Papua New Guinea

Controlled flight into terrain
11 km south-east of Kokoda Airstrip
Papua New Guinea
11 August 2009
P2-MCB
De Havilland Canada DHC-6-300

CONTENTS

AIC CHAIRMANS SUMMARY vii

Sequence of events vii

Aircraft navigation vii

Conclusion viii

Introduction xi

1 FACTUAL INFORMATION 1

1.1 HISTORY OF THE FLIGHT 1

1.1.1 Sequence of events 3

1.1.2 Other aircraft operations in the Kokoda area 5

1.2 INJURIES TO PERSONS 5

1.3 DAMAGE TO THE AIRCRAFT 5

1.4 PERSONNEL INFORMATION 5

1.4.1 Pilot in command 5

1.4.2 Copilot 7

1.5 AIRCRAFT INFORMATION 9

1.5.1 Aircraft equipment 10

1.5.2 Radar altimeter 13

1.5.3 Weather Radar 13

1.6 METEOROLOGICAL INFORMATION 13

1.6.1 Relevant weather forecasts and reports 13

1.6.2 Observed weather 14

1.7 AIDS TO NAVIGATION 17

1.7.1 Kokoda Airstrip 17

1.7.2 Port Moresby radar 17

1.7.3 Ground-based navigation aids 17

1.8 COMMUNICATIONS 17

1.9 AERODROME INFORMATION 18

1.10 FLIGHT RECORDERS 18

1.10.1 Latitude Technology Skynode S100 19

1.10.2 Data recovered from the aircraft's S100 20

1.11 WRECKAGE AND IMPACT INFORMATION 21

1.11.1 Accident site description 21

1.12 DAMAGE TO THE AIRCRAFT 23

1.12.1 Airframe and controls 23
1.12.2 Engines and propellers 24
1.12.3 Fuel system 25
1.12.4 Oxygen 25
1.12.5 Radio altimeter 25
1.12.6 Examination of recovered components 26
1.13 OTHER DAMAGE 27
1.14 MEDICAL AND PATHOLOGICAL INFORMATION 27
1.14.1 Pilot in command 27
1.14.2 Copilot 28
1.15 FIRE 28
1.16 SURVIVAL ASPECTS 28
1.16.1 Search and rescue 29
1.17 TESTS AND RESEARCH 30
1.18 ORGANISATIONAL AND MANAGEMENT INFORMATION 30
1.18.1 Aircraft operator 30
1.18.2 Civil Aviation Safety Authority of Papua New Guinea 31
1.18.3 International Civil Aviation Organization Audit of the then CAA PNG of March 2009 32
1.19 ADDITIONAL INFORMATION 34
1.19.1 Normalised pilot response to continuing alerts 34
1.19.2 Threat and error management 34
1.19.3 Controlled flight into terrain 36
1.19.4 Situational awareness 36
1.19.5 International travel warnings and advisories 38
2 ANALYSIS 39
2.1 OVERVIEW 39
2.2 CONTROLLED FLIGHT INTO TERRAIN 39
2.3 WEATHER 40
2.4 OPERATIONAL CONSIDERATIONS 40
2.5 PILOT INCAPACITATION 41
2.6 AIDS TO NAVIGATION 41
2.7 TERRAIN AWARENESS AND AIRCRAFT SEPARATION 42
2.8 ASSISTANCE AVAILABLE TO THE CREW 42
2.9 THREAT AND ERROR MANAGEMENT 42
3 FINDINGS 45
3.1 CONTRIBUTING SAFETY FACTORS 45
3.2 OTHER SAFETY FACTORS 45

3.3 OTHER KEY FINDINGS ... 46

4 SAFETY ACTION ... 47

4.1 CIVIL AVIATION SAFETY AUTHORITY OF PAPUA NEW GUINEA ... 47

4.1.1 Administration of the Papua New Guinea aviation medical regime ... 47

4.1.2 Mandatory occurrence reporting system ... 48

4.2 Accident Investigation Commission of PNG ... 48

4.2.1 Fitment of cockpit voice recorders in aircraft certified to carry 18 or more passengers ... 48

4.3 AIRCRAFT OPERATOR ... 49

4.3.1 Emergency recovery from inadvertent flight into instrument meteorological conditions ... 49

4.3.2 Operations to and from Kokoda Airstrip ... 50

APPENDIX A: AIRCRAFT OPERATOR'S FLIGHT OPERATIONS EXPOSITION ... 59

APPENDIX B: RELEVANT CIVIL AVIATION SAFETY AUTHORITY RULES ... 65

APPENDIX C: SOURCES AND SUBMISSIONS ... 71

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Figure 1: Department of Peacekeeping Operations Cartographic Section
Figure 2: Major Charlie Lynn (RET), Adventure Kokoda

Abstract

On 11 August 2009, a de Havilland Canada DHC-6 Twin Otter aircraft, registered P2-MCB, with two pilots and 11 passengers, was being operated on a scheduled regular public transport service from Port Moresby to Kokoda Airstrip, Papua New Guinea (PNG).

At about 1113, the aircraft impacted terrain on the eastern slope of the Kokoda Gap at about 5,780 ft above mean sea level in heavily-timbered jungle about 11 km south-east of Kokoda Airstrip. The aircraft was destroyed by impact forces. There were no survivors.

Prior to the accident the crew were manoeuvring the aircraft within the Kokoda Gap, probably in an attempt to maintain visual flight in reported cloudy conditions. The investigation concluded that the accident was probably the result of controlled flight into terrain: that is, an otherwise airworthy aircraft was unintentionally flown into terrain, with little or no awareness by the crew of the impending collision.

The investigation identified a number of factors that led to increased safety risk. Those related to the crew of the aircraft, the weather conditions affecting the flight, crew training and the conduct of the flight. A number of the safety factors had the potential to adversely affect the safety of future aviation operations.

As a result of the investigation, the Accident Investigation Commission of PNG (AIC PNG) issued a safety recommendation in respect of the installation of cockpit voice recorders (CVR) in PNG aircraft with a seating capacity of 18 or more passengers. In response, the Civil Aviation Safety Authority of PNG (CASA PNG) intends legislating to require the installation of CVRs in turbine-powered aircraft with seating for more than nine passengers. As a result of the investigation, CASA PNG has also established a principal medical officer position and has advised of action to move responsibility for the administration of the PNG mandatory occurrence notification system to the AIC PNG. Extensive proactive safety action has been taken by the aircraft operator in response to the risk of inadvertent flight into cloud while employing visual flight procedures and in regard to operations into Kokoda Airstrip an effort to prevent a recurrence.

AIC CHAIRMAN'S SUMMARY

Sequence of events

On 11 August 2009, a de Havilland Canada DHC-6-300 Twin Otter aircraft, registered P2-MCB (MCB), with 2 pilots and 11 passengers on board, was being operated on a scheduled regular public transport service from Jackson's International Airport, Port Moresby to Kokoda Airstrip, Papua New Guinea (PNG) and return. During the flight there were no recorded or reported radio transmissions to indicate that the crew was experiencing any operational or technical difficulties.

Sometime between 1112:46 and 1114:00, the aircraft impacted terrain on the eastern slope of the Kokoda Gap at about 5,780 ft above mean sea level (AMSL) near Misima village in heavily-timbered terrain, about 11 km south-east of Kokoda Airstrip. The aircraft was destroyed by impact forces. There were no survivors.

The crew were probably attempting to descend visually within the Kokoda Gap (the Gap) while flying under the instrument flight rules (IFR). The last known radio transmission from the aircraft was at 1111:40, when the copilot communicated with the crew of an aircraft that had departed from Kokoda Airstrip. The departing aircraft was north-east of MCB and climbing through 9,000 ft. At about the time of the accident there was a solid bank of cloud situated at the junction of the Kokoda Gap and Kokoda valley. Witnesses at Isurava village stated that they observed an aircraft fly low over the village, and that cloud obscured the eastern ridge of the Gap at that time.

Witnesses at Misima village stated that they heard an aircraft fly near their village but that they could not see the aircraft as the area was covered by cloud. They reported that shortly after, there was a loud bang above their village and the sound of the aircraft stopped.

The on-site evidence indicated that at impact, the aircraft was flying in a direction of about 110° magnetic in level, upright flight and with a right bank of about 25°. The engines were producing power at impact and the primary flight and navigation instruments were operational at that time. The airframe and flight controls were all accounted for at the accident site and the engine and flight control systems exhibited operational continuity.

The investigation concluded that the accident was probably the result of controlled flight into terrain, in which the otherwise airworthy aircraft was unintentionally flown into terrain, with little or no awareness by the crew of the impending collision.

Aircraft navigation

The crew had submitted an IFR flight plan for the flight from Jackson's International Airport and return, which was intended to be conducted using visual procedures. That meant that the crew could operate the aircraft below the lowest safe instrument flight altitude of 13,700 ft if the weather conditions satisfied the stipulated visual requirements.

It was common practice for the operator's pilots to submit an IFR plan to facilitate a departure and landing at Jackson's International Airport, as the airport was equipped with the navigation aids required for IFR departure and landings.

There were no navigation aids at Kokoda to assist crews during their arrival or departure from the airstrip.

Conclusion

The investigation identified a number of contributing safety factors related to the crew of the aircraft, the weather conditions affecting the flight, crew training and the conduct of the flight. In addition, the operator's emergency recovery procedure for application in the case of inadvertent flight into instrument meteorological conditions was found to be ineffective in preventing the controlled flight into terrain.

