damaging events. In other cases, although PIREP issues did not contribute directly to the accident and incident causes, the investigations discovered similar PIREP-related concerns. The prevalence of these issues across numerous investigations, as well as the similarities between these issues and the concerns voiced by PIREP user groups, suggests that such problems are widespread; the NTSB believes that correcting these systemic PIREP-related issues can help reduce the occurrence of hazardous weather encounters in the NAS.’

1.18.15 The NTSB report stated that not only would better PIREPS improve weather information to pilots, it would also improve information for meteorological forecasters, in turn leading to better weather forecasts for pilots.

1.18.16 The NTSB report noted that one of the challenges of encouraging pilots to provide information on actual weather conditions, is that many pilots fear criticisms and disciplinary action from regulators and their own company oversight assessors for exposing themselves to the risk of adverse weather systems.

1.18.17 Although the North American airspace system is significantly larger than and different from the Fijian airspace system, the NTSB study into the need for improved pilot reporting in the United States is useful for reference purposes when considering improvements to pilot weather reporting in Fiji. The Analysis Section of this report discusses this in more detail.

1.18.18 The NTSB reports of the Alaskan accident and the special study into pilot reporting may be found in Appendix E of this report.

56 NTSB Report: NTSB/SIR-17/02 PB2017-101424 Notation 24828 Adopted March 29, 2017
A discrepancy in the Fiji Aeronautical Chart

1.18.19 During this investigation, a possible chart error was found on the Fiji Aeronautical Chart. A discrepancy was found between scale markings on the map and the scale markings of the navigation ruler that pilots use to measure nautical miles on the map. The discrepancy is approximately 5%. The photograph below illustrates this discrepancy.

Fig 7: A scale discrepancy between the scale rule used to measure nautical miles in aeronautical navigation and the scale markings of the Fiji Aeronautical Chart.

Experiences of other Fijian pilots

1.18.20 During the course of this investigation, other pilots were interviewed to obtain information on their experience and decision-making procedures when encountering bad weather.

1.18.21 One pilot experienced a rapid height loss of 3,000 feet due to extreme downdraughts when flying on Instrument Flight Rules (IFR) in bad weather in a light twin engine aircraft. Further enquiries revealed two other similar anecdotal reports; in both incidents height losses of 3,000 feet were experienced in twin engine turboprop aircraft.

1.18.22 Another experienced pilot reflected on the fact that uncertain Fiji weather often came in waves or bands and if the weather was bad at a particular time, that it would not take long to improve. In his view, the management of bad weather was simply a matter of timing.

1.18.23 In relation to cross country flying exercises over Vanua Levu, one instructor suggested that the coastal route from Labasa to Nausori around and to the South West of the central mountain range was
seldom flown; instead pilots normally flew across the mountain range at a height of approximately 7,500 feet in order to allow the aircraft to glide to a suitable forced landing site in the event of an engine failure.

1.18.24 Another instructor advised that his students would not normally be permitted to fly solo to Labasa because the weather at Labasa was often bad, particularly in the wet season.

1.18.25 Some Fijian commercial pilots interviewed in relation to this accident stated that METARS and weather reports were often optimistic and did not reflect the actual conditions that they encountered.

1.18.26 A Flight Information Service Officer at a remote aerodrome stated that weather can deteriorate to below SPECI conditions for only 10 minutes and this may occur only on one side of the runway. Under these conditions, it is often difficult to know whether or not to issue a SPECI weather report as it may not be truly representative, both in terms of the field of view or what is likely to occur over the next hour.

1.19 Useful or effective investigation techniques

1.19.1 The investigation technique based on the STAMP\textsuperscript{58} and CAST\textsuperscript{59} processes developed by the Massachusetts Institute of Technology (MIT)\textsuperscript{60} was useful in assessing the way different service providers related to each other in providing weather information to pilots in Fiji.

1.19.2 The document titled ‘Proposed improvements to Fiji weather information; dissemination and feedback’ that may be found in Appendix F, includes a STAMP based model identifying how different aviation service providers in Fiji disseminate weather information to pilots, and how results are fed back to the originator, the Fiji Meteorological Service (FMS). This helped to understand the bad weather decision making on the part of the PIC of the accident aircraft.

1.19.3 The model helped to identify several recommendations in order to prevent this accident from recurring. This was explained in a presentation that the writer provided to the stakeholders of this accident investigation at the offices of CAAF in Nadi on the 17th of July 2018.

\textsuperscript{57} A SPECI report is issued by the FISO or Air Traffic Controller when certain weather conditions change adversely or improve by certain criteria. This is an ICAO requirement.

\textsuperscript{58} STAMP means Systems-Theoretic Accident Model and Process

\textsuperscript{59} CAST means Causal Analysis based on Systems Theory

\textsuperscript{60} These processes are outlined in the text: Leveson, Nancy G; Engineering a Safer World; Massachusetts Institute of Technology; 2011
2 ANALYSIS

2.1 Introduction

2.1.1 This accident occurred when the Cessna 172R operated by the Pacific Flying School collided with steep mountainous terrain 6.6 nautical miles South of Labasa and near Mt Delaikoro at a height of 2,600 feet. The aircraft was on a cross country training flight and was piloted by a student and her instructor, with her instructor as Pilot in Command (PIC). This training flight was being operated under Visual Flight Rules (VFR) which required the pilots to be in sight of ground or water, clear of cloud and with a visibility of at least 5,000 metres\(^1\).

2.1.2 The following analysis assesses and determines the factors that contributed to the accident so that recommendations can be implemented to prevent a similar accident from occurring in the future.

2.1.3 The analysis begins by addressing qualifications and experience of the PIC and also the student pilot, as well as their medical conditions and any toxicology findings. It also examines the maintenance history of the aircraft and determines whether or not the aircraft was operating satisfactorily under power at the time of impact.

2.1.4 It then examines the evidence available to try and understand the PIC’s decision-making process during the final and earlier stages of the accident flight after the aircraft departed Labasa. The ADS-B plots, meteorological reports and RTF communications will be referred to in this analysis. The analysis will then examine the period at Labasa when the accident pilots waited for the weather to improve. Of interest during this time is any updated weather information that was available to the pilots in the form of revised TAF’s, METARS, SPECIS, rain radar images, satellite cloud images and recent weather observations from other visiting pilots.

2.1.5 Finally, in line with ICAO investigation protocols, organisational aspects will be discussed. This will address risk management processes, relevant documentation guides, manuals, regulations and audits. A summary of relevant findings will be presented in the conclusion of this report and many of these will support a series of recommendations that are found in the following section.

2.2 Flight crew qualifications and medical conditions

Pilot qualifications, experience and medical history

2.2.1 The accident flight instructor and Pilot in Command (PIC) was certified, current and qualified to act as Pilot in Command in accordance with Fiji’s regulations.

\(^1\) As stated in Paragraph 111 of Fiji’s Air Navigation Regulations
2.2.2 The accident student pilot was nearing the end of her training as a commercial pilot and although she had completed the theoretical ground course requirements, she had not yet completed her flying training. She was authorised to train as a pilot under the guidance of a training institution such as the Pacific Flying School in accordance with Fiji’s Air Navigation Regulations and relevant Standards Documents.

2.2.3 The PIC possessed a current Class I medical certificate that was current to the 4th of September 2018. The accident student pilot possessed a valid flying training permit valid to the 25th of April 2018. Both certificates permitted them to operate an aircraft in accordance with their respective flying roles. A review of information about the PIC’s recent activities, CAAF records, work schedule data and reports from close friends indicated no evidence of possible impairment or performance degradation due to any pre-existing behavioural or medical conditions.

**Toxicology test results**

2.2.4 Toxicology tests on specimens from each pilot found alcohol in both samples, with a relatively high concentration in the sample from the PIC. However, the toxicologist concluded that the alcohol had most probably been generated due to putrefaction during the extended period which elapsed between the accident and the time the specimens were obtained and analysed. Alcohol was not available immediately prior to the accident flight. Circumstantial evidence and witness reports indicated that they were unlikely to have consumed Marijuana and/or Kava on the morning of the accident flight between 7 am and 12 midday when the accident occurred. This together with toxicology information suggests that these substances would unlikely have been present to the extent needed to impair human performance. No information relating to the PIC’s medical history could be found that indicated chronic or mental health conditions or regular use of medications.

**Duty time history of the Pilot in Command (PIC)**

2.2.5 All working commercial pilots have limits on their flight and duty times in order to avoid the risk of fatigue. PFS documentation had permitted a maximum duty time of 100 hours over 14 days. During the 14 days leading up to the accident, the PIC had exceeded this limit; he had attended PFS for 108.8 hours. His flying time on the other hand, was significantly less than what was permitted. During the past 28 days he had flown 46 ½ hours, less than half of the 100-hour limit. Also, he had two days off on the 23rd and 24th of February. The accident flight had occurred after waiting on the ground at Labasa for nearly three hours, which would have included some rest time. He also enjoyed being at the PFS for extended hours.

2.2.6 Therefore, while his duty time had technically exceeded the limits by approximately 10%, there were several other aspects of his duty and flight time profiles that were favourable and could have offset his duty time excess. It is therefore difficult to attribute the duty time breach as a significant contributing factor to the accident.
2.3 **Wreckage information & Maintenance history**

2.3.1 A review of the aircraft maintenance documentation indicated that it was satisfactorily maintained in accordance with Fiji regulations. This documentation indicated that its engine was replaced with a fully overhauled engine approximately one month before the accident.

2.3.2 Analysis of the strike damage on one of the propeller blades confirmed that the propeller was operating under power at the time of impact. An inspection of the aircraft control cables indicated that they had no pre-accident anomalies or defects. Therefore, the aircraft would have been controllable when it collided with the cliff face.

2.3.3 Further examination of the aircraft’s airframe, engine, propeller and systems indicated no evidence of pre-impact anomalies or malfunction that would have indicated abnormal operation at the time of impact.

2.3.4 The damage to the leading edge of each wing was similar, consistent with the aircraft impacting the cliff symmetrically about the aircraft centreline. This is also consistent with the final few seconds of the ADS-B track plot, which in Section 2.5 below shows the cliff face approximately perpendicular with the line of the aircraft flight path.

2.3.5 The flaps were found retracted, indicating that the pilots had not configured the aircraft for the bad weather configuration and low speed flight. Lowering the flaps lowers the stall speed of the aircraft and this provides a greater margin above the stall speed when it may need to fly slower in conditions of reducing visibility. Being able to do so assists a pilot with decision making and control.

2.3.6 However, lowering the flaps introduces an upper speed limit which if exceeded can damage the flaps, reducing controllability. As the ADS-B speed data shows, a significant speed variation during the descent phase, with frequent episodes above 110 knots, could have been one reason why the pilots decided not to lower the flaps, as they were having difficulty controlling the aircraft’s speed in turbulent conditions over the mountain range.

2.3.7 It is also possible that because of the heavy mental workload during the latter stages of flight, the pilots had overlooked the advantage of reducing the airspeed of the aircraft and lowering flaps when they were approaching terrain.

2.3.8 Having ruled out the possibility of aircraft mechanical and systems failure, it is necessary to assess other operational factors such as pilot decision making. Before doing so it is useful to review the weather at the time leading up to and during the accident, and also evidence from the ADS-B data and Radiotelephony (RTF) communications.
2.4 Weather

2.4.1 The analysis in this section will attempt to understand what made sense to the accident pilots at the time\textsuperscript{62} - what motivated them to depart in apparently bad weather after they had already decided to wait nearly three hours at Labasa for it to improve?

2.4.2 Having established that they were qualified and competent to exercise their respective roles, it is reasonable to begin this part of the analysis with the assumption that their competencies were at least similar to that of their peers, and this justifies the concern that other pilots could succumb to a similar fate if placed in a similar position. It is therefore important to try to understand the factors that influenced their decision making, in order to prevent this type of accident from happening again.

2.4.3 This section analyses the weather forecasts available to the pilots before the aircraft departed Nadi, the actual and forecast weather reports while the pilots were waiting for the weather to improve at Labasa and also the actual weather during the accident flight after the aircraft departed Labasa. Reference will be made to satellite cloud and rain radar images supplied by the Fiji Meteorological Service (FMS) that may be found in Appendices A2 to A4. Communications with other pilots and PFS personnel will also be considered.

Weather information and decision making before departure

2.4.4 The only weather reports that the pilots likely obtained and reviewed before departing Nadi was the General Area Forecast. No TAFs or METARS of Labasa or Savusavu were available because the FMS had not yet received observations from the FISO’s at these locations.

2.4.5 While the General Area Forecast was not ideal, it was not prohibitive for an instructor and advanced CPL student.\textsuperscript{63} The Cb’s and associated reduced visibility that were forecast were occasional and isolated and therefore could be avoided if necessary. The cloud base cover was reasonable for flight around the coast and low-lying areas. The forecast suggested that the weather would worsen during the afternoon and the PFS schedules showed that the aircraft was due back at Nadi by 12 o’clock midday. Some instructors might have considered this an ideal opportunity for training in bad weather decision making.

2.4.6 Other weather information available to the pilots were the Mean Sea

\textsuperscript{62} ‘What made sense to the accident participants’ is a procedural question introduced by the well-known safety thinker Sydney Dekker. It also forms a basis for the STAMP investigation process that has been developed by the Massachusetts Institute of Technology (MIT). It supports and is consistent with the ICAO investigation protocol.

\textsuperscript{63} While the accident flight instructor was Pilot in Command (PIC) the student was relatively advanced in her training and would have been able to contribute to some flying responsibilities and decision making. For this reason, the term ‘accident pilots’ is often used, rather than the term ‘Pilot in Command’ when referring to pilot decision making.
Level Synoptic Chart that the FMS publishes for mariners and cloud and rain radar images. It is unlikely that the pilots viewed these.

2.4.7 Had the pilots viewed the satellite cloud images before they departed Nadi, they would have likely concluded that the weather was reasonable. A satellite cloud image at 7:30 am may be seen in Fig A2.1 of Appendix A2, and this shows fine weather.

2.4.8 While SIGMET 06 was issued at the bottom of the General Area Forecast, it was located to the North East of Vanua Levu. However, for this to be meaningful, it would need to have been plotted on a map and the pilots are unlikely to have done this. To understand the significance of SIGMET 06 which related to embedded thunderstorms, it would have best been plotted on the Mean Sea Level Synoptic Chart so that its proximity to the low-pressure trough could be noted. There is no procedure that requires or recommends this. A plot of SIGMET 06 on the Mean Sea Level Synoptic Chart for 6:00 am may be found in Fig A5.5 of Appendix A5.

2.4.9 Another source of information available to the pilots was a personal weather briefing from an FMS forecaster. This would have been available on request from the head office of the FMS, which is located only 15 minutes’ walk from the Pacific Flying School (PFS). They did not receive a weather briefing from an FMS forecaster, and nor was this required by the PFS VFR (day) aeroplane training manual.

2.4.10 No PFS or CAAF document specifies exactly what weather information pilots on VFR flight plans are required to assess before embarking on a cross country flight. ICAO documentation does not recognise the need for Mean Sea Level Synoptic Charts, satellite cloud and rain radar images, although many commercial pilots in Fiji are known to refer to these.

2.4.11 The 300 nm exercise can take several hours to complete during which time weather in Fiji can change substantially. However, there are no guidelines or requirements in PFS or CAAF documentation that include procedures for updating this information en route and at remote aerodromes.

Weather-bound at Labasa

2.4.12 After landing at Labasa at 8:40 am, the pilots of the accident aircraft dipped the tanks to check their contents, and then it began to rain.

2.4.13 While waiting in the Labasa terminal for the weather to improve, they received weather reports from the relatives of the accident student pilot based at Savusavu and also from a colleague of the accident flight instructor based at Nausori, who was also a flying instructor.

2.4.14 However, while it may have been possible for the accident pilots to

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64 Refer to Analyses Section 2.6 to understand the significance of this.
download the latest weather information from the FMS on their mobile phones, it was unlikely that they did so, as the FMS website is not mobile friendly, and the accident student pilot advised her friend who alighted at Labasa that her mobile phone did not possess much mobile data. This friend who was also a student pilot advised that they did not discuss or review updated weather information while she was waiting with them from the time they arrived until 10 am when she left them. The call logs of the PIC’s mobile phone indicated no downloaded data large enough to indicate satellite or rain radar images had been interrogated.

2.4.15 Therefore, it is unlikely that the accident pilots reviewed the Savusavu SPECI at 11 am which indicated heavy rain, with a visibility of only 500 metres and a cloud base of 700 feet. This weather would not have been suitable for any flight into Savusavu.

2.4.16 The best way for the accident pilots to have been updated on the latest weather would have been for them to phone the Labasa Flight Information Service Office (FISO) and request to sight the latest weather on the FISO’s computer. This would have enabled the accident pilots to sight the latest TAF’s, METARS, SPECIS, satellite cloud and rain radar images. It would also have facilitated a discussion on local weather characteristics of Labasa, utilising the local weather knowledge of the Labasa Flight Information Service Officers.

2.4.17 While satellite cloud and rain radar images are not formal weather information sources recognised by ICAO, they do, according to the FMS, portray the development and progression of low pressure trough weather systems. This is discussed more fully later in Section 2.6 of this report.

2.4.18 However, for the accident pilots to be able to visit the FISO tower would have required the FISO to send the fire crash tender to them in the terminal and transport them to the FISO tower, as this is the only form of access available to the tower.

2.4.19 Regrettably the AIP Manual does not state whether or not the computer in the Flight Information Service Tower at Labasa would be available for providing weather updates to pilots, including rain radar and cloud satellite images. Nor is the AIP Manual clear as to whether or not meteorological briefing services are available at Labasa or only at Nausori and Nadi. The AIP Manual does not contain a telephone number for the Labasa FISO tower, even though it may be possible to locate this number as other commercial pilots have been known to phone the Labasa FISO tower regularly.

2.4.20 The lack of clarity in the AIP Manual about meteorological services for Labasa aerodrome suggests that although the type of assistance the accident pilots needed that day could have been provided by the Labasa FISO tower, the request would have been unusual and non-standard. To a pilot with a reserved personality as some suggested was characteristic of the PIC, the additional challenge may have contributed to him not availing himself of this assistance.
The decision to depart Labasa

2.4.21 The decision to depart Labasa after the pilots had already waited nearly three hours and at a time when subsequent facts showed the weather to be deteriorating is, at first glance, difficult to understand.

2.4.22 There is no evidence of the PIC succumbing to undue pressure and leaving prematurely. He had long forfeited any hope of returning in time for his midday training flight appointment at Nadi. The flight with the prospective student at Nausori was arranged while the accident flight was en route and had not been booked ahead of time. However, although there was no evidence of undue pressure having been applied, every pilot likes to get home before the end of the day, especially if provisions have not been made to stay away from home overnight.

2.4.23 To understand what the pilots saw, it is necessary to review information about the weather before and around the time of their departure, at 11:37 am. This information includes the 11 am METAR, the cloud satellite and rain radar images, the photograph taken by the accident student pilot which was posted on Instagram and the weather advice provided to a commercial flight that landed at Labasa shortly after 11 am. The satellite cloud and rain radar images may be found in Appendices A2 to A4. The photograph that the accident student pilot posted on Instagram may be found in Fig C1 of Appendix C.

2.4.24 The 11 am METAR indicated a visibility of 30km in rain, a scattered cloud base (3/8 to 4/8 cover) at 2,000 feet and broken (5/8 to 7/8 cover) at 4,000 feet. The General Area Forecast stated that the wind at 5,000 feet was forecast at 10 knots from the North East. While not ideal, this weather may have been good enough to cross the mountain range. Mt Delaikoro, the highest peak in the area, was 3,200 feet.

2.4.25 The cloud satellite imagery at 11 am (Fig A2.3) indicates a band of clear air beginning to open up North East of Labasa. The rain radar images between 11 am and 11:30 am indicate only light rain between 0.1mm and 1mm per hour (dark green and blue shades) to the South of Labasa across the mountain range. The FMS indicates that this rain intensity would correlate with a visibility of between 15 and 30 kms, depending on the direction of line of sight. This is consistent with the clear air band shown in the satellite cloud image at 11 am.

2.4.26 The photograph that the accident student pilot took of the Fiji Link Twin Otter was taken between 11:11 am and 11:20 am. This indicates medium height overcast, consistent with the 11 am METAR of 4,000 feet, the clear air band of the satellite cloud image for 11 am and rain radar images between 11 am and 11:30 am.

2.4.27 The rain radar images show that the air was clearest over the mountains at 11:30 am. According to the FMS, the rain radar images suggest a visibility of between 20 and 30 kms over the mountains. A screenshot of this image is reproduced in Fig 7 below.
Fig 7: Screen shot of rain radar image at 11:30 am showing relatively clear air to the South of Labasa including over the mountain range near Mt Delaikoro. However, rain masses were converging from the Northwest and Northeast.