LIST OF ACROYNOMS USED IN THIS REPORT

AIC	Accident Investigation Commission of PNG
ALERFA	Alert Search and Rescue phase
AMSL	Above mean sea level
ATC	Air traffic control
ATSB	Australian Transport Safety Bureau
CAA PNG	Civil Aviation Authority Papua New Guinea
CASA PNG	Civil Aviation Safety Authority of Papua New Guinea
CPL	Commercial Pilot License
CRM	Crew resource management
CTA	Controlled airspace
DISTRESFA	Distress search and rescue phase
ELB	Electronic locator beacon (406 MHZ)
DOT	PNG Department of Transport
FIS	Flight Information Service
FT	Feet expressed as altitude
FSR	Flight Safety Regulation
GPS	Global positioning system
HF	High frequency radio communication
HRS	Time expressed in hours
IFR	Instrument flight rules
IIC	Investigator in charge
KM	Distance expressed in kilometres
LAT	Latitude
LONG	Longitude
MB	Millibars of atmospheric pressure

MR	Maintenance release
NM	Nautical Mile
NZ	New Zealand
OCTA	Outside controlled airspace
P2	PNG aircraft identification
PF	Pilot flying
PNF	Pilot not flying
PNG	Independent state of Papua New Guinea
POB	Persons on board
PPL	Private pilot license
PRN	Pseudo random number
QNH	Aircraft altimeter sub scale barometric pressure setting
RCC	Rescue Co-ordination Centre
RX	Receive
SAR	Search and Rescue
TAFOR	Terminal area forecast
TX	Transmit
VHF	Very high frequency
VOR	Very high frequency omni radial

INTRODUCTION

The Accident Investigation Commission (AIC) is an independent Government statutory agency. The AIC is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The AIC's function is to determine the circumstances and causes of accidents and incidents with a view to avoiding similar occurrences in the future, rather than to ascribe blame to any person.

The AIC performs its functions by making inquiries and undertaking investigations, preparing and publishing findings and recommendations, including any recommendations for changes or improvements that the AIC considers will ensure avoidance of accidents and incidents in the future.

1 FACTUAL INFORMATION

On 11 August 2009, the Accident Investigation Commission was notified of an accident in the Kokoda region of Papua New Guinea (PNG) that involved a PNG-registered aircraft, P2-MCB (MCB).

On 12 August 2009, the Government of Papua New Guinea requested assistance from the Australian Government to assist with the accident investigation.

An accredited representative from the Australian Transport Safety Bureau (ATSB) was appointed to the PNG investigation in accordance with International Civil Aviation Organization (ICAO) Annex 13 to the Convention on International Civil Aviation, Part 5.23.

1.1 HISTORY OF THE FLIGHT

On 11 August 2009, a de Havilland Canada DHC-6 – 300 (DHC6) Twin Otter aircraft, registered P2-MCB (MCB) with two pilots and 11 passengers, was being operated on a scheduled regular public transport service from Jackson's International Airport, Port Moresby to Kokoda Airstrip, PNG and return (Figures 1 and 2).

Figure 1: Papua New Guinea territory including the Port Moresby, Kokoda and Popondetta regions

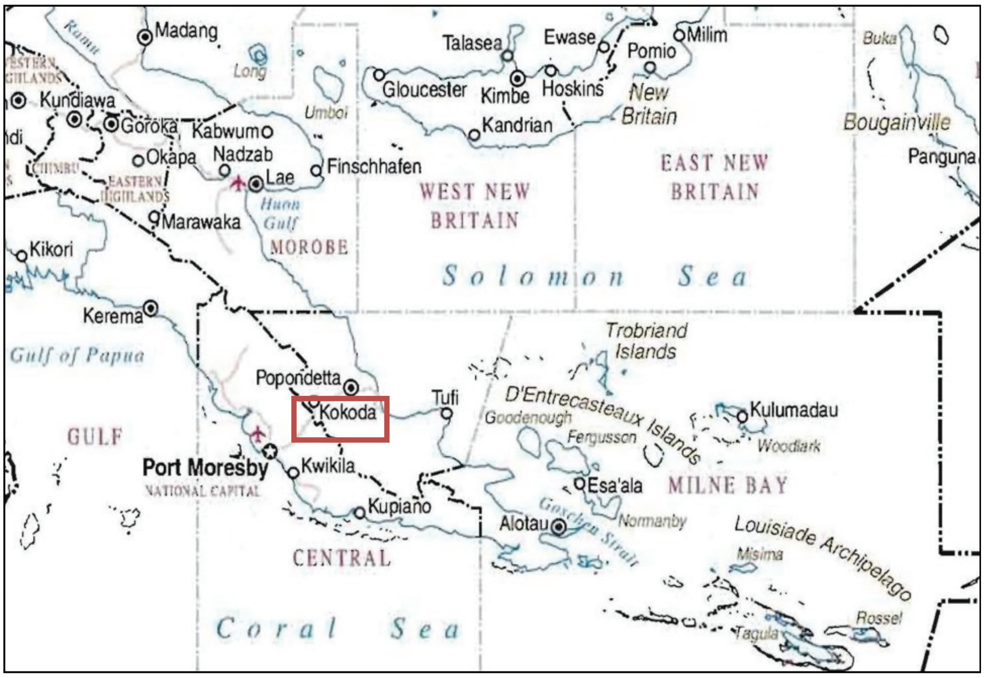
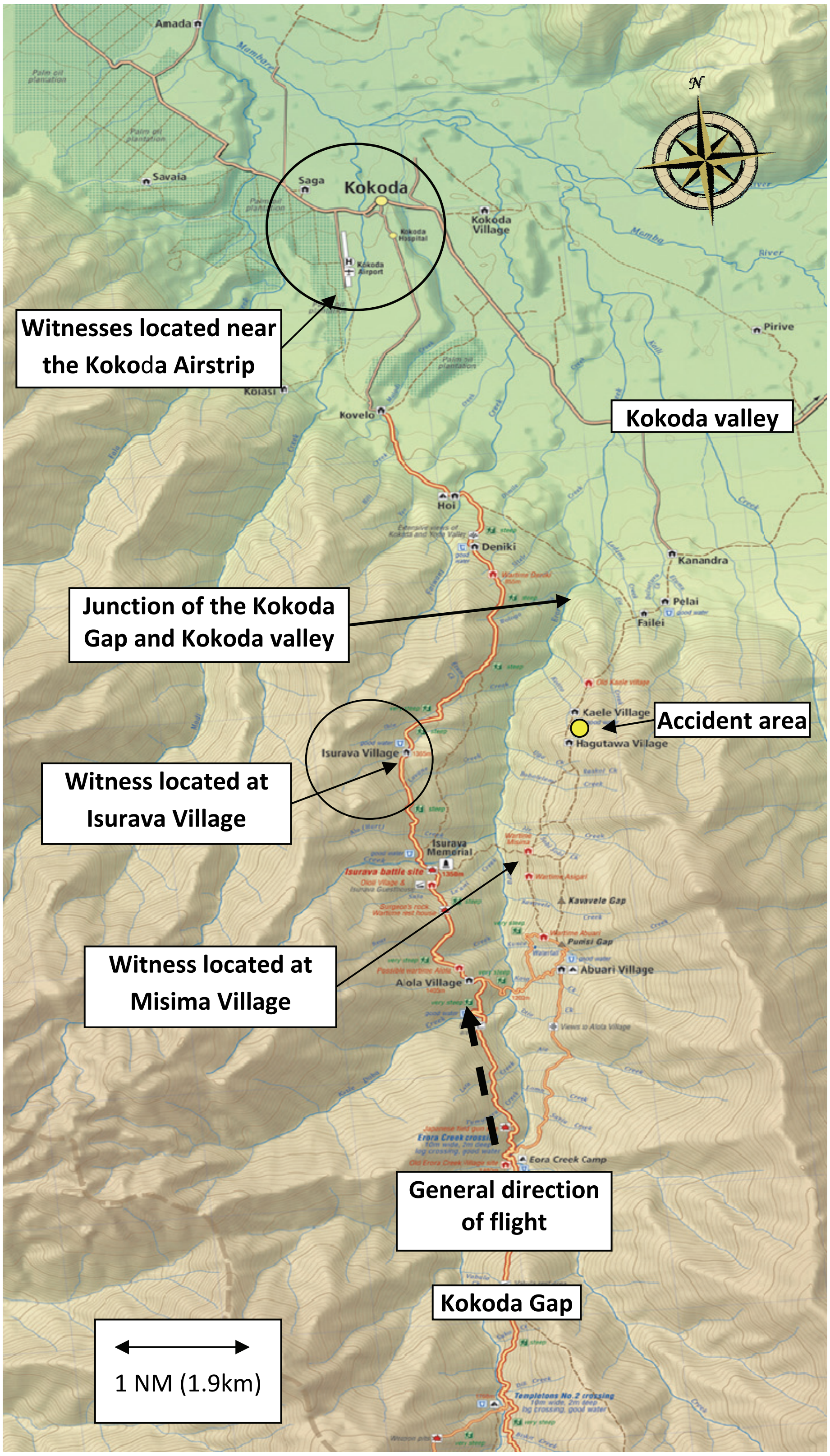


Figure 2: Detailed map of the Kokoda region



The aircraft impacted terrain at about 1113[1] on the eastern slope of the Kokoda Gap at about 5,780 ft above mean sea level (AMSL). The wreckage was located in heavily-timbered terrain above Misima Village, about 11 km south-east of Kokoda Airstrip.

The aircraft was destroyed by impact forces. There were no survivors.

A small area of the heavily-timbered terrain was damaged by the aircraft and impact forces, and some clearing of vegetation was conducted by the local rescue and recovery teams.

There was no fire.

1.1.1 Sequence of events

On the morning of 11 August 2009, a different crew carried out an earlier flight in MCB to six other destinations, for a total flight time of about 2.5 hours. That crew reported that the aircraft was serviceable with no known problems when they landed at Jackson's International Airport at about 1020. They also reported that when handing over the aircraft to the accident crew for the aircraft's second planned flight, they talked for a while and everything was normal. The accident flight crew were reported to be upbeat and keen to commence their flying activities.

The crew had lodged an instrument flight rules (IFR) flight plan with the PNG Airservices Ltd briefing office for the aircraft's second flight, which was planned from Port Moresby to Kokoda via the Kokoda Gap, and return. The flight plan was nominated to be flown using visual procedures, with an estimated departure time of 1010 from Port Moresby and with a fuel load of 1,200 lbs (544 kg). The crew subsequently reported taxiing at Jackson's International Airport for Kokoda at 1050. The crew reported departure at 1052, that they were climbing to 9,000 ft, and that they estimated arriving at Kokoda at 1120.

At 1111, while en route to the Kokoda Airstrip and on descent in the Kokoda Gap, the crew of MCB conversed with the crew of an aircraft, registered P2-KST (KST), which was departing Kokoda. A review of that radio conversation did not reveal any apparent problems with the crew of MCB or the aircraft. This was the last known radio transmission from MCB. The aircraft movements and communications between MCB, KST, a third aircraft (P2-MCD (MCD)) and air traffic control (ATC) are listed at Table 1.

Witnesses at Isurava village stated that they observed an aircraft fly low over the village at about the estimated time of the accident. Witnesses at the nearby Misima village stated that they heard an aircraft fly near their village but that they could not see the aircraft, as the area was covered by cloud. They reported that shortly after, there was a loud bang above their village and the sound of the aircraft stopped.

At about 1114, Port Moresby ATC called the aircraft via high frequency[2] radio but there was no response. Port Moresby ATC continued its attempts to call the aircraft and utilised other aircraft in the area in an attempt to locate or contact MCB.

[1] The 24-hour clock is used in this report to describe the local time of day, Papua New Guinea local time, as particular events occurred. Papua New Guinea local time was Coordinated Universal Time (UTC) +10 hours.

[2] For convenience, the electromagnetic frequency spectrum has been divided into arbitrary 'bands'. The high frequency band encompasses 3 to 30 MHz.

Table 1: Relevant communications

TIME		
1016:00	KST	Departs Port Moresby for Kokoda (second attempt)
1052:00	KST	Lands at Kokoda Airstrip
1052:32	MCB	Airborne at Port Moresby for Kokoda Airstrip. S100 aircraft position capture at 122 ft
1055:00	MCB	Reports departure from Port Moresby
1059:20	MCB	S100 records aircraft position capture at 6,976 ft
1104:00	KST	Departs Kokoda Airstrip for Port Moresby
1106:00	MCB	S100 aircraft position capture at 9,743 ft
1109:00	MCB	Reports over the radio that they were '12 NM (22 km) from Kokoda Airstrip at 9,000 ft'
1110:19	MCB	Reports over the radio that they were 'at the False Gap leaving 9,000 ft climbing to get above a cloud layer'
1111:10	MCB	Reports over the radio that 'now leaving 9,000 ft on descent to Kokoda'
1111:30	MCB	Reports over the radio'... Kokoda via the Kokoda Gap on descent now through the Gap'
1111.38	KST	Reports over the radio that 'Copied, climbing to 10,000 ft will be maintaining 10,000 ft, just be careful'
1111.40	MCB	Reports over the radio 'thank you very much, morning long you'
1112:54	MCB	S100 aircraft position capture at 8,079 ft
1114:25	ATC	Called MCB over the radio several times with no response from MCB
1115:00	Agent	Agent at Kokoda calls operator stating that the weather is very bad at Kokoda
1119:25	MCB	Expected time of next S100 position recording event based on an average recording interval of 6:38 - no event was recorded
1122:00	MCD	Reported that they were departing Efogi for Kokoda
1125:04	ATC	Called MCB over the radio twice with no response from MCB
1134:00	MCD	Arrived in circuit at Kokoda
1135:00	MCD	Confirms that MCB is not at Kokoda
1136:00	ATC	Declared ALERFA SAR phase for MCB
1140:00	MCD	Lands at Kokoda
1225:00	ATC	Declared DISTRESFA SAR phase for MCB

Another company aircraft (MCD) departed from Efogi, which was about 16 NM (30 km) south-south-west of Kokoda Airstrip at about 1122 for Kokoda. That aircraft initially headed north-west from Efogi and then turned north-east and flew over Kokoda before landing at about 1135. The crew of MCD confirmed to ATC that MCB was not at the airstrip.

At 1136, Port Moresby ATC declared an Alert search and rescue (SAR) (ALERFA) phase. That phase was upgraded to a Distress SAR phase (DISTRESFA) at

1225 because of the level of concern for the status of MCB. In response, resources from the operator, the PNG Government, a number of private companies in PNG, and the Australian Government were mobilised to assist with the search for MCB.

As part of the Australian Government's response, AMSA deployed a Dornier 328 aircraft from Cairns, Queensland with an infrared camera and emergency locator transmitter (ELT)-locating equipment on board. That equipment allowed the aircraft to commence searching during the night of 11 August 2009.

The search continued on 12 August and at 0747, the crew of the Dornier detected a weak ELT signal and passed that information to other search aircraft. The accident aircraft wreckage was located at 0810.

1.1.2 Other aircraft operations in the Kokoda area

On the morning of the accident, a number of other aircraft landed at, and departed from Kokoda Airstrip. However none of those aircraft descended in the Kokoda Gap en route to the airstrip.

Passengers from one of those aircraft, a DHC6 (KST) reported that they had flown from Port Moresby to Kokoda earlier that morning but the aircraft could not land due to adverse weather. The aircraft returned to Port Moresby and after refuelling, immediately returned to Kokoda, arriving at about 1037. KST departed Kokoda at about 1103 and returned to Port Moresby.

A third company DHC6 aircraft (MCD) landed at Kokoda Airstrip at about 1140, about 26 minutes after the estimated time of the accident.

1.2 INJURIES TO PERSONS

Injuries	Crew	Passengers	Other	Total
Fatal	2	11	0	13
Serious				
None				
Total	2	11		13

1.3 DAMAGE TO THE AIRCRAFT

The aircraft was destroyed by impact forces (see Section 1.11 - *WRECKAGE AND IMPACT INFORMATION*).

1.4 PERSONNEL INFORMATION

1.4.1 Pilot in command

Aeronautical experience and qualifications

The pilot in command (PIC) held a Civil Aviation Safety Authority (CASA) PNG Commercial Pilot Licence (Aeroplane) (CPL(A)) and a multi-engine command instrument rating (MECIR). The PIC's estimated aeronautical experience and qualifications are at Table 2.

Table 2: PIC details[3]

Type of licence and instrument rating	CPL(A),MEICR
Total flying hours	2,177[4]
Total flying hours on DHC6	1,836[4]
Total flying hours last 90 days	115[4]
Total flying hours last 30 days	50[4]
Total flying hours last 7 days	11[4]
Total flying hours multi-crew ops	1,805[4]
Last Crew Resource Management (CRM) training	25 August 2008
Command line check	29 April 2009
Last route proficiency check	29 April 2009
Last Medical certificate	22 August 2008

PIC training

Aircraft type training was conducted by the aircraft operator as part of its DHC6 aircraft type endorsement. The operator reported that all crew received route checks that included the practise of emergency procedures and specific airstrip training.

The investigation was unable to find any evidence that the pilot had received formal training on the Global Positioning System (GPS) equipment that was fitted to the aircraft. However, training records that were provided by the operator showed that items identified within the operator's training syllabus that included the introduction to, and use of the GPS for en route navigation had been 'ticked' by the training captain as complete. No evidence as to the extent of that training, or level of understanding attained by the trainee was provided by the operator. The operator stated that at about the time of the accident, a GPS training package specific to the conduct of GPS non-precision approaches was being 'rolled out'.

The PIC had not received any specific Threat and Error Management (TEM) training as part of her CPL training in New Zealand, nor was that required by the New Zealand or Papua New Guinean rules at the time.

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3 As at 9 August 2009.

4 The PIC's logbooks were incomplete and the estimation of the PIC's total aeronautical experience was based on information from the PIC's pilot logbook, flight and duty records and flight summary information written by the captain on the aircraft's take-off and landing data cards (TOLD). The TOLD card was primarily used by flight crews to display aircraft operational and flight data.

General

On the day before the accident, the PIC had a rostered day off and was on reserve[5] on the day of the accident. The PIC had accumulated about 27 hours of duty in the preceding 7 days.

On the evening of 10 August 2009 and in preparation for being on reserve, the PIC was reported to have contacted the operator's operations department to ascertain the flight crew requirements for the next day. At about 2100, the PIC went to bed having been advised that there was currently no operational requirement affecting the PIC on the following day. Later that night, the company operations department contacted the PIC to advise that the PIC was required for a Port Moresby to Kokoda flight.

It was reported that the PIC was healthy, exercised regularly, and had no significant medical history or recent medical issues. The PIC's partner reported meeting the PIC at the aerodrome on the day of the accident, and that the PIC was happy and well. Similar reports were received later from several pilots who talked to the PIC before the accident flight.

1.4.2 Copilot

Aeronautical experience and qualifications

The copilot held a CASA PNG CPL(A).The operator's training records indicated that the copilot had been assessed for instrument procedures,[6] but did not hold an instrument rating. The operator could not provide any information about the copilot's training that would have enabled the investigation to assess the copilot's understanding of the fundamental principles for conducting instrument approaches or use of the aircraft's GPS equipment. The training and assessment of instrument approach procedures would be included as part of the assessment for an instrument rating.

The copilot's estimated aeronautical experience and qualifications are at Table 3.

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5 The operator's exposition stated that 'reserve period means the period of time during which crew member is required to hold themselves for active duty.'

6 Including knowledge of the relevant aviation regulations, assisting the PIC as and when directed, PIC/copilot interaction during flight, and so on.

Table 3: Copilot details[7]

Type of licence	CPL(A)
Total flying hours	2,150
Total flying hours on DHC6	1,940
Total flying hours last 90 days	83.9
Total flying hours last 30 days	25
Total flying hours last 7 days	9
Total flying hours multi-crew ops	1,940
Last CRM training	16 August 2008
Last flight proficiency check	13 March 2009
Last Medical certificate	Unable to be confirmed

The operator had a facsimile copy of the copilot's current medical certificate on file, the currency of which was illegible. The doctor's surgery that was nominated on that certificate as having carried out the examination of the copilot stated that they had no knowledge of the copilot. The investigation was unable to confirm the validity of the copilot's medical certificate as no pilot medical assessment information was held by CASA PNG or by the doctor's surgery.

CASA PNG advised that:

> ...pilot licences issued by CASA PNG are perpetual and renewed by medical [examination] completed by the pilot and [the results] presented to CASA PNG.