2.4.28 So, the evidence shows that the local weather improved significantly between 11 am and 11:30 am. This explains the decision on the part of the accident pilots to depart Labasa at that time. It also explains the reason why they departed over the mountains instead of via the coast. The rain radar shows that it was raining heavily towards the coast and visibility towards the coast would have been significantly less than over the mountains to the South.

2.4.29 This evidence may also explain why the accident pilots did not see a need to discuss the weather with the pilots of the Fiji Link Twin Otter pilots who landed at Labasa shortly after 11 am. The Twin Otter pilots would have approached Labasa from a higher altitude and a different direction than the route which the accident pilots were planning to fly on their departure. It is also possible that the accident pilots decided to depart Labasa after the Fiji Link Twin Otter pilots embarked their aircraft prior to their departure.

2.4.30 Having already landed at Labasa earlier in the morning and having flown in from Nausori, it is likely that the Twin Otter pilots had a good understanding of the weather situation and how the weather was deteriorating. Had they been able to share this information with the accident pilots, the accident pilots may have been better informed in their decision making.

2.4.31 One of the major flaws with the decision to depart Labasa after 11 am, is that the Savusavu 11 am SPECI which indicated that visibility was 500 metres with a cloud base of 700 feet, was not good enough to land there. It would not have been wise to commit to Savusavu until they knew that the weather there had improved, particularly in an advancing low-pressure trough weather system. It is also relevant to note that this SPECI indicated that the weather was deteriorating at Savusavu more rapidly than the Savusavu TAF predicted. Regrettably the pilots had probably not reviewed the 11 am Savusavu SPECI.
2.4.32 The rain radar image at 11 am (Fig A4.7) also shows more rain to the Northwest than to the South and explains why the visibility notified to the commercial flight approaching Labasa from the Northwest was only 15 kms, appreciably less than the 30 km visibility reported in the METAR. The METAR was required to be representative and the rain radar image at 11 am shows the area to the Northwest of Labasa was receiving more rainfall than other areas to the Southeast and Southwest, which supported a higher visibility estimate, and in the mind of the FISO weather reporter, would have been more representative of the general area.

2.4.33 However, the rain radar images show that after 11:30 am the local weather began to deteriorate again. This is consistent with the cloud satellite images and advice from a Labasa Flight Information Service Officer who was on duty at that time.

2.4.34 The rain radar images from 11:30 to 12:00 midday show the weather deteriorating rapidly from the Northwest and Northeast, closing over the crash site, and subjecting the pilots to flight in Instrument Meteorological Conditions (IMC) for which they had only received limited training.

2.4.35 The cloud satellite images also show significant deterioration; the clear band line that was showing at 11 am had completely clouded over at 12:00 midday.

2.4.36 The evidence has shown that this type of unstable weather is difficult to characterise in numbers and words, and can clear over large areas, before also deteriorating rapidly, closing in on airfields and aircraft. As seems to have happened to the accident aircraft, this sequence of conditions can ensnare and overcome aircraft reliant on VFR procedures, providing no escape route. For reasons explained below, the risk of this occurring is greater over mountainous areas than over coastal areas.

The decision to fly over the mountain range near Mt Delaikoro

2.4.37 A significant risk to this cross-country training flight was the plan to fly over the mountain range near Mt Delaikoro. It is therefore helpful to review the background to this decision, which began early in the flight planning stage.

2.4.38 The plan to cross the central mountain range of Vanua Levu with the General Area Forecast indicating a low-pressure trough and cloud cover as scattered with a base between 3,000 and 5,000 feet deserved particular attention. This is because a low-pressure trough would likely degrade conditions over the mountains before the weather deteriorated over the coast, so the chance of thunderstorm rain would have been greater over the mountains than over the coast. The alternative was to divert around the central mountain range of Vanua Levu and fly direct down the coast to Nausori, bypassing Savusavu if the weather over the mountains was prohibitive. This diversion was well within the aircraft’s fuel reserves.
2.4.39 However, neither the accident flight instructor nor the accident student pilot had received mountain flying training to help them decide whether or not a diversion around the coast was necessary, and the General Area Forecast did not include a section specifically for mountainous areas of Fiji.

2.4.40 No ICAO, CAAF or PFS documentation was found with guidelines or risk identifiers that might have helped them decide whether or not a flight over the central mountain range of Vanua Levu was advisable. Nor were any guidelines found in the CPL and ATPL study guides. Examples of such guidelines are minimum cloud base, wind speed and the absence or otherwise of thunderstorm clouds (Cb’s) and showers mentioned in weather forecasts. Risk identifiers associated with these factors have already been discussed in section 1.18 of this report. They may also be found in the New Zealand CAA mountain flying training documents located in Appendix D of this report.

2.4.41 Mountain flying risks related to downdrafts and blind valley traps are discussed in the next section of this report and have been identified from the ADS-B data as contributing to this accident.

2.4.42 However, risks associated with low-pressure troughs as occurred on the day of the accident would not necessarily have been identified from the New Zealand CAA information because New Zealand does not commonly experience the same type of highly unstable weather conditions. This is discussed later in Section 2.8 of this report.

2.4.43 The experience gained by the accident flight instructor flying over this mountain range four times previously, was not sufficient for him to successfully manage the mountain flying risks that contributed to the accident.
2.5 **Analysis of ADS-B data and RTF information**

2.5.1 The following analysis builds on the factual information derived in Section 1.9 earlier in this report and refers extensively to the images and graphs shown in Appendix B.

**Poor speed control - evidence of control difficulties**

2.5.2 The ADS-B data in Appendix B provides ground speed data. To derive the airspeed information that the pilots would be seeing in their airspeed indicator, the wind speed would have to be considered. The wind speed at 2,000 feet was forecast to be 5 knots, at 5,000 feet it was forecast to be 10 knots. Therefore, in a constant turn with perfect speed control, the ground speed may have varied by 10 knots at 2,000 feet and 20 knots at 5,000 feet.

2.5.3 The speeds that a pilot of this aircraft would aim to control depend on the flight activity and are stated earlier in the table of data shown in Fig B6. A competent pilot would be required to control these speeds within plus or minus 5 knots of these speed targets. Adding these allowances together would provide an expected variation of 20 knots at 2,000 feet and 30 knots at 5,000 feet.

2.5.4 However, as stated in Section 1.9 and shown in figure B8, the speeds ranged in excess of these allowances. Speed Tags 1 and 2 in Fig B8 ranged between 55 knots and 111 knots. Speed tags 3 and 4 ranged between 53 knots and 147 knots.

2.5.5 This suggests that the pilots had difficulty controlling the aircraft most probably because they were flying in turbulence, or Instrument Meteorological Conditions (IMC), or both. They were not trained to fly to Instrument Flight Rules (IFR) however they did receive limited training that would have allowed them to maintain some control in IMC.

2.5.6 The ADS-B data shows that even though speed control was poor, the pilots had been able to carry out controlled descents and turns suggesting that this limited training was effective to some extent.

**The climb to 6,000 feet and subsequent descent.**

2.5.7 After climbing to 6,000 feet the PIC decided to descend. This decision coincides with receipt of weather information from the Savusavu FISO and the PIC’s advice that he was returning to Labasa, estimating Labasa at 12:15 pm. At this time, he was not aware that a commercial flight was flying to Labasa and was shortly to provide an ETA for Labasa of 12:07 pm.

2.5.8 The decision by the accident PIC to descend may not have been only in preparation for landing at Labasa, it may have also been because he needed to maintain sight of the ground, so he could comply with Visual Flight Rules (VFR).

2.5.9 The rate at which the accident aircraft descended was on average
approximately 1,200 feet per minute. While this may be considered high for a normal descent for this type of aircraft, it is not excessive. It may have been high to allow the pilots to descend through gaps or breaks in cloud.

2.5.10 The altitude of the accident aircraft when its pilots were advised of the arrival of the commercial aircraft would have been in the range of 3,500 to 4,000 feet and descending. The PIC of the accident aircraft advised that his altitude was 3,200 feet in response to this information. This was at 11:56:16 pm FDT.

2.5.11 Shortly after this at 11:56:43 pm, the PIC of the accident aircraft acknowledged receipt of further information about the arrival of the commercial aircraft. This was the last communication from the accident aircraft.

2.5.12 Following this communication, the speed of the aircraft varied from 133 knots (Tag D) to 65 knots (Tag E), indicating control difficulties. This may have been the reason why the pilots stopped communicating, as the control difficulties were absorbing all of their mental capacity, leaving nothing left for radio communication.

2.5.13 The graph in Fig B13 titled ‘Altitude Difference per second’ indicates the aircraft was subject to severe updrafts and downdrafts from the time that the aircraft descended from 6,000 feet until impact with the cliff face. This turbulence caused the accident aircraft to climb and descend at a rate that ranged from 25 feet per second to 75 feet per second. While this turbulence and the accelerations it induced would probably not have risked damage to the aircraft itself, it would have been disconcerting to the pilots and likely added to the control difficulties that they were experiencing.

2.5.14 The graph in Fig B13 shows that speed extremes coincide with periods of rapid altitude variation, confirming that turbulence is likely to have contributed to speed control difficulties.

2.5.15 The saw tooth pattern in the final stages of flight evident between Tags G and H in Fig B12 is also another indication of severe air turbulence.

2.5.16 The pilots are likely to have tried to manage the turbulence not only by control inputs but also by varying the engine power. The resulting throttle setting changes are consistent with reports from the Doguru villagers who heard fluctuations in engine noise, attributing this to changes in RPM.

2.5.17 The extent to which the aircraft was flying in Visual Meteorological Conditions (VMC) and Instrument Meteorological Conditions (IMC) is unknown. The fact that one Doguru villager saw the aircraft for some of the time in the final stages of flight would suggest that for at least

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65 As defined in Fiji’s ANR regulations; this is the minimum visibility requirements to fly under Visual Flight Rules, as stated previously.
some of the time the pilots were in sight of the ground. However, their visibility - the extent to which they could see ahead of the aircraft, could not be ascertained.

2.5.18 The witness account of the Doguru villager who was located within a few miles of the Mt Delaikoro mast but could not see it due to fog, mist and cloud, indicates that visibility around the crash site was probably poor.

2.5.19 The final moments of the aircraft are depicted illustratively in Fig 8 below. This shows the aircraft following the terrain in order to descend and enter the valley. It then turned left towards the cliff face. Following this turn it climbed and then descended before colliding with the cliff face. The final descent is not clearly visible in Fig 8 below but is depicted in the altitude graph shown in Figs B9 and B11.

2.5.20 The elevator trim worm drive was found in the full nose down position, indicating that in the final moments the pilots were endeavouring to descend, consistent with the final section of the altitude graphs.

2.5.21 It is not possible to fully determine the reasons for the final descent. The cloud satellite and rain radar images at that time indicate that the pilots were probably flying with limited visibility and intermittent sight of the ground. They may have seen the valley below them as a possible escape route without understanding that it was blocked to the South by the cliff face that they subsequently collided with. Alternatively, the decision to descend at the last minute may have been to pursue a gap or break in the cloud below which together with limited forward visibility, was too confined to allow them to see the cliff immediately ahead.

2.5.22 With limited visibility that the pilots were likely experiencing, the last segment effectively became a flight up a blind valley without any exit path. This is a common error in mountain flying that mountain flying training may have been able to address. The New Zealand CAA mountain flying guidelines in the GAP booklet66 that may be found in Appendix D state: ‘don’t fly up a valley that you haven’t already flown down’. Other risks that these guidelines refer to are turbulence and downdrafts, both of which feature in the ADS-B evidence.

66 ‘Mountain Flying’ a booklet in the GAP education series published by the New Zealand CAA, March 2012. This may be found in Appendix D of this report.
Fig 8: Two different views of the final moments of the accident flight path highlighting the point where the PIC decided to descend into the mountain valley and then turn towards the cliff. The mountain valley had no exit path in this direction.
2.6 Risks of tropical weather systems and challenges in managing them

2.6.1 In order to understand the decision-making processes of the pilots, it is necessary to study the risks of tropical low-pressure trough weather systems and understand how these may have related to the decision-making processes of the accident pilots.

Fiji’s weather context

2.6.2 Fiji is situated within the tropics and is subject to tropical cyclones and low-pressure troughs. Both these types of weather systems produce intense weather events and amongst meteorological forecasters, are renowned for being unpredictable at times, both in terms of their characteristics and their movements. The weather system that brought bad weather to Vanua Levu on the day of the accident was a low-pressure trough.

2.6.3 Fiji also experiences frontal systems. These are well described in literature and on the World Wide Web. A diagram of a frontal system is presented below

![Fig 9: A warm frontal weather system](image)

2.6.4 The weather at the interface of the front is relatively predictable. Cloud and rain occur because warm air is forced to rise as it meets a cold air ‘wedge’. This occurs at both a cold and a warm front, although the type of bad weather that results, differs depending on the type of front. The speed at which the weather deteriorates can be accurately...
forecast without difficulty, as it follows the speed at which the front moves, which can be tracked and ‘ground truthed’. Frontal systems in most countries, including Fiji can now be forecast with reasonable accuracy 24 hours ahead.

2.6.5 Literature about the formation and characteristics of tropical low-pressure troughs is less plentiful than information on frontal systems. The ground course theoretical study notes for the Australian CPL and ATPL examinations which Fijian pilots sit do not discuss the formation and characteristics of low-pressure troughs to the same extent that other meteorological phenomena are covered.

2.6.6 The Fiji Meteorological Service (FMS) were consulted about this discrepancy. They advised that compared to frontal systems, low pressure troughs are more difficult to forecast in terms of weather characteristics, intensity, and movement. The FMS advised that during the wet season, which occurs between mid-November and mid-May, Fiji would be exposed to a low-pressure weather trough on average once a week, and less frequently during the dry season. In fact, most bad weather systems in Fiji are associated with low-pressure troughs.

2.6.7 The FMS advised that the weather systems of countries located in temperate latitudes, which includes most of the fully developed countries, consist mainly of frontal systems. Intense low-pressure systems in these countries are less common than frontal systems. The paragraphs to follow describe the nature and characteristics of tropical low-pressure trough systems which characterise much of Fiji’s weather.

Tropical low-pressure trough systems

2.6.8 In the South Pacific, due to the tilt of the earth’s axis, the radiant heat from the sun is greatest in an area between Fiji and the equator, and at a time between November and May. This causes hot humid air near the ocean surface to rise. As the moist air rises it cools, causing condensation to occur in the form of dense clouds including Cumulonimbus or CB’s, which can generate heavy rain. The condensation of water vapour releases latent heat which warms the air, reducing its density, causing strong up currents which in turn draws up more moist air from near the sea. Equally strong downdrafts within the heavy rain can contribute to turbulence in and near the clouds and these can also generate atmospheric downbursts which are a hazard to aircraft flying at low altitude.

2.6.9 Low pressure troughs are essentially bands or waves in which unstable atmospheric uplift draws in airstreams of varying temperature and humidity, resulting in uncertain weather patterns and turbulence. A diagram below illustrates this schematically.

67 The term ‘Ground Truth’ is a meteorological term and refers to the practice of verifying forecast parameters with real observations, either by way of automatic weather stations or human observations.
2.6.10 Intertropical convergence zones form on a global scale by the collision of large-scale wind currents moving in different directions. The South Pacific Convergence Zone (SPCZ) is one such area where humid air carried by the tropical trade winds encounters cooler air currents from the South. Unstable convective clouds are induced by the collision of these airstreams in which localised waves of instability contribute strongly to trough formation. The SPCZ generates a consistent long-range weather pattern in the South Pacific, as indicated by large areas of cloud that form in a band from Papua New Guinea to East of the Cook Islands. Fig 11 below shows the SPCZ.
Fig 11: The South Pacific Convergence Zone located near Fiji

2.6.11 On the day of the accident the low-pressure trough that caused bad weather to move on to Vanua Levu, originated to the North of the island in the South Pacific Convergence Zone.

2.6.12 The way in which various airstreams converge at a low-pressure trough is difficult to predict on a local scale. The air movement in a low-pressure trough is not stable and moves less uniformly and predictably than the air in a frontal system. The practical significance of this is that TAF’s, METARS and SPECIS are not as useful in understanding how weather changes in a low-pressure trough system as they are in a temperate frontal system. For example, in a low-pressure trough system, the weather can change rapidly and may advance in bands or patches, with significant gaps between weather features. A METAR and SPECI report depicts cloud and visibility at a certain time in a particular direction. It may not represent the weather over the whole preceding or succeeding time interval and may not encompass conditions throughout the surrounding environment.

2.6.13 This is not usually the case with temperate frontal systems, in which weather changes more uniformly and consistently from a known direction as the front advances. In the case of a frontal system, METARS and SPECIS can be very useful in tracking the movement of the active weather band.

2.6.14 Satellite cloud and rain radar images on the other hand, are more useful at tracking the progress of a tropical low-pressure trough

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68 This figure is from the article by K Kodama & S Businger ‘Weather and Forecasting Challenges in the Pacific Region of the National Weather Service’ © American Meteorological Society
weather system because the images can be looped together electronically, enabling the direction and form of an evolving system to be reviewed as it progresses. The assistance of a meteorological forecaster is also beneficial during this assessment. Appendix A3 includes electronic images of satellite cloud images on the day of the accident, which can be easily looped together on a personal computer.

2.6.15 Another problem in forecasting weather at a low-pressure trough is that it is difficult to predict whether cloud formation and rain will advance ahead of the movement of a trough line, or alternatively, follow behind an advancing trough line. A senior FMS forecaster advised that on the day of the accident, bad weather advanced ahead of the low-pressure trough line, even though embedded Cb’s also followed behind the trough line.

2.6.16 Unpredictable atmospheric instability on the day of the accident may be seen by comparing the cloud satellite image at 8.30 am (20:30 UTC) with the cloud satellite image at 9 am (21:00 UTC). Ref Appendix A3. A build-up of thick convective cloud suddenly appears on the Southwest coast of Vanua Levu, indicating heavy rain at 9 am (21:00 UTC) without any apparent build-up evident beforehand at 8:30 am (20:30 UTC).

2.6.17 On the day of the accident, full and comprehensive details of atmospheric conditions are unknown. However, there was only 1 degree of difference between the air temperature and dewpoint stated in the Labasa METARS, indicating that the clear air around Labasa was very humid. Localised atmospheric instability along the South Western coast of the island likely quickly lifted a portion of similarly humid air to form convective rain cloud between 8:30 am and 9:00 am.

2.6.18 These conditions lead to the risk of aircraft entrapment. A rising mass of clear air which may initially appear suitable for VFR flight can quickly condense into cloud and rain, entrapping aircraft and closing over airfields.

2.6.19 Additional evidence of unpredictability may be seen in the Savusavu weather at and after 11 am. Even though the accident pilots had probably not reviewed the 11 am SPECI that indicated prohibitive weather, the rain radar images show that it began to clear when they departed Labasa at 11:37 am. Had they survived the journey over the mountains, they probably would have been able to land at Savusavu. Such is the unpredictable nature of these types of low-pressure trough systems.

2.6.20 The 11 am Labasa METAR indicated visibility was 30 km but it did not correctly represent the bad weather that was occurring to the Northwest of the airfield. It is in this area that commercial aircraft approaching Labasa would have carried out instrument approach procedures. According to the rain radar images, the weather over the coast between 11 am and 11:30 am was significantly worse than to the South over the mountains near Mt Delaikoro. For a tropical low-pressure trough system, this would be unexpected and counterintuitive; instead, as discussed below, the weather would be expected to be better on the coast and worse over the mountains. This is evidence that intense
weather in low-pressure trough systems can be very localised and
difficult to characterise representatively in standard METAR format.

2.6.21 A Flight Information Service Officer also noted that conditions during
some weather events can be very localised. This officer stated that
weather can deteriorate to below SPECI conditions for only 10 minutes
and this may only occur on one side of the runway. Under these
conditions, it can be difficult to know whether or not to issue a SPECI
weather report as it may not be truly representative, both in terms of
the field of view or what is likely to occur over the next hour.

2.6.22 The formation of bad weather in a low-pressure trough system is
commonly enhanced by the presence of elevated terrain when currents
of humid air are forced to rise when they encounter hills and
mountains, resulting in cloud and rain formation.

2.6.23 Turbulence is also a characteristic of a low-pressure trough. Shear
occurs between converging airstreams and this generates turbulence,
both on a large and small scale.

2.6.24 The local turbulence can be increased by the air currents within and
outside cumulonimbus clouds and will be further increased by airflow
over mountainous terrain. Significant turbulence typically occurs when
wind greater than 15 knots flows over ridge lines and mountainous
peaks creating updrafts, eddies and downdrafts. If the moving air mass
meets a stable air layer located downstream of the ridgeline, mountain
waves and intense wind ‘rotors’ can form in the lee of the ridge lines.