The appointment of a qualified Director (or similar) of Aviation Medicine to guide and direct Aviation Medicine Policy in PNG could also be expected to enhance the administration of the PNG aviation medical regime, including of pilot's aviation medical certificates.

Copilot training

The copilot's aircraft type training was conducted by the aircraft operator as part of its DHC6 aircraft type endorsement.

The investigation was unable to find any evidence of the copilot's training on the GPS equipment that was fitted to the aircraft. The copilot had not received any specific TEM training as part of his CPL training in Australia, nor was that required by the Australian or Papua New Guinean rules at the time.

General

In the 7 days before the accident, the copilot accumulated about 36 hours of duty over 5 days away from the operator's Port Moresby home base. During that time,

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7 The copilot's logbook(s) and original medical certificate were not located. The operator provided records that were used to derive the copilot's current aeronautical experience.

the copilot accumulated an estimated 9 flying hours. The day of the accident was the sixth day worked by the copilot, and was rostered as a reserve day. The rostering was in accordance with CASA PNG requirements.

1.5 AIRCRAFT INFORMATION

The aircraft, model DHC-6-300, serial number 441 was constructed by de Havilland Canada in 1974 as a short take-off and landing aircraft (Figure 3). The total recorded flight time for the aircraft was about 46,700 hours. MCB was a high-wing, fixed tricycle undercarriage aircraft that was powered by two Pratt & Whitney Canada PT6A-27 turboprop engines that were derated to 620 Hp. The details of both engines are at Table 4 and 5.

Figure 3: MCB at Jackson's International Airport

The aircraft had a current Certificate of Airworthiness that was issued by CASA PNG and under CASA PNG rules, was to be operated under Part 125 *Air Operations - Medium Aeroplanes*. The aircraft was configured to carry 19 passengers and two crew, and had a maximum take-off weight of 5,670 kg.

The aircraft was fitted with the required equipment for two-pilot IFR flight and was maintained in accordance with that standard. The aircraft was not fitted, and was not required to be fitted by regulation with a stabilisation or autopilot system.

Table 4: Left engine details

Manufacturer	Pratt & Whitney Canada
Model	PT6A-27
Serial Number	PCE-PG0073
Time since overhaul	10,062 hours (15,000 hours stipulated Time Between Overhaul (TBO))
Total time in service (TTIS)	10,062 hours
Time since last hot section inspection	1,026 hours (2,000 hours stipulated Time Between Inspection (TBI))

Table 5: Right engine details

Manufacturer	Pratt & Whitney Canada
Model	PT6A-27
Serial Number	PCE-PG0143
Time since overhaul	10,416 hours (15,000 hours stipulated TBO)
TTIS	10,416 hours
Time since last hot section inspection	448 hours (2,000 hours stipulated TBI)

1.5.1 Aircraft equipment

In addition to the standard equipment required for IFR flight, the aircraft was also fitted with two Garmin GNS430W Navigation Systems (GNS430W) and one Garmin GMX200 multifunction display unit. The GMX200 had the ability to display information from the GNS430W.

The GNS430W had several functions, including:

- the display of GPS-derived navigation information
- the management of communications and radio navigation equipment and selection of relevant frequencies for very high frequency (VHF)[8] radio transceivers, and VHF omnidirectional radio range (VOR) navigation equipment
- a terrain awareness database.

The terrain awareness database was designed to increase crew situational awareness, and to reduce the risk of controlled flight into terrain. The aircraft's GPS was capable of displaying the surrounding terrain in colour that varied from black to yellow to red,[9] depending on the relative position of the aircraft to the terrain. The Garmin GNS430W that was fitted to MCB did not have an aural terrain awareness and warning system (TAWS) alert function.[10] The Garmin 400/500 series optional displays manual for the GPS stated:

> Do not use it [terrain information] to navigate or manoeuvre to avoid terrain.

The investigation could not determine whether the crew had an understanding of the terrain awareness feature in the GNS430W.

Depending on the mode selected, the GMX200 multifunction display unit could be used to display either the information from the GNS430 navigation system, or information from the aircraft's weather radar system.

Figure 4 is a photograph of the aircraft's GNS430 and GMX200 prior to departing Jackson's International Airport, Port Moresby for Kokoda. The displays in the photograph show the information that was displayed to the flight crew at departure,

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8 The very high frequency band encompasses 30 to 300 MHz.

9 In the face of approaching rising terrain, the GPS display progressed from black, through yellow to red.

10 Advanced TAWS systems use a hazard awareness aural warning system in response to different situations such as a recorded message stating 'Caution Terrain' or 'Terrain Terrain'

including the GPS satellite availability, the aircraft's position and intended route, and the selected radio frequencies.

The investigation could not determine the configuration of the GNS430 or GMX200 during flight or at impact.

The flight plan indicated that the fuel load on board the aircraft was 1,200 lb (544 kg) of which 410 lb (186 kg) were for the cruise segment of the flight and 100 lb (45 kg) for taxiing. Jet A-1 is the approved fuel type for the aircraft.

The operator's policy for weight and balance and loading control was refined over an extended period of time due to the variable loading conditions experienced on a daily basis at the operator's many destinations. The loads were distributed throughout the aircraft cabin and cargo holds in accordance with the operator's Quick Trim System. That system ensured that when correctly loaded, the aircraft's centre of gravity was within the aircraft's approved flight envelope.

Figure 4: Photograph of the aircraft's GMX200 and GNS430 prior to departure from Jackson's International Airport[11]

(1) GMX200 showing a GPS image of Jackson's Aerodrome (AYPY) and the aircraft's current position.
(2) GNX430 showing the primary and secondary radio frequency set for communication 1 and the intended route to Kokoda (KOK) via the Kokoda Gap (KOKGP) to Jackson's aerodrome (AYPY)
(3) GNX430 showing the primary and secondary radio frequency set for communication 2 and the available satellites at the time.

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[11] Figure 4 is an expanded section of the original photo that was taken by one of the passengers in the accident aircraft. Clarity is lost due to the limitation of the photo pixel rate when amplified.

1.5.2 Radar altimeter

The aircraft was fitted with a Bendix/King radar altimeter (RADALT)[12] system. Unlike conventional barometric or pressure altimeters, which indicate the barometric pressure affecting an aircraft, a radar altimeter provides crews with an indication of the aircraft's absolute height above terrain.

A RADALT is unable to detect terrain ahead of an aircraft. Therefore, the aircraft's RADALT would not have provided an effective advanced warning of the impending collision with terrain.

1.5.3 Weather Radar

Weather radar is designed to assist a crew to avoid significant en route weather. The aircraft's weather radar utilised the Garmin GMX 200 multifunction display to display the en route weather to the flight crew.

The regulatory requirements for visual flight required the crew to maintain visual separation from cloud.

1.6 METEOROLOGICAL INFORMATION

1.6.1 Relevant weather forecasts and reports

The PNG National Weather Service Forecasting & Warning Centre in Port Moresby issued a PNG en route and area forecast that covered the region for the intended flight and was valid from 0400 to 1800. The forecast overview indicated isolated showers and thunderstorms with areas of rain and reduced visibility in any rain showers or drizzle. Significant cloud layers with base levels of 500 ft AMSL were also forecast for the area.

The Kokoda Airstrip did not have an on-site weather observation facility to record and report the actual weather conditions at Kokoda that, if available, may have allowed pilots to substantiate the weather forecasts that were generated for that area. There were no aerodrome forecasts issued for the Kokoda Airstrip.

The operator advised that it was normal practice for departing crews to collect the available area forecasts, notices to airmen (NOTAMs)[13], TAFs[14] and METARs[15] relevant to the flight. The investigation was unable to ascertain if the crew obtained that information before the flight.

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12 An instrument that gives a readout of an aircraft's height above ground level by time-varying frequency and measuring the difference in the frequency of the received waves. That difference is proportional to time and therefore to the aircraft's height.

13 Notice to Airmen, identified as a notice or as an Airmen Advisory, disseminated by all means to give information on the establishment, condition or change in any aeronautical facility, service, procedure or hazard.

14 TAF is a terminal area (aerodrome) meteorological forecast.

15 METAR is an aviation routine weather report, which is used to identify routine hourly or half-hourly observations when conditions are above specified levels.

If the crew could not land at Kokoda due to the weather conditions, they had the option of returning to Jackson's International Airport (AYPY) as an alternate aerodrome, if no more than 4/8s of cloud existed below 1,874ft and the visibility was not below 4,400 m.

The TAF for Jackson's International Airport that was valid for the morning of the flight forecast that from 0900 the wind would be 150° at 10 kts, there would be scattered cloud[16] at 1,500 ft and scattered cloud at 15,000 ft and visibility would be 10 km. That TAF indicated that Jackson's International Airport was a suitable alternate aerodrome for the flight. The crew's flight-planned fuel calculations indicated that the PIC had allowed for 30 minutes holding fuel, in addition to the flight fuel and fuel reserves planned for the route.

A TAF was also available for Girua (near Popondetta), an aerodrome to the east of Kokoda. The Girua TAF was valid from 0500 to 1900 and forecast a wind at 140° at 12 kts, a visibility of 10km, and rain and drizzle with scattered cloud at 1,800ft and broken cloud at 14,000ft.

1.6.2 Observed weather

Observed weather from the air

Another aircraft flew over the False Gap area at about the time of the accident. The crew of that aircraft described the Kokoda Gap as 'a solid blanket of cloud that covered the whole area', and did not report encountering any turbulence. They later reported that when they landed at Kokoda Airstrip, the wind strength was about 10 kts from the north-east.

A photo taken by a passenger in another aircraft flying to Kokoda Airstrip about 30 minutes before the estimated time of the accident, showed that the Kokoda Valley was clear of cloud at that time (Figure 5).