2.6.25 Helicopter pilots who were searching around the crash site for the
wreckage of the accident aircraft experienced significant turbulence, at
times severe, on the afternoon of the accident day and also the
following day.

2.6.26 With this improved understanding of tropical low-pressure systems, and
utilising the weather on the accident day as a case study example, it is
possible to summarise the risks of tropical low-pressure trough systems
as follows:

Tropical low-pressure trough weather systems:

1. Are more difficult to forecast and predict than frontal systems;

2. Produce weather patterns which are patchy, non-uniform and
difficult to characterise utilising conventional aviation weather
communicators such as TAF’s, METARS and SPECIS;

3. Progress due to movement of an unstable air mass involving

69 A SPECI report is issued by the FISO or Air Traffic Controller when certain weather conditions
change adversely or improve by certain criteria. This is an ICAO requirement.

70 Quoted in ‘Orographic Precipitation in the Tropics’ by R B Smith et al; American Meteorological
Society Oct 2012; DOI:10.1175/BAMS-D-II-00194.1
intense convection and active cloud formation, which is difficult to predict on a local scale;

4. Are best tracked utilising cloud satellite and rain radar imagery;

5. Produce gaps of fine weather that form between bands and patches of cloud. These can appear suitable for VFR flight but may quickly close and entrap an aircraft.

6. Generate turbulence which becomes a risk to flight control in mountainous terrain;

7. Intensify around mountainous terrain;

8. Require the assistance of a meteorological forecaster to help identify and understand the risks to aviation;

9. Generate risks that are more uncertain and therefore more difficult to manage than frontal weather systems.

2.7 Assembling the facts

2.7.1 Before beginning to analyse organisational aspects, it is useful to recap on the analysis discussed so far. This relates to weather on the day, characteristics of tropical low-pressure weather troughs and information from the ADS-B data.

2.7.2 The pilots flew to Labasa in reasonable weather, arriving at 8:40 am. The weather then deteriorated and it began raining heavily. The pilots waited until it improved. Satellite and rain radar imagery along with the 11 am METAR at Labasa and one photograph taken after 11 am showed that the weather improved significantly between 11 am and 11:30 am to the South of Labasa and towards Savusavu. Conditions across the mountains to the South of Labasa appeared more suitable than weather to the Northwest and Northeast over the coastline of Vanua Levu. This explains why the pilots decided to depart for Savusavu around this time and over the mountains instead of via the coast. However, when the aircraft departed at 11:37 am or soon after, the weather began to deteriorate at Labasa and over the mountains.

2.7.3 The ADS-B data indicated that the aircraft speed varied significantly throughout the flight, suggesting control difficulties. From the time that it began to descend from its maximum height of 6,000 feet, it was subject to severe downdrafts, which at times caused the aircraft to descend suddenly at the rate of 75 feet per second. Approximately three and a half minutes before impact, the pilots stopped responding to calls from the Labasa Flight Information Service suggesting a heavy workload, consistent with flight in bad weather and limited or no visibility.

2.7.4 The final moments of ADS-B flight data suggest the pilots looked for a way out of the cloud by descending into a mountain valley. However, following this decision, they turned the wrong way towards the cliff face which they impacted. All this evidence suggests that the aircraft
was subject to flight in poor visibility and/or Instrument Meteorological Conditions (IMC) for which they were not qualified. This is also consistent with cloud satellite and rain radar images which show that convective cloud and moderate to heavy rain had closed in over the Mt Delaikoro area at 12:00 midday.

2.7.5 Bad weather had overtaken the aircraft, entrapping it without an escape route. Clear but humid air had rapidly condensed into cloud, fog, mist and rain, and this had occurred at a faster rate than the pilots could assess and avoid. This had occurred unpredictably as can occur in tropical low-pressure trough weather systems.

2.7.6 The Air Navigation Regulations para 69 states that it is the responsibility of the Pilot In Command (PIC) for operating an aircraft safely. It is the PIC’s responsibility to determine whether or not an aircraft should be flown in or around bad weather when flying to Visual Flight Rules.

2.7.7 Judging bad weather can be difficult at times. One reason for this is because horizontal visibility cannot be measured and may be continuously changing due to rapidly developing conditions during the flight. Flight Information Service Officers (FISO’s) and Air Traffic Controllers are able to estimate cloud height and visibility with better accuracy because they are able to refer to known landmarks near the aerodrome with which they have become familiar.

2.7.8 The difficulty of judging visibility and changing weather conditions means that it is important that pilots carefully assess the type of weather that the aircraft is likely to encounter before the aircraft departs, so that the destination can be reached safely. As mentioned previously in section 1.17, this is a requirement of paragraph 4.3.5.1, Annex 6 Part I of ICAO.

2.7.9 The PIC had not reviewed all the useable weather information available to him at the time, when exercising the decision to depart Labasa and fly over the central mountain range of Vanua Levu to Savusavu. He had not consulted the commercial pilot that had landed at Labasa after 11 am. It is unlikely that he had reviewed the latest MSL synoptic chart, the 11 am SPECI on Savusavu and recent rain radar and cloud satellite images. Nor had he received a briefing from a meteorological forecaster before departing Nadi. But he had complied with all the procedures and requirements that PFS had documented in relation to bad weather decision making and crossing mountain ranges.

2.7.10 As has been discussed previously, low-pressure trough systems are difficult to forecast, and they generate transient clear-air gaps which misleadingly indicate weather improvement. These risks are magnified in mountainous terrain due to blind valley traps, downdrafts and non-uniform terrain. Also, mountainous terrain is able to induce orographic lift of humid air resulting in condensation and formation of cloud, mist, fog and rain, all of which reduces visibility.

2.7.11 The PIC had not been taught these risks. His CPL and ATPL meteorological study guides had not comprehensively identified the risks of tropical low-pressure weather trough systems in Fiji and
mountain flying, or how to manage them. Nor had his flight training at PFS. Had he been trained to identify the risks of flying over mountainous terrain and low-pressure weather troughs, and how to manage them, he would have been better informed about the types of weather information that would have been useful in his decision making, and how to interpret them. This would have included cloud satellite and rain radar images which are not bona fide ICAO weather information instruments. He could have also understood the importance of obtaining additional assistance from other more experienced pilots, or an FMS forecaster. With a more comprehensive evaluation of this weather information, he might not have decided to fly across the central mountain range of Vanua Levu.

2.7.12 The next section analyses the contribution of possible organisational deficiencies that may have contributed to the PIC’s poor decision making.

2.8 Organisational factors

2.8.1 This section discusses the performance of the risk management processes that were available to identify and manage the risks that led to this accident.

2.8.2 These risk management processes were investigated by reviewing documentation provided by the PFS, CAAF and ICAO organisations. As discussed below, none of these processes were able to identify and manage the risks related to flying over mountainous terrain during the onset of a low-pressure trough weather system.

The risk management processes of Pacific Flying School (PFS)

2.8.3 The risks of low tropical low-pressure trough weather systems over Fiji’s mountainous terrain have been comprehensively discussed previously.

2.8.4 The Pacific Flying School did not identify these risks in its Operations Manual, its day Flying Training Manual or its Safety Management System (SMS) Manual. One possible reason for this omission is that aviation training in Fiji follows the Australian flight training syllabus. The training course study guides for the CPL and ATPL meteorological theory exams are tailored for Australian weather systems which may not present these risks, or if they do, the risks are less significant. It is likely that this omission led to deficiencies in PFS’ risk identification and management processes which are discussed in paragraphs below.

2.8.5 The PFS Operations Manual discusses VFR limitations and disciplinary action but does not admit that decision making could be difficult in some weather systems and that consultation with other experienced pilots, both within and external to PFS could be beneficial and in some instances, required.

2.8.6 The PFS Flight Training Manual did not specify the types of weather information such as satellite cloud and rain radar imagery that students
need to interpret in order to assess the risks of a complex low-pressure trough system, nor did it require students to obtain updated weather en route from established aviation agencies and other pilots. It did not require its students to obtain weather briefings from the Fiji Meteorological Service before embarking on a cross country training exercise.

2.8.7 The PFS Operations Manual provided no decision-making guidelines to help pilots decide when flight over mountainous terrain was not advisable.

2.8.8 The PFS training syllabus provided no training on mountain flying and did not identify mountain flying risks, particularly in tropical low-pressure trough weather systems.

2.8.9 The PFS Operations Manual, contrary to what it promised in Section 3.7, did not provide sufficient guidelines to protect the accident pilots. The PFS Operations Manual specifically prohibited flight in the vicinity of thunderstorm clouds and in areas bounded by a SIGMET warning. However, the forecasted SIGMET area in this case did not encroach on Vanua Levu and although the Doguru and other villagers noted heavy rain, fog, cloud and mist, they provided no reports of thunder and lightning, suggesting that thunderstorms were not prevalent.

2.8.10 However, ADS-B data indicated that downdrafts were severe, up to 75 feet per second from as high as 6,000 feet, during the descent, and immediately prior to impact. (Ref Fig B13 of Appendix B2) This is consistent with advice in the IATA paper (Ref Appendix G) which states in Section 4.4 that convective clouds capable of generating severe turbulence may be found in ‘groups of cells at differing stages of development’, indicating that formation of cumulonimbus cloud was not a prerequisite for severe turbulence.

2.8.11 The IATA paper recommends if possible, that flight through convergence zones be avoided completely. If this is not possible, Section 4.4 of the IATA paper concedes that ‘very little guidance exists on how best to manage the transit of convective cloud concentrations’. Although the context of this accident flight differs from high altitude flying which is the subject of the IATA paper, the admission of uncertainty in the IATA paper reflects the real problems that these types of weather systems can cause.

2.8.12 Sections 8 and 9 of the PFS SMS Manual discuss several different risk management processes. However, it does not provide relevant aviation examples or specific guidance as to how they should be applied to identify and manage the risks of PFS operations such as the risks of bad weather decision making and mountain flying.

2.8.13 One of the risk management processes referred to in Section 9 include safety surveys. However, no details are provided regarding how safety surveys should be conducted, apart from references to a collection of forms in Section 16.

2.8.14 Despite bad weather and tropical low-pressure trough systems being a
regular occurrence during the wet season, bad weather decision making was not included in the 20 items that Paragraph 13.3.1 of the Safety Management System (SMS) Manual requires to be audited regularly.

2.8.15 Section 13 does not explain how these internal audits should be conducted, nor does it provide details of the audit process required. It does not for example, include any audit checklists.

2.8.16 The PFS Safety Management System was unable to identify the risks of low-pressure weather trough systems and mountain flying which contributed to this accident.

Safety oversight by CAAF

2.8.17 The CAAF SMS and ATIC audits of early 2017 did not identify these omissions in the PFS documentation. Nor did the audits express any findings or comments in relation to the risk assessment of cross-country flight training in bad weather and over mountainous terrain.

2.8.18 The items that were identified in the audits did not relate directly to bad weather risks or mountain flying and are therefore unlikely to be relevant to this accident.

2.8.19 Unlike New Zealand, CAAF had not been able to identify mountain flying risks and had not followed New Zealand’s guidelines in addressing them.

2.8.20 Although New Zealand does not experience tropical low-pressure trough systems, its mountain flying training does consider similar consequences of bad weather such as turbulence and weather entrapment, when addressing mountain flying risks.

2.8.21 None of the CAAF Aviation Safety Bulletins between 2012 and 2018 identified the risks of low-pressure weather troughs and mountain flying.

2.8.22 CAAF did not address the ‘local needs’ that are mentioned in the executive summary of the ‘SSP Fiji’ document. These include the needs to identify and manage the risks of LP weather troughs which are peculiar to Fiji and other South Pacific countries near the SPCZ, and mountain flying risks.

2.8.23 CAAF in its document titled ‘State Safety Programme Fiji’ in Paragraph 2.1 under ‘safety policy’, referred to ‘a continuous flow and exchange of safety management data between CAAF and operators/service providers.’ However, this did not occur with regards to the risks of tropical low-pressure trough systems and mountain flying.

2.8.24 With respect to this accident, CAAF was unable to provide the safety oversight mentioned in the ‘SSP Fiji’ document.  

71 See section 4.1 titled ‘Safety Oversight’ of the document titled ‘State Safety Programme Fiji’
2.8.25 One possible reason why CAAF was unable to provide the necessary safety oversight needed to prevent this accident was that it relied on the regulatory controls provided by the CASA Flight Training Syllabus, exams and associated pilot study guides to identify the risks of low-pressure weather troughs and mountain flying, which regrettably they did not. This is probably because the majority of the Australian land mass does not have the same types of oceanic tropical weather systems and mountainous terrain that Fiji has.

2.8.26 CAAF would also have relied on the meteorological processes and controls provided by ICAO which the FMS complied with. Regrettably these were not sufficient to fully address the risks of low-pressure weather troughs that occurred on the day of the accident.

2.8.27 Oversight of the Safety Management System is part of the State Safety Programme (SSP) which under ICAO, CAAF is required to promulgate and maintain. The definition of ‘Predictive’ and ‘Proactive’ management systems in the SMS Standards Document is not clear. The definitions could benefit with reference to examples of Predictive and Proactive risk management studies that would be applicable and practically relevant to “the size, nature and complexity”\(^{72}\) of Fiji’s aviation service providers. It is likely that a proactive or predictive risk management strategy would have been needed to identify and manage the risks that led to this accident.

Harmonisation with New Zealand regulations.

2.8.28 At the time of the accident, Fiji was considering harmonising some of its regulations with those of New Zealand. Harmonisation with Parts 61 and 135 of New Zealand’s regulations would have identified the risks of mountain flying hazards and provided strategies to mitigate them.

2.8.29 Harmonisation requires extensive regulatory resources to implement and maintain. However, it would have been possible to identify and manage the mountain flying risks that contributed to this accident by adopting only the relevant aspects of applicable New Zealand Advisory Circulars, without having to harmonise or implement a complete set of New Zealand’s regulations formally into Fiji’s regulatory framework.

ICAO’s contribution

2.8.30 The recommendations that arose from the last ICAO audit of CAAF in 2006 were reviewed as part of this investigation. While ICAO issued many recommendations, none related to the risks of low-pressure weather troughs or mountain flying.

2.8.31 The Protocol Questions (PQ’s) which are used in the Universal Safety Oversight Audit Programme (USOAP) to assess a state’s rating were also reviewed as part of this investigation. The PQ’s are based on the ICAO annexes which were also reviewed. No questions were identified that

\(^{72}\) As referred to in Paragraph 5.1 of the SMS Standards Document
related to the risks of low-pressure weather troughs and mountain flying.

2.8.32 The ICAO Annexes, audits and monitoring to date have not revealed any shortcomings in the regulations or recommended practices that are promulgated and administered by CAAF and which could relate to the risks of mountain flying operations and low-pressure weather troughs.

2.8.33 ICAO documents have not formally identified the risk that tropical low-pressure trough weather systems are more uncertain, less predictable and more difficult to manage than frontal systems. Nor have they identified mountain flying risks. It is perhaps useful to consider why ICAO documentation and audit processes have not identified the risks that contributed to this accident.

2.8.34 The annexes to the Chicago Convention imply that ICAO’s emphasis on air safety is directed to international flight operations which are conducted in aircraft heavier than 5700 kg, and by operations which may compromise the safety of international flights in these aircraft.

2.8.35 The weight of the accident aircraft was less than 2250 kg. ICAO does not log accident and incident reports for aircraft in this category. Therefore, it may not be aware of recurring accidents affecting these types of aircraft which would otherwise justify amendments or additions to ICAO Annexes and processes. This possibly explains why the risks of tropical low-pressure trough weather systems and mountain flying may not have been comprehensively understood or addressed by the international aviation community.

2.8.36 Mountain flying in an aircraft of this category is unlikely to register high in ICAO’s priorities, interests and objectives because the flying operation occurs within a single ICAO state and not as a result of international travel between ICAO states or countries.

Legal matters between CAAF and Joyce Aviation

2.8.37 The allegations against Joyce Aviation are subject to investigations by other professionals who are required to follow legal processes and rules that differ to those which this investigation must follow, and at the time of writing, the legal processes had not yet concluded. Regarding the question as to whether these allegations have demonstrated a less than desirable safety culture that could have contributed to this accident, it is not possible in this report, to conclude whether or not this was the case.

2.8.38 However, it would not be unreasonable to conclude that the time and resources that both sides have spent in processing and defending these allegations has detracted from the task of identifying and managing the risks that led to this accident.

It is appropriate to note that the incidents which are the subject of the allegations do not appear to relate directly to risks of flying in an environment with a combination of low-pressure weather troughs and mountainous terrain.
3 CONCLUSION

3.1 Introduction

3.1.1 This conclusion consists of findings and contributing factors. Findings include significant facts uncovered during the course of the investigation which may relate to the factors which contributed to the crash.

3.1.2 Contributing factors include actions, omissions, events, conditions, or a combination thereof, which, if eliminated, avoided or absent, would have reduced the probability of the accident occurring.\(^{73}\)

3.2 Findings

3.2.1 None of the following were factors in the accident:

1. The qualifications of the Pilot in Command and the student pilot. These were fully compliant to Fiji regulations.

2. The medical conditions of the Pilot in Command (PIC) and the student pilot. There was no evidence to suggest that their health was impaired.

3. The mechanical condition of the aircraft. The engine of the aircraft and its control systems were operating normally at the time of impact.

3.2.2 The operator of the aircraft, the Pacific Flying School, had a valid Air Training Institute Certificate (ATIC) at the time of the accident.

3.2.3 The weather conditions for the first leg of the cross-country training flight between Nadi and Labasa complied with Visual Flight Rules in accordance with Fiji’s Air Navigation Regulations and the cross-country training flight plan.

3.2.4 When the pilots departed Labasa for the accident flight, it is likely that visibility and cloud cover complied with Visual Flight Rules in accordance with Fiji’s Air Navigation Regulations.

3.2.5 It is likely that after the aircraft departed Labasa, the weather across the mountains deteriorated rapidly, entrapping the aircraft and providing no escape route. The final stages of flight were probably flown in poor visibility and in Instrument Meteorological Conditions (IMC) for which the pilots had received only limited training. It is therefore unlikely that this stage of the flight was conducted in accordance with Visual Flight Rules that complied with Fiji’s Air Navigation Regulations.

\(^{73}\) As defined in Annex 13 of ICAO
3.2.6 Because of likely poor visibility, the PIC chose to enter a mountain valley in a direction and manner which provided the aircraft with no escape route out of the valley, causing it to impact steep mountainous terrain.

3.2.7 The weather over Vanua Levu at the time of the accident was associated with the onset of a tropical low-pressure trough system, which are common in Fiji during the wet season and are renowned amongst meteorologists for being unpredictable and difficult to forecast.

3.2.8 During the course of the investigation, a discrepancy was found between scale markings on the Fiji aeronautical map and the scale markings of the navigation ruler that pilots use to measure nautical miles on the map. It was not possible to determine which scale was correct. This did not contribute to the accident.

3.3 Contributing factors

3.3.1 In this section, factors which contributed to the decision of the Pilot in Command (PIC) to depart Labasa and fly into apparently suitable weather that quickly deteriorated, are summarised. Several factors were identified.

3.3.2 The risks and unique characteristics of tropical low-pressure trough weather systems are set out below. As discussed in paragraphs to follow, little or no understanding of these aspects contributed to the cause of the accident.

Tropical low-pressure trough weather systems:

1. Are more difficult to forecast and predict than frontal systems;

2. Produce weather patterns which are patchy, non-uniform and difficult to characterise representatively utilising conventional aviation weather methods such as TAF’s, METARS and SPECI’s;

3. Progress by a combination of cloud movement and rapid convective condensation, both of which are difficult to predict;

4. Are best tracked utilising cloud satellite and rain radar imagery;

5. Produce gaps of fine weather that form between cloud bands and mist patches. These can appear suitable for VFR flight but may quickly close, subjecting pilots to poor visibility and flight in IMC conditions;

6. Intensify over mountainous terrain, producing not only mist, cloud and rain but also severe turbulence;

7. Require the assistance of a meteorological forecaster to help identify and understand the risks to aviation;

8. Generate risks that are more uncertain and therefore difficult to
manage than frontal weather systems.

3.3.3 These characteristics and risks were not identified in any documentation that provided guidelines or regulatory controls which the pilots were required or recommended to follow. This documentation included the meteorological study guides that were provided to the pilots in preparation for the Commercial Pilot Licence and Air Transport Pilot Licence exams. It also included the PFS VFR Training Manual, the PFS Operations Manual, the PFS 172 Operating Procedures, the PFS Safety Management System Manual, the Sunflower Aviation Cessna 172 Route Guide, the CAAF Standards Documents (SD’s), the CAAF ATIC and SMS audit of PFS in 2017, Section 5 of the Application for the Issue of a Commercial Pilot Licence, the Air Safety Bulletins that CAAF published quarterly, the ICAO annexes and the ICAO Protocol Questions (PQ’s) used to assess a state’s rating in the Universal Safety Oversight Audit Programme (USOAP).