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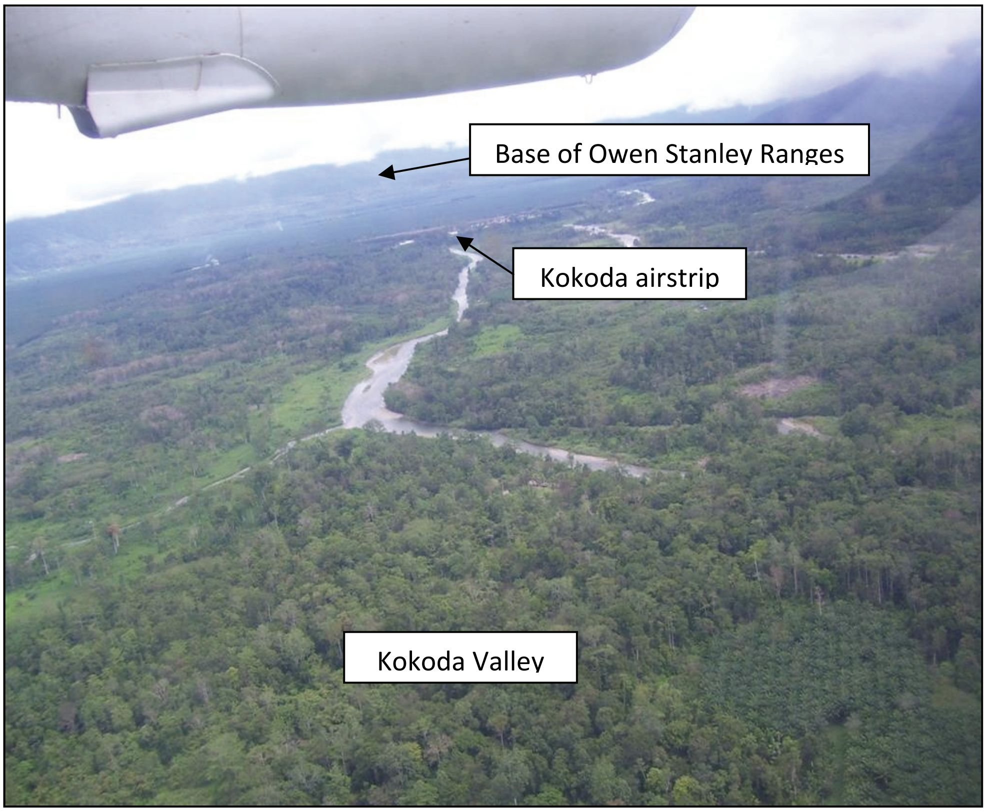
16 Cloud amounts are reported in oktas. An okta is a unit of sky area equal to one-eighth of total sky visible to the celestial horizon. Few = 1 to 2 oktas, scattered = 3 to 4 oktas, broken = 5 to 7 oktas and overcast = 8 oktas.

Figure 5: Kokoda Valley about 30 minutes before the estimated time of the accident



Observed weather from the ground

The operator had a handling agent that was located near the Kokoda Airstrip. That agent would report the observed weather conditions at Kokoda to operations staff at Port Moresby several times a day. On the day of the accident, the agent reported the weather in the vicinity of the airstrip to the operator's staff at about 0800, 1000 and 1115. The agent's observations were limited to the area around the Kokoda Airstrip and did not extend to the Kokoda Gap.

The agent did not have any training in weather observation, interpretation or forecasting. The agent had lived in the region for more than 10 years and was familiar with the seasons and rapid weather changes.

The operator later advised that any weather observations from the agent at Kokoda would be relayed to departing crew by telephone before they left the terminal or after their departure by radio on a dedicated company frequency.

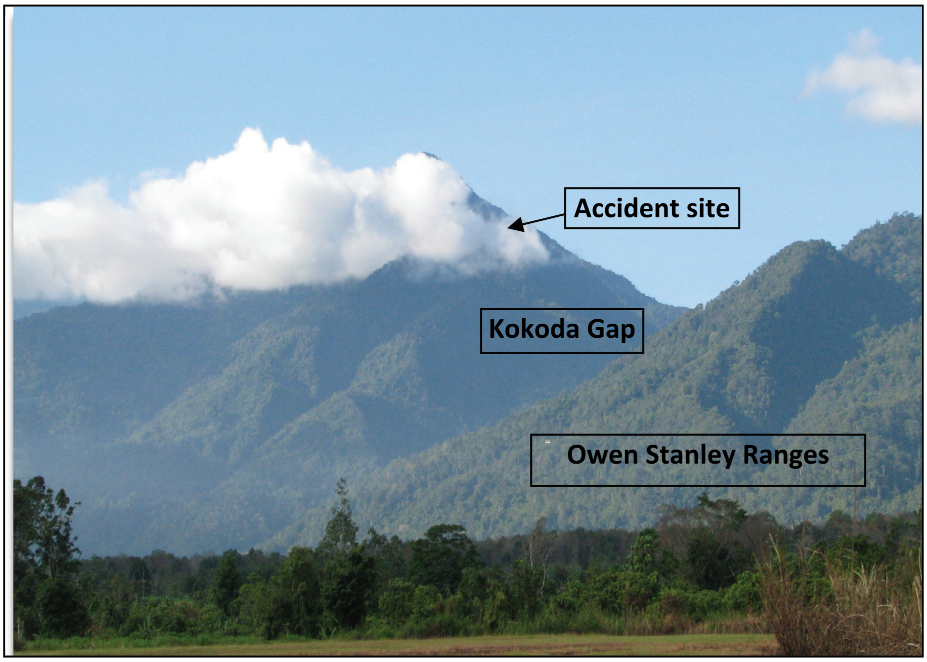
At about 1000 that day, the agent discussed the Kokoda weather observations with the airline's operations staff, advising that the weather was not changing significantly. The investigation was not able to determine if any updated weather observations were relayed to the crew of MCB.

Witnesses at Isurava village stated that they observed an aircraft flying low over the village and that cloud obscured the eastern side of the ridge of the Kokoda Gap at that time. Similarly, witnesses at Misima village reported that they heard an aircraft fly near their village but that they could not see the aircraft, as the area was covered by cloud. They stated that shortly after they heard the aircraft, there was a loud bang above their village and the aircraft sound stopped.

At about 1115, the Kokoda agent telephoned the operator's operation's centre and advised staff that 'the weather was very bad [at Kokoda].' A photo that was taken at Kokoda Airstrip looking toward the Kokoda Gap at about the time of the accident showed the Kokoda Gap completely obscured by cloud (Figure 6). A comparative photograph of the Kokoda Gap on a good weather day is at Figure 7.

Figure 6: View from Kokoda airstrip at about the time of the accident, showing the Kokoda Gap obscured by cloud

Figure 7: View from Kokoda airstrip showing the Kokoda Gap on a good weather day



1.7 AIDS TO NAVIGATION

1.7.1 Kokoda Airstrip

There were no ground-based navigation aids or published instrument approach procedures at Kokoda Airstrip.

1.7.2 Port Moresby radar

Port Moresby ATC reported that depending on a number of factors, radar coverage generally extended to about 200 NM (371 km) from Port Moresby. However, the effectiveness of a radar signal is limited by 'line of sight' reception, and the radar coverage in the Kokoda Gap would have been shielded by the surrounding terrain.

There was no recorded radar information for the aircraft after it passed north of the False Gap.

1.7.3 Ground-based navigation aids

Jackson's International Airport had a number of navigation aids to facilitate an instrument approach.

Once outside of the Port Moresby control zone, the nearest navigation aid to Kokoda was a ground-based non-directional beacon (NDB)/distance measuring equipment (DME) installation at Girua, near the town of Popondetta, north-east of Kokoda.

The PNG Aeronautical Information Publication dated May 2005 stated that the NDB/DME equipment at Girua had an effective by-day range of 25 to 35 NM (46 to 65 km). The NDB/DME equipment at Girua could be used by suitably-qualified crews in suitably-equipped aircraft in instrument meteorological conditions to obtain directional and distance guidance to the Girua transmitter and for an instrument approach at Girua. However, when flown in mountainous terrain and despite being within the effective range of the NDB, the indications on an aircraft's in-cockpit automatic direction-finding equipment (ADF) that displays information from the selected NDB, may fluctuate as a consequence of multiple reflected radio wave signals.[17] Such ADF indications would likely not be considered reliable by flight crew.

The aircraft impacted terrain about 32 NM (59 km) from the Girua NDB/DME transmitter. The wreckage was about 1,000 ft below the highest terrain between the aircraft and that transmitter.

1.8 COMMUNICATIONS

The aircraft was fitted with two VHF radios and an HF radio. Air traffic control at Port Moresby's Jackson's International Airport recorded all radio transmissions on selected radio frequencies. A review of the recorded audio found that a number of

[17] Also known as 'mountain effect'.

HF radio transmissions had been overtransmitted[18], making some unable to be understood.

The crew of MCB used the appropriate radio frequencies for the area of operation and the copilot was identified as operating the aircraft radios during the flight. The operator's procedures included that the non-flying pilot in a two-crew operation operated the aircraft's radios, which enabled the pilot flying to concentrate on flying the aircraft. That was consistent with the PIC flying the aircraft.

The recorded radio transmissions from MCB during taxi, departure and en route did not indicate any abnormal operations or situations.

There was no capability to record radio transmissions at Kokoda Airstrip.

1.9 AERODROME INFORMATION

The Kokoda Airstrip is a Z-class aerodrome in the Oro Province of PNG at location 08° 53.00' S and 147° 44.00' E. The published elevation of the aerodrome is 387 m (1,270 ft) AMSL. It is in an area to the north of Port Moresby commonly known as the jungles. The Oro Provincial Government is responsible for the maintenance of the aerodrome. The Kokoda Airstrip has none of the developments or services normally associated with busy aerodromes found in developed nations.

The 855 m long by 45 m wide runway is constructed on grassed black silt terrain and aligned 17/35° M. The runway has a 2.2 % slope down to the north, which restricts operations to landing runway 17 and taking off from runway 35. The aerodrome's published hours of operation are restricted to daylight hours only.

At the time of the accident there were no cone markers along the movement areas and there was no evidence that regular aerodrome inspections or maintenance were being carried out. Any decisions in respect of the serviceability of the aerodrome rested with the companies who operated into Kokoda.

The area is well known for experiencing regular substantial rainfall, which has a direct impact on the surface condition of the runways due to there being no drainage system or hard surface areas in place.