3.3.4 None of this documentation provided guidelines, procedures or recommendations for understanding and assessing tropical low-pressure weather systems and exercising good decision making when encountering this type of weather.

3.3.5 It is probably for this reason that the pilots had not reviewed all the weather information that was available to them during the morning prior to the accident flight when deciding whether to depart Labasa for Savusavu. This information included:

- A personal briefing with a meteorological forecaster of the Fiji Meteorological Service (FMS) before departing Nadi;
- A review of the Mean Sea Level Synoptic Chart showing the location of the low-pressure trough over Vanua Levu and a plot of SIGMET 06 in relation to the low-pressure trough line, both at Nadi prior to departure and at Labasa while they were waiting for the weather to improve;
- A review of cloud satellite and rain radar imagery both at Nadi and at Labasa while they were waiting for the weather to improve;
- An update of the TAF’s, METARS and SPECI’s of Labasa and Savusavu while they were waiting at Labasa for the weather to improve;
- A conversation with a commercial pilot who had landed at Labasa just before the accident aircraft departed on its last flight.

3.3.6 Had the pilots fully understood the risks of tropical low-pressure weather systems particularly over mountainous terrain, and reviewed all this weather information, they may not have decided to depart Labasa.

3.3.7 The FMS advised that around 2012 after the FMS promulgated weather information on its website, pilots stopped attending weather briefings.
This is likely to have led to a deterioration in the understanding of Fiji tropical weather systems by pilots in Fiji.

3.3.8 The website of the FMS is not ‘mobile friendly’ to smartphones.

3.3.9 The risks of mountain flying identified in this accident are severe turbulence, downdrafts, and blind valley traps. Also, mountain flying risks compound with low-pressure weather troughs which add increased turbulence together with an even greater tendency for cloud and rain to form around mountainous terrain due to orographic lift.

3.3.10 None of the documentation identified above addressed the risks of flying over the central mountain range of Vanua Levu.

3.3.11 The pilots had not received any formal mountain flying training which if based on lessons learnt from New Zealand mountain flying accidents, would have highlighted the need to consider increased turbulence and downdrafts around mountainous terrain and the need to enter valleys at a height and in such a way that an escape route is always available.

3.3.12 The flight training syllabus in Fiji follows the Australian CASA Flight Training Syllabus which may not have the same mountain flying and tropical weather risks as Fiji.

3.3.13 The Safety Management System of PFS had not identified the risks of tropical low-pressure weather troughs and mountain flying.

3.3.14 CAAF’s State Safety Programme (SSP) had not addressed the risks due to tropical low-pressure weather troughs, despite them occurring on average once a week during the wet season. Nor had it addressed the risks due to mountain flying.

3.3.15 Although CAAF had in past years been subject to an ICAO audit and continuous ICAO monitoring via the USOAP, none of the findings, Protocol Questions (PQ’s) or recommendations identified any issues or deficiencies with CAAF’s processes, regulatory controls and audit programs which revealed that the hazards of low-pressure weather troughs and mountain flying were not being adequately addressed in Fiji.

3.3.16 One reason for this omission is probably because these risks are not identified in any of the ICAO Annexes and/or Supplementary ICAO publications.

3.3.17 The Pilot in Command’s (PIC) duty time in the 14 days leading up to the accident exceeded the limit permitted in the PFS Operations Manual by approximately 10%. It is unlikely that this contributed significantly to the accident. One reason for this is that the PIC’s flight time in the 28 days leading up to the accident, was less than half of the limit permitted by the PFS Operations Manual.

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74 Orographic lift refers to the rising of air as it flows over mountainous or elevated terrain.
4 SAFETY RECOMMENDATIONS

4.1 Introduction

4.1.1 Most of these recommendations in this section relate to the need for improved provision of Fiji weather information because tropical low-pressure weather troughs are uncertain and difficult to manage. It should also be noted that as global warming progresses over time, these adverse conditions are likely to become more prevalent and intense in Fiji.

4.1.2 A comprehensive technical basis for these recommendations is set out in two documents that may be found in Appendix F of this report. These documents are titled ‘Fiji Climatology’ and ‘Proposed Improvements to Fiji Aviation Weather Information’.

4.1.3 These documents were explained and presented to stakeholders of this accident investigation on the 17th of July 2018 at the CAAF offices in Nadi.

4.2 Recommendations to the Civil Aviation Authority of Fiji (CAAF)

Mountain Flying Training

4.2.1 One of the contributing factors to this accident was a lack of awareness of mountain flying risks and strategies to address them.

4.2.2 Therefore, it is recommended that CAAF require pilots to undergo mountain flying training for both PPL and CPL licences and that this be required for both fixed wing and rotary wing aircraft. The New Zealand CAA mountain flying training documents in Appendix D of this report should be followed as a guide with supplementary information appropriate for Fiji. CAAF should consider incorporating mountain flying training information from the New Zealand CAA documents into Fijian documents such as the ATIC and SMS Standards Documents, and other Aviation Information Circulars (AIC’s) as required.

Fiji Climatology

4.2.3 Fiji frequently experiences tropical low-pressure trough systems. This investigation has shown that these conditions generate risks different to, and more unpredictable than those occurring in other countries.

4.2.4 It is therefore recommended that CAAF, in conjunction with the Fiji Meteorological Service develop a new training and information module related to Fiji Climatology. The development of this new training module should follow the guidelines proposed in Appendix F of this report. The Fiji Climatology paper should be promulgated by means of an Aviation Information Circular or an appropriate Standards Document. PPL and CPL students should be examined on the contents of the Fiji
Climatology paper and may need to attend training courses to become familiar with its contents. All Fiji pilots should be provided with a copy of the Fiji Climatology paper.

PIREPS (Pilot reporting)

4.2.5 This investigation has highlighted the value of pilots sharing weather information among each other when identifying bad weather risks and addressing them. The NTSB report on PIREPS in the USA also identified the value of PIREPS as observation and feedback information to weather forecasters.

4.2.6 It is therefore recommended that CAAF require, facilitate, co-ordinate and encourage the execution of pilot reports to assist other pilots in bad weather decision making and also to provide feedback to meteorological forecasters.

4.2.7 It is also recommended that CAAF require the implementation of communication systems involving cell phones, radios and email communications as appropriate to provide weather information at remote sites back to aviation forecasters at the Fiji Meteorological Service (FMS). While some information may be currently returned to the FMS, more is required.

4.2.8 It is also recommended that CAAF facilitate a culture of effective communication between student pilots and experienced commercial pilots, which may be undertaken through social activities, promulgating safety notices in the quarterly Aviation Safety Bulletin and noticeboard posters.

Weather briefings in person

4.2.9 This investigation has demonstrated the importance of student pilots and instructors receiving weather briefings in person from meteorological forecasters, as suggested by Paragraph 9.2.1 of Annex 3 of ICAO.

4.2.10 It is therefore recommended that CAAF require flight training organisations to compel their students and instructors to attend briefings in person at the premises of the FMS, particularly during the wet season when tropical low-pressure troughs and bad weather are forecast. It is also recommended that CAAF specify the types of weather briefing information to be evaluated before a flight is commenced, as referred to in ANR 69. The weather briefing information that should be specified as being necessary is:

- General Area Forecast
- TAF’s
- METARS
- SIGMET warnings
- Mean Sea Level Synoptic Charts
- Satellite images of cloud build-up, viewed as a loop on a computer screen
- Rain radar images, viewed as a loop on a computer screen.

**Cross country flight tests**

4.2.11 This investigation has shown that audits had not reviewed, assessed or identified the elements in flight training that are required for good decision making in bad weather. New Zealand and Australia require students to be subject to a cross country flight test. This test would provide an opportunity to assess the ability of the student to understand these elements and how to apply them. New Zealand permits the flight examiner to be an experienced instructor employed by the flight training organisation that trained the student.

4.2.12 It is therefore recommended that CAAF require flight training organisations to subject their students to a cross country flight test, as it is required in New Zealand.

**Simulated ‘Lost procedure’ flight training.**

4.2.13 This investigation has shown the risks and dangers that the accident pilots encountered when they tried to navigate in poor visibility close to mountainous terrain. It is possible that had the accident pilots requested assistance from the Air Traffic Control (ATC) centre at Nadi, before or during the final descent while they still had sufficient height available to them, that ADS-B vectors could have been provided to direct them to the coast, away from mountainous terrain and towards clear air.

4.2.14 It is therefore recommended that CAAF in conjunction with the ATM section of Fiji Airports derive a ‘lost procedure’ that can be rehearsed by student pilots during training that will allow pilots to request ADS-B surveillance assistance from ATC centres if inadvertently caught in adverse weather conditions. Such a procedure could be incorporated in the basic panel Instrument flying that is required as part of the Commercial Pilot’s Licence (CPL). It is likely that the ATC centre involved will need access to rain radar and cloud satellite images that the FMS displays on its website so that it is able to ascertain possible locations of clear air and advise these locations to pilots if necessary. ATM may itself need to develop a procedure to be able to provide this service utilising ADS-B surveillance technology.

**Weather briefings at remote aerodromes**

4.2.15 This investigation has shown the value of meteorological information that Flight Information Services (FIS) are able to provide at remote airfields such as Labasa and Savusavu. Such information is available from the FIS computers to provide updated TAF’s, METARS and SPECIS as well as cloud satellite and rain radar images. Itinerant pilots should be encouraged to utilise this information.
4.2.16 It is therefore recommended that CAAF, with the cooperation and assistance of Fiji Airports, update the AIP Manual for remote airfields so that the details and extent of these services as mentioned above are clearly known and pilots are able to phone the FIS centres at remote airfields directly for weather updates and other meteorological information.

4.2.17 It is also recommended that CAAF encourage pilots to learn from the local weather knowledge of Flight Information Service Officers (FISO’s) when communicating and visiting them.

Implementation of these recommendations.

4.2.18 There are several ways that these recommendations may be implemented. The document titled ‘Proposed improvements to Fiji Weather Information’ that may be found in Appendix F has shown that informal processes can be useful in communicating important meteorological information between pilots. Regulatory controls can also be useful for ensuring that other types of information are conveyed. Both Fiji legislation and the ICAO State Safety Programme require a balance between these approaches. The information forums and processes available to CAAF to ensure that these recommendations are implemented include the following:

- Standards Documents (SD’s); alterations or additions to existing SD’s or new SD’s;
- Aviation Information Circulars (AIC’s); alterations or additions to existing AIC’s or new AIC’s;
- Audits. The information in this report may be used as risk identifiers and checklist prompts when auditing air service organisations.
- Compelling aviation service providers to include new risk mitigation processes in their SMS utilising Audit results, SD’s, AIC’s, and Aviation Safety Bulletins. The types of documents produced by air service providers that are able to facilitate this report’s recommendations are operations manuals, training manuals, SMS manuals and route guides.

4.2.19 It is therefore recommended that CAAF utilise all the means available to ensure that the recommendations in this report are properly facilitated and fully implemented. This includes recommendations that require the expertise and efforts of other organisations such as the Fiji Meteorological Service (FMS) and Fiji Airports (FA).

4.3 Recommendations to the Fiji Meteorological Service (FMS)

The need for additional facilities and services

4.3.1 This investigation has concluded that tropical low-pressure trough systems are difficult to forecast and present risks that are different and

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at times more difficult to manage than risks derived from conventional frontal systems. The Fijian aviation industry would benefit from the availability of more meteorological information and observations to facilitate improved forecasting and monitoring of tropical low-pressure weather systems.

4.3.2 It is therefore recommended that the FMS provides the following additional weather instrumentation, facilities and services:

1. **Automatic Weather Stations (AWS) should be installed at Labasa, Mt Delaikoro and Mt Evans.** An AWS at Labasa would enable a TAF to be issued early in the morning from 6:00 am. This would assist commercial flights that arrive there at 8:00 am. An AWS mounted on the existing telecommunications mast at Mt Delaikoro would assist VFR pilots in weather decision making across the central mountain range of Vanua Levu. An AWS at Mt Delaikoro and Mt Evans would also assist in the monitoring of low-pressure troughs that develop and progress over Fiji during the wet season. They would also enable a separate General Area Forecast to be provided for the mountainous areas of Fiji.

2. **The rain radar facility at Nadi should be repaired and made operational.** Rain radar images are necessary for tracking the progress of tropical low-pressure weather systems. Along with satellite cloud imagery, they are important tools for identifying build-up of bad weather and are therefore strategic risk mitigation measures against poor decision-making in these conditions.

3. **The FMS website should be made more user friendly for mobile smartphones.** This will allow smartphones and tablets to download updated TAF’s, METARS, SPECIS, cloud satellite and rain radar images. Improved information will allow managers of air service providers, pilots and other personnel to be able to track the progress of tropical low-pressure weather troughs more regularly.

4. **The FMS should issue SIGMET plots on Mean Sea Level Synoptic Charts.** This would help pilots to understand the risks of an approaching low-pressure weather trough, if the SIGMET weather boundary is associated visually with a low-pressure trough.

5. **The FMS should promulgate AIRMET information.** An AIRMET weather report should be used to report on the progress of low pressure weather troughs and should be written in plain English. AIRMET reports should be able to be despatched by text to registered smartphone users.
The need for a separate mountainous area in the General Area Forecast

4.3.3 This investigation has shown that tropical low-pressure trough systems generate air turbulence which can be magnified over mountainous areas, which for VFR pilots, generate additional risks.

4.3.4 There are also risks to commercial flights which fly on Instrument Flight Rules (IFR). During the course of this investigation, one first hand report and two anecdotal reports were received of commercial twin engine aircraft rapidly losing up to 3,000 feet during normal commercial flying. These incidents which are likely to have occurred as a result of tropical weather systems over mountainous areas, are extreme events and could have resulted in accidents, as Minimum Safe Altitude (MSA) levels for IFR pilots are calculated assuming a maximum height loss of only 1,000 feet. It is therefore recommended that the FMS provide a separate mountain area forecast in its General Area Forecast, for both Vanua Levu and Viti Levu.

Fiji Climatology

4.3.5 It is recommended that the FMS provide assistance to CAAF, in developing a new training and information module related to Fiji Climatology. The development of this new training module should follow the guidelines proposed in Appendix F of this report.

4.4 Recommendations to ATM of Fiji Airports

The need for Flight Information Services to advise visibility and cloud base to aircraft at remote aerodromes.

4.4.1 This investigation has found that it can be difficult for pilots to estimate visibility while flying in adverse weather. It is also difficult for untrained people to estimate visibility and cloud height while on the ground. Flight Information Service Officers (FISO’s) at remote aerodromes are able to provide these estimates by means of reference to known landmarks and their locations.

4.4.2 It is therefore recommended that FISO’s at remote aerodromes provide visibility and cloud base information to pilots before starting or while taxying, prior to departure.

The need for updated weather information to be made available to pilots at remote aerodromes.

4.4.3 This investigation has shown the need for pilots to be continually updated with new weather information prior to the arrival and during the presence of a tropical low-pressure trough system.

4.4.4 It is therefore recommended that Flight Information Services at remote aerodromes be encouraged to make their computer facilities available to itinerant pilots who may need the latest weather information. This information should include rain radar and cloud satellite images, as well as General Area Forecasts, TAF’s, METARS, SPECIS and Mean Sea Level...
Synoptic Charts. These services should be clearly promulgated in the AIP manual for each remote aerodrome.

The need for reliable ADS-B data services in the aftermath of an accident

4.4.5 This investigation has shown the value of ADS-B data in determining the aircraft movements leading up to an accident. The track data can provide valuable information that can be analysed and used to prevent a repeat of the accident. It can also be used to locate an aircraft that has crashed in thick vegetation in mountainous terrain. In Fiji this is a necessary facility, given that Emergency Locator Transmitters (ELT’s) have a reputation for being unreliable and Fiji no longer requires these to be installed in its aircraft as ADS-B equipment can provide superior information.

4.4.6 Regrettably, for reasons unknown, ADS-B data relating to the final moments of the accident aircraft flight was not accessible to Search and Rescue services. This, together with bad weather at the time, resulted in delays in locating the aircraft. Had there been any survivors from the crash, these delays would have lessened the chance of their survival.

4.4.7 It is therefore recommended that ATM services improve the facilities for recovering and plotting ADS-B data in the aftermath of an accident in order to improve the survivability of crash survivors.

A possible discrepancy with the scale on the Fiji Aeronautical chart

4.4.8 During the course of this investigation, a discrepancy between a navigational scale ruler and the scale on the Fiji aeronautical chart was identified. The discrepancy is in the order of 5%.

4.4.9 Although this did not contribute to the accident it could, depending on the cause of the discrepancy, contribute to an accident or incident in the future.

4.4.10 It is therefore recommended that ATM services investigate the cause of this discrepancy, resolve it, and if necessary reprint the Fiji aeronautical chart so that its scale may be corrected.

The need for development of a ‘lost procedure’ for pilots caught in a low-pressure weather trough system

4.4.11 This investigation has demonstrated the need to develop a ‘lost procedure’ to assist pilots who are overcome by bad weather. It is envisaged that such a procedure would enable a pilot in distress to seek surveillance assistance from an ATC centre which would allow the pilot, utilising basic instrument flight training, to follow ATC directions to areas of clear air. In order to provide this assistance, an ATC centre would need to be able to access satellite cloud and rain radar images, and understand how to interpret them.

4.4.12 It is therefore recommended that ATM of Fiji Airports work with CAAF in
deriving this procedure. It is also recommended that ATM provide and facilitate the training and weather briefing services that ATC personnel will need to be able to provide this assistance.

4.5 **Recommendations to the Pacific Flying School (PFS)**

**A Proactive Risk Management Review Process**

4.5.1 It is recommended that the PFS subject its flying training operations to a proactive risk management review process fully considering the weather and mountain flying risks discussed in this report as identifier prompts and the basis to review the safety of existing flying training operations. It is recommended that this be undertaken as part of its Safety Management System (SMS).

4.5.2 An example of an appropriate proactive risk management review process is a brainstorming exercise involving instructors and managers. The meeting minutes would reflect identified risks and actions which may require further research and investigation before being closed out. The meeting minutes should show that the risk mitigation strategies discussed in this report have been considered. Some of the items may require contributions from other aviation service providers, such as CAAF (new climatology information), Fiji Meteorological Service (weather forecasting), and ATM of Fiji Airports (new ‘lost procedure’). A subsequent meeting may be required to confirm closed out actions.

**Amendments to PFS’ VFR (day) training and operations manuals**

4.5.3 It is recommended that PFS incorporate the results of the risk management review process into its flight training and operations manuals. Such amendments would be expected to include bad weather decision making guidelines, including the identification of all useful weather information instruments such as cloud satellite, rain radar imagery, consultation with experienced pilots and other risk mitigation strategies discussed in this report.

4.5.4 The amendments should also include decision making guidelines to help pilots evaluate whether or not to fly over mountainous terrain. These guidelines should be derived from the applicable New Zealand Advisory Circulars that may be found in Appendix D of this report. Cloud base, wind speed, visibility and the type of weather forecast should be considered as relevant guideline parameters.
5 SCHEDULE OF APPENDICES

Appendix A: Weather Information
A1: General Area Forecast, TAFS, METARS, SPECIS
A2: Satellite cloud images; annotated
A3: Satellite cloud images; electronic
A4: Rain radar images
A5: MSL Synoptic charts

Appendix B: Radiotelephony (RTF) and ADSB information
B1: RTF transcripts (Confidential; available on application)
B2: ADS-B information; plots and graphs

Appendix C: Photographs and Diagrams
Fig C1: photograph of Twin Otter at Labasa
Fig C2: Labasa runway
Fig C3: Labasa Apron

Appendix D: NZ CAA documents
- Advisory Circulars AC061-3, AC061-5, AC119-3
- NZ CAA cross country training requirements (Excerpts)
- NZ CAA Mountain flying GAP booklet documentation
- NZ CAA Mountain flying training standards guide
- NZ CAA Mountain flying training video (Provided separately)
- NZCAA ELT policy
Appendix E: NTSB Reports

- Full report C208 Caravan, CFIT, Alaska 2016
- Summarised report C208 Caravan, CFIT, Alaska 2016, for public meeting April 2008
- Special investigation report; improving pilot weather reporting and dissemination

Appendix F: Recommendations re Fiji Climatology and improving weather information

F1: Fiji climatology; proposed headline information and training topics
F2: Proposed improvements to Fiji aviation weather reporting

Appendix G: Relevant articles

- Environmental factors affecting loss of control in flight; IATA
- Weather forecasting and challenges in the Pacific

Appendix H: Court judgments

- Judicial review HBJ 5; 5 July 2018
- Judicial review HBJ 8,9; 9 April 2018
- Conviction; 8-12-2017