1.10 FLIGHT RECORDERS

The aircraft was not equipped with a flight data recorder or a cockpit voice recorder, neither of which was required to be fitted to the aircraft by the relevant aviation rules.

The potential safety benefits of the carriage of on-board recording devices have been highlighted in a number of previous investigations. The ATSB investigation into the controlled flight into terrain (CFIT) accident that occurred near Benalla, Victoria, Australia on 28 July 2004 and involved Piper PA31T Cheyenne, registered VH-TNP included the recommendation that:[19]

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18 An overtransmission is when two aircraft attempt to broadcast at the same time and on the same frequency. The result is an unclear and broken transmission from both aircraft.

19 Available at http://www.atsb.gov.au/publications/investigation_reports/2004/aair/aair200402797.aspx

> ...[Australian] Civil Aviation Safety Authority (CASA), review the requirements for the carriage of on-board recording devices in Australian registered aircraft as a consequence of technological developments.

In response to that recommendation, the Australian CASA conducted a cost-benefit analysis (CBA) of the potential safety benefits of the carriage of on-board recorders (OBR) in aircraft that were involved in operations such as took place near Benalla. The CBA found that mandating the carriage of OBRs could not be justified in smaller aircraft and determined that operators were unlikely to install such equipment of their own accord. However, on 23 November 2008, the Australian CASA advised the ATSB that:

> With the recent emergence of low cost recorders for small aircraft it is expected that the take up of recorders may gather momentum over the next couple of years once suppliers become more active in the market and prices come down.

It could be expected that the lesser number of on-aerodrome radio transmission recorders in PNG, and the adverse impact of the mountainous terrain on radio reception and aircraft tracking via radar, would increase the utility of OBRs in accident investigations in PNG.

1.10.1 Latitude Technology Skynode S100

The aircraft was fitted with a Latitude Technology Skynode S100 (S100) electronic GPS tracking and data telemetry device. During normal operations, the S100 received position fixes from the Global Star GPS network and transmitted those fixes via the Iridium satellites to the SkyNet network, and then to the operator.

The installation was independent from all other aircraft systems and was used by the operator as a flight-following[20] device.

When electrically powered, and with the aircraft more than 30 ft above ground level (AGL), the S100 recorded takeoffs and landings and the aircraft's position, groundspeed, direction and GPS-derived height about every 6 minutes 45 seconds. That recording interval may have varied depending on the environmental conditions and satellite position at the time.

The S100 was not an item of minimum equipment required for flight, and its availability did not affect the airworthiness of the aircraft. The aircraft's S100 had not been transmitting recorded data for about 6 weeks.

The non-volatile memory chip[21] from the aircraft's S100 was recovered from the accident site and forwarded to the manufacturer for examination. That examination found that the data, although not transmitted, was stored in the chip and included the last 1,092 flight events. The data from the accident flight was identified and subsequently downloaded for analysis.

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20 Flight following is the process of maintaining contact with an aircraft to monitor the progress of its flight.

21 Non-volatile memory retains data when electrical power is removed.

1.10.2 Data recovered from the aircraft's S100

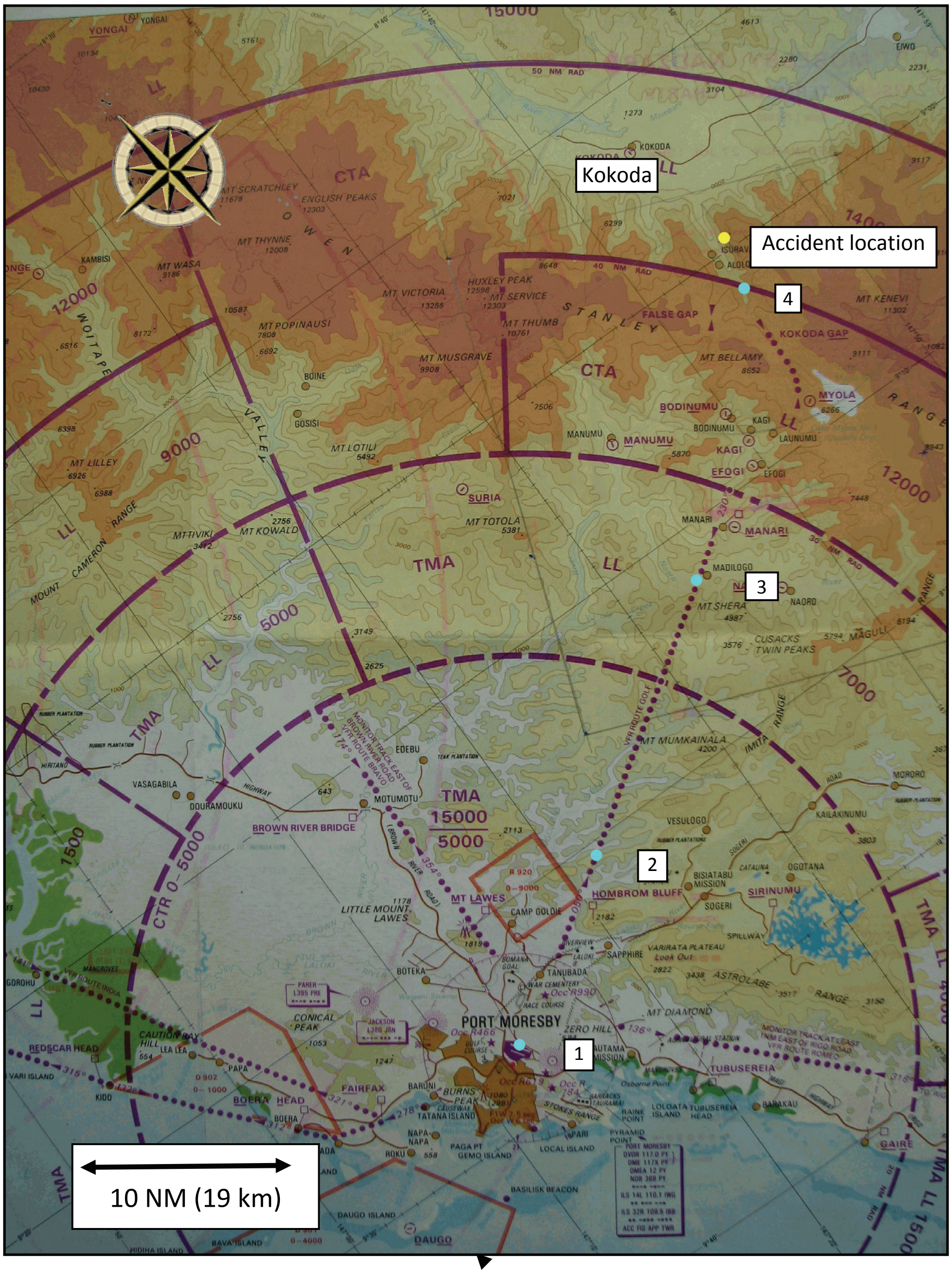
The data that was recovered from the S100 showed the aircraft departing Jackson's International Airport Port Moresby at 1052 (Table 6) and that there were three other S100 recordings during the flight (highlighted blue in Figure 8). Those recordings showed the aircraft's track to Kokoda Gap at a maximum recorded altitude of 9,742 ft. That was consistent with the crew's radio communications with Port Moresby ATC.

The last data recovered from the S100 showed that at 1112, the aircraft was in the Kokoda Gap at 8,079 ft, on a heading of 002° true (T) and at 127 kts groundspeed. The recorded position fixes over the last 20 minutes of the flight were consistent with a GPS position fix about every 6 minutes and 45 seconds. The next scheduled S100 position fix was due at 1118.

Table 6: Data recovered from the aircraft's S100 for the flight

Recording	Time	Latitude (°S)	Longitude (°E)	Speed (kts)	Heading (° True)	Altitude (ft)
1	1052:32	9° 26.20′	147° 12.85′	60	148°	122′
2	1059:20	9° 20.73′	147° 21.65′	110	056°	6,976′
3	1106:07	9° 12.31′	147° 33.87′	154	054°	9,742′
4	1112:46	9° 01.69′	147° 44.49′	127	002°	8,079′

Figure 8: Port Moresby Visual Terminal Chart overlayed with the aircraft's S100-derived positions during the flight

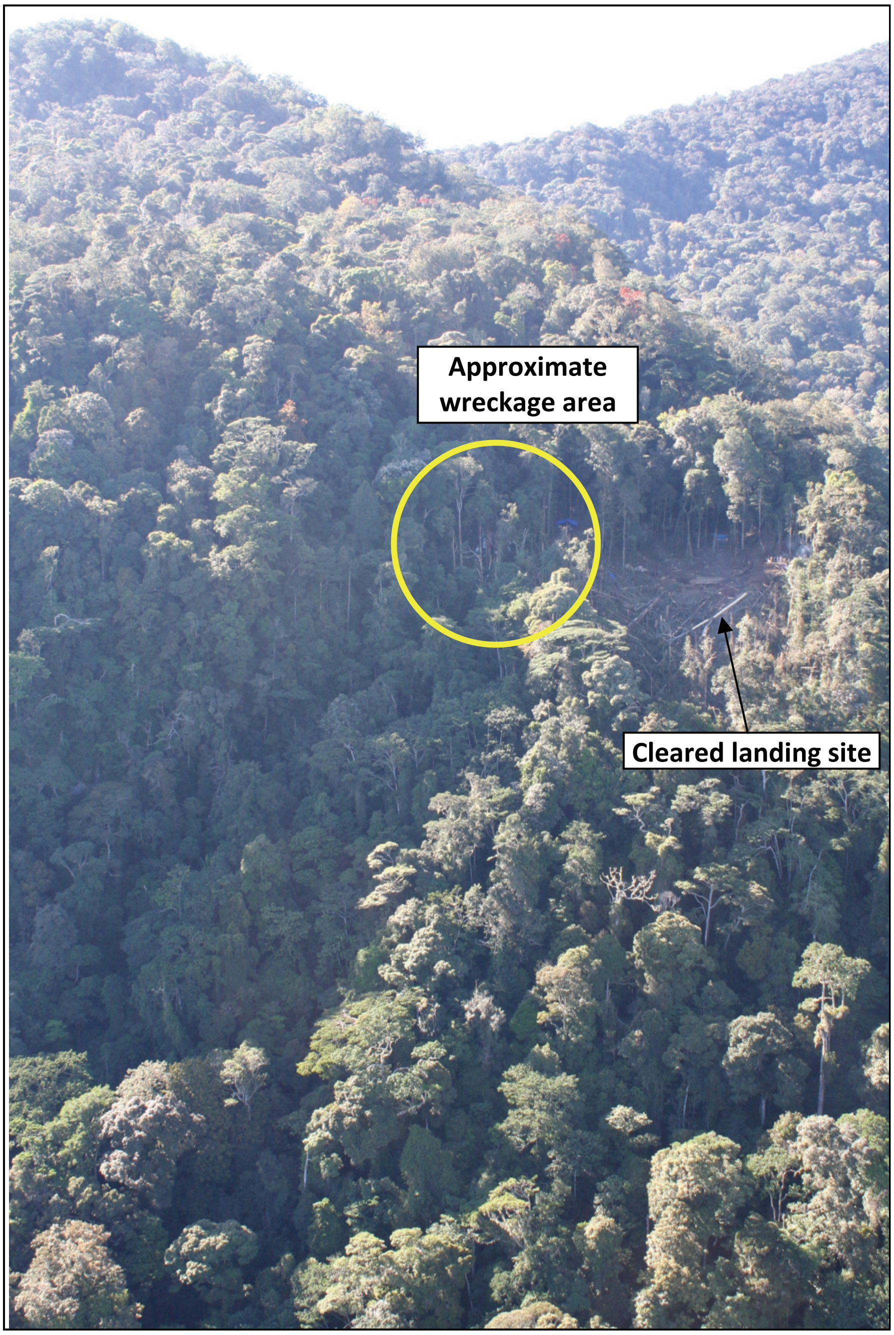


1.11 WRECKAGE AND IMPACT INFORMATION

1.11.1 Accident site description

The accident site was located at an elevation of about 5,780 ft (1,760 m) on the eastern side of the Kokoda Gap. The terrain to the east of the accident site continued to rise for about another 1,000 ft to the top of the ridge line. The wreckage trail was oriented on heading of about 110° M and extended for about 100 m on a slope of about 45° up to the horizon in heavily-timbered terrain (Figure 9).

Figure 9: Accident site and terrain



A detailed on-site examination of the wreckage and interpretation of the ground scars (including the surrounding trees, foliage and terrain) determined that the aircraft was in approximately level flight and banking to the right at an angle of about 25° at the time of impact.

The aircraft's structure was significantly disrupted from impact forces. A number of items were recovered from the site for further examination, including the engines and propellers, various aircraft instruments, and a number of electronic and radio components.

1.12 DAMAGE TO THE AIRCRAFT

The severe airframe disruption was consistent with multiple high-energy impacts with the trees and terrain during the impact sequence (Figure 10). There was no evidence of pre-impact structural failure. All of the flight controls were identified at the accident site; however, the flight control deflection angle prior to the collision with terrain could not be determined.

Figure 10: Forward section of the fuselage

The PIC's and copilot's instrument panels were extensively disrupted as a result of impact forces, and only small portions of a number of instruments and electronic components were able to be recovered for technical examination.

There was no evidence to indicate that the aircraft had sustained any foreign object damage, such as from a birdstrike.

1.12.1 Airframe and controls

All of the aircraft's flight and engine control cables and pushrods were identified on-site. Most of the cables and pushrods had failed in overload, including at their respective anchor points. That was consistent with the heavy disruption of the aircraft during the impact sequence (Figure 10). In addition, a number of cables were authorised by the investigator in charge to be cut by disaster victim identification (DVI) personnel to allow the DVI team to perform their role. The remainder were attached to their respective components. Hence, although the continuity of all control runs could not be definitively established, no evidence of the pre-impact failure of the engine or flight control systems was found.

A section of the left wing and left wingtip, including the red navigation light[22], were the first aircraft components identified along the wreckage trail, to the left of the general trail centreline. The right wingtip, including the blue-green navigation light, was located to the right of the main wreckage. The relative position of those components indicated that the aircraft impacted terrain in an upright attitude.

The forward portion of the aircraft and cockpit was severely disrupted. A number of the components from the cockpit section were scattered along the centre and to the right of the wreckage trail.

The main cabin area was destroyed and not identifiable as an assembly. The right side of the cabin was fragmented from the floor level to the ceiling and back to the aft cabin bulkhead. The left side of the cabin including the main door frame were in position, although severely disrupted.

The aft section of the main cabin between the empennage and the cargo bay, displayed evidence of torsional twisting (Figure 11). The cargo bay remained intact.

Figure 11: Aft section of the main fuselage showing torsional twisting

The ELT installation was housed within the cargo bay area, near the cargo door. The performance of the ELT was unaffected by the impact. The ELT antenna on top of the fuselage sustained significant impact damage, leaving only the base plate of the antenna attached to the fuselage. That could explain the weakness and incompleteness of the signal that was received by the Dornier search and rescue aircraft that was looking for MCB.

1.12.2 Engines and propellers

Both engines had separated from their respective wings and the propellers remained attached to the engines. The exhaust casings on both engines displayed signs of torque twisting opposite to the direction of propeller rotation. Both propellers

22 Red and blue-green wingtip lights are regulated on the left and right wingtips respectively.

showed torque twisting and bending of their respective blades, consistent with the engines producing power when impacting terrain. Two blades were liberated from the left propeller hub during the impact.

1.12.3 Fuel system

A number of fuel system components were identified, with a majority in the north-eastern section of the site. Sections of the bladder-type fuel cells were heavily shredded. The boost pump panel and plumbing was inspected and a small quantity of fuel was present in the lines. In addition, fuel drained from a number of the engine fuel components during the recovery of the engines, and there was a strong smell of jet fuel at the accident site.

The electric fuel shutoff valves for each engine and for the fuel cross-feed were identified. Each was in the correct position for in-flight engine operation.

1.12.4 Oxygen

There was no evidence to indicate that either the flight crew or cabin oxygen cylinders were in use prior to the accident, or had failed prior to impact.

1.12.5 Radio altimeter

An examination of the aircraft's radio altimeter (RADALT) indicator determined that at impact, the pointer was captured at the 80 ft (24 m) position and that the decision height 'bug'[23] was set to 0 ft (Figure 12).

Figure 12: Radar altimeter instrument

The aircraft had two RADALT antenna's (transmitter and receiver). One antenna cable connector was found attached, although the cable had separated from that connector. The other antenna's cable connector was not attached to the antenna.

[23] The decision height bug is manually set by the pilot. When set, an aural alert is generated when that selected height is reached on descent or when there is rising terrain or a combination of both.

Further examination determined that the antenna cable connector had been torn from the antenna as a result of the impact forces (Figure 13).

Figure 13: Radar altimeter antennas

1.12.6 Examination of recovered components

ATSB examination of recovered components

A number of electronic components and flight instruments were examined in the ATSB's technical facilities in Australia. Those examinations found that:

- One of the aircraft's altimeters that was recovered from the wreckage was found to have a barometric setting of 1011 hPa,[24] which corresponded to the conditions at the time of the accident.
- All of the remaining instruments that were examined were found to be operative at the time of impact; except for the copilot's turn and slip indicator[25], which showed no evidence that its internal gyroscope was rotating at impact. It could be expected that the gyroscope in that instrument would take a number of minutes to run down from its normal operating RPM.

The copilot's turn and slip indicator was not a primary instrument and, given that the PIC was the pilot flying, it was unlikely that it would have contributed to the accident.

Engine examination

The aircraft's engines were transported to the engine manufacturer's facilities in Canada for examination under the supervision of the Transport Safety Board (TSB)

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24 An altimeter is an instrument for measuring and indicating an aircraft's altitude above a specific datum; normally mean sea level. A sensitive altimeter includes a setting knob to adjust to different sea level or airfield pressures.

25 A turn and slip indicator shows the rate and slip/skid of an aircraft's turn.

of Canada. The TSB reported that '...both engines showed that they were making power at impact with no pre-impact abnormalities.'

Latitude Technology examination of the S100

A portion of the S100 circuit board (referred to as the DUT) was sent to the manufacturer's facility in Canada for technical examination under the supervision of the TSB. During that examination, the electronically-erasable programmable read-only memory chips on the DUT were isolated and the stored data was successfully extracted (see section 1.10.2 - *Data recovered from the aircraft's S100*).

Fuel quality

Due to the extensive disruption of the aircraft's fuel system, insufficient fuel was available for recovery from on-site for laboratory testing. However, it was established that a number of other aircraft had used the same fuel supply that day with no reports of fuel-related problems. In addition, the fuel distributor conducted its own test of the fuel from that source, and established that it was suitable for aviation use.

1.13 OTHER DAMAGE

The mountain side where this accident occurred can, at best, be described as remote and inhospitable. There were no evident developments or structures in the immediate area. During the impact sequence the surrounding trees and foliage were damaged either as a direct result of the accident or from the resulting intense post-accident recovery and investigatory activities. There were a number of villages in the general area, the closest of which was some 5 KM to the south-west of the accident site.

The local villagers depend largely upon this environment for their daily survival during hunting or gathering excursions or they are directly involved with the many trekking parties that pass through the area while walking the Kokoda track. There were subsequent claims of environmental damage to a river well below the accident site which, it was claimed, was the local villagers' source for fresh water.

The general area is subjected to frequent heavy rainfall.

1.14 MEDICAL AND PATHOLOGICAL INFORMATION

Following the recovery and identification processes that were conducted in PNG, the remains of the flight crew were sent to Australia for autopsy.

1.14.1 Pilot in command

The autopsy was conducted by the Victorian Institute of Forensic Medicine in Melbourne, Australia on 13 November 2009. The report indicated that the PIC sustained extreme injuries during the impact sequence. Toxicological testing showed no drugs or poisons. Testing for alcohol was not possible.

The cause of death was assigned as multiple injuries sustained during the impact sequence.

1.14.2 Copilot

The copilot's autopsy report found that:

> ...the coronary artery tree disclosed complete stenosis of the most proximal part of the anterior descending branch of the left coronary artery (immediately distal to the bifurcation of the left stem artery) extending to 90% stenosis by eccentric atheroma more proximally... histological examination showed and confirmed critical atherosclerotic stenosis, however there was no evidence of acute intraluminal thrombus formation.

In all other aspects the examination concluded that there were no apparent abnormalities.

Toxicological testing detected a blood alcohol concentration (BAC) of 0.05 gm/ml. The toxicologist reported that the BAC may in part be ascribed to the endogenous production of alcohol by the decomposition processes, or the possibility of alcohol being imbibed. No distinction was possible between those possibilities. However, in PNG, these results are historically not unusual when accidents occur in tropical areas and when there has been a delay in recovery.

No other drugs or toxins were detected during examination.

The examining pathologist was unable to ascertain the cause of death.

A report titled the *Interpretation of measured alcohol levels in fatal aviation victims*[26] is available at http://www.atsb.gov.au/media/36390/Measured_alcohol_lev.pdf

1.15 FIRE

There was no evidence of an in-flight or post-impact fire.

1.16 SURVIVAL ASPECTS

The seat track sections that secured the seats to the cabin floor were found throughout the accident site. The track fracture surfaces of those seats were examined and were consistent with overload-type failures (Figure 14).

Sections of the aircraft's 'checker-plate'[27] protective floor covering were identified throughout the accident site. It could not be ascertained how the flooring had been secured to the aircraft's floor.

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[26] Overview by Dr Shelley Robertson MBBS, LLB, FRCPA, DMJ, FACLM, DAvMed, MHealSc (AvMed).

[27] A light-weight metal stock with a regular pattern of raised diamonds or lines.

Figure 14: Exemplar overload failure of seat track

The aircraft's seats and seat belts were also examined. The majority of the seats were distorted and disrupted (Figure 15). Some of the still-complete seat belts remained attached to their seat frames and were undone. The Disaster Victim Identification team confirmed that they had undone a number of seat belts during their on-site activities. The investigation could not establish if all of the passengers had their seat belts secured at the time of impact.

Figure 15: Distorted passenger seat with seat belt attached

1.16.1 Search and rescue

Shortly after receiving advice that MCB had not arrived at Kokoda Airstrip, the operator diverted a company aircraft to the area, and arranged for two private helicopters to commence a search for the aircraft. The operator later advised the AMSA Rescue Coordination Centre (RCC) that MCB had not arrived at Kokoda Airstrip.

At the request of the PNG Government, the AMSA RCC tasked an Aero Rescue Dornier aircraft to support the search for the missing aircraft. That aircraft departed Cairns late in the afternoon of 11 August 2009 and overflew the Kokoda area that evening en route to Port Moresby, but did not detect or sight the accident aircraft.

The Dornier resumed the search on the morning of 12 August and, at 0747 detected an ELT signal in the search area that might have been a 406 MHz distress beacon. The signal was weak and did not include the normal hexadecimal ELT identifier.[28] The crew of the Dornier passed that information to other search aircraft. At 0810, a search helicopter reported that they had located the aircraft wreckage.

1.17 TESTS AND RESEARCH

Not applicable to this investigation.

1.18 ORGANISATIONAL AND MANAGEMENT INFORMATION

1.18.1 Aircraft operator

Operator's Certificate

In PNG, air transport operators were required to have an Air Operators Certificate (AOC) that was issued by CASA PNG and the renewal of that certificate was subject to regular audits by CASA PNG. The aircraft operator had a valid AOC.

One of CASA PNG's functions was to oversight air operators in PNG in matters of safety and regulatory compliance, including of airworthiness and operational compliance. After the accident, CASA PNG performed a scheduled audit of the operator. That audit identified a number of deficiencies with the operation of the airline and as a result, CASA PNG placed a number of restrictions on the operator's AOC until those issues were addressed. The continued operations by the operator after that audit suggested that those deficiencies were not considered significant enough by CASA PNG to prevent the airline from continuing to operate.

Operator exposition

Under CASA PNG Rule 119, air operators are required to have an exposition that outlines how the operator will conform to the rules in order to maintain a safe operation. An operator is also required to have an internal audit system so that it can monitor its own standards and conformance.

CASA PNG Advisory Circular AC119-1 - *Air Operations- Certification*, subsection 119-75 explained the purpose of an exposition as follows:

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28 Unique hexadecimal code to identify an aircraft's ELT.

> ....an exposition is a general description of how their [an operator's] operation works; a tool of management in the operation of the business; and a means of instructing staff in how they are to perform their tasks....
>
> The purpose of an exposition is to express the Chief Executive's requirements for the conduct of the organisation and to state how the organisation will meet regulatory requirements. It sets out the procedures and methods of a certificated organisation. The philosophical benefits of the manual are considerable and important to the safe operation of commercial aviation. The complex nature of aviation may give rise to procedural needs an operator is unaware of including ongoing changes to rules, airspace, compliance requirements and they all require a follow up system that the exposition must provide.
>
> The exposition is the means by which an organisation defines its operation, and shows both its employees and the CAA [CASA PNG] how it will conduct its day-to-day business and ensure compliance with the rules.

A number of sections in the operator's exposition stipulated higher standards than those required by regulation.

The sections of the operator's exposition that was current at the time of the flight, and that affected operations that were similar to the flight, are included at Appendix A.

The operator's system for ensuring compliance was not effective in meeting the requirements of the amendment to Rule 91.112 that, for flight under the IFR, both pilots be instrument-rated unless the aircraft was fitted with an autopilot.

1.18.2 Civil Aviation Safety Authority of Papua New Guinea

Requirements for flight under the IFR

The flight from Port Moresby to Kokoda was planned under the IFR and flown using visual procedures. An approach to land under the IFR using visual approach procedures is authorised if:[29]

- the aircraft is within 30 NM (56 km) of the landing aerodrome
- visibility at the destination is at least 5 km
- the approach can be carried out with continuous visual reference to the surface.

The CASA PNG regulations currently state that for IFR flight:[30]

- an aircraft must be equipped with instruments suitable for flight under those rules (Rule 91.517)
- unless the aircraft is fitted with an autopilot:
  - the aircraft must be crewed by two pilots (Rule 91.401), and
  - both pilots must be instrument rated (Rule 91.112).

The CASA PNG Rule 91 that was released with an effective date of January 2004 did not include Rule 91.112, which was added as part of a subsequent amendment.

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[29] CAA PNG Rule 91.423 refers – see Appendix B.

[30] Also see Appendix B.

CASA PNG advised that before any rule was amended, the aviation industry was consulted about the proposed change. After that consultation, and the proposed changes to the Rules had been through CASA PNG's review and approval process, amendments to the Rules were updated, published through the media and were available from the CASA PNG website. The investigation could not determine when that amendment was 'made', although they were in place at the time of the accident.

On 2 June 2005, the operator sought clarification of the regulations in respect of the need for its first officers (copilots) to be IFR rated. An interpretation of the relevant regulations by CASA PNG[31] titled *First Officer Qualifications for IFR Operations* dated 5 July 2005 responded in part, that:

> I refer to your letter of 2nd June. As you are aware CAA's interpretation of CAR 166 and CAO 20.18 4.1 prior to the introduction of the present rules was that the First Officer was required to hold a type rating for the aircraft type being flown, but did not need to hold an instrument rating.
>
> With respect to your question regarding part 91.401 it is appropriate to consider that this interpretation remains the case.

The operator understood from the CASA PNG letter that a copilot was required to hold a type rating for the aircraft type being flown, but did not need to hold an instrument rating.

The CASA PNG interpretation appeared to the investigation to vary the requirements of Rule 91.112 and clarification was sought from that authority. In response, CASA PNG advised that:

> ...current best practice places the responsibility on the operator to ensure compliance and indeed this is the philosophy of the PNG rules which are outcome based. The letter from the Flight Operations inspector was written at the early stages of the transition to the new rule set and only took into account 91.401. The operator should have verified the advice and requestioned [sic] its inconsistency with 91.112, before acting on it.

The CASA PNG's surveillance of the operator since Rule 91.112 was 'made' did not identify the operations by the operator in contravention of Rule 91.112.

1.18.3 International Civil Aviation Organization Audit of the then CAA PNG of March 2009

PNG is a signatory to the Chicago Convention on International Civil Aviation and as a result is a contracting State (or member) of the International Civil Aviation Organization (ICAO). ICAO sets the standards and recommended practices to promote aviation safety that are followed by its members.

All contracting States are routinely audited by ICAO as part of its Universal Safety Oversight Audit Program (USOAP).[32] The last USOAP audit of PNG was conducted in March 2009. At that time, the audit identified a number of deficiencies, including that:

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31 Then titled Civil Aviation Authority, subsequently re-designated CASA PNG.

32 ICAO plans to move to a continuous monitoring approach to the audit of States' safety oversight over the period 2011 to 2013.

- There was no mechanism for the evaluation of medical reports that were submitted by designated aviation medical examiners.
- The flying operations area of the then CAA had not developed and implemented a comprehensive surveillance program.
- There was no surveillance system to confirm a pilot's proficiency (including instrument training).
- There was no mandatory or voluntary incident reporting system.

The overall level of implementation by PNG of the critical elements of a safety oversight system, as determined by the ICAO audit of March 2009, is shown in Table 7.

Table 7: ICAO critical elements of a safety oversight system – CAA PNG audit results March 2009

Level of Implementation of the Critical Elements of a Safety Oversight System										
Critical Element	1 = Not Implemented									
	10 = Fully Implemented									
	■ = States Level of Implementation									
	□ = Global Average									
	1	2	3	4	5	6	7	8	9	10
Primary Aviation Legislation							□		■	
Specific Operating Regulations					■	□				
State Civil Aviation System and Safety Oversight Function						■				
Technical Personnel Qualification and Training			■	□						
Technical Guidance, Tools and the Provision of Safety-Critical Information				■		□				
Licensing, Certification, Authorization and Approval Obligations					■		□			
Surveillance Obligations						■				

Level of Implementation of the Critical Elements of a Safety Oversight System										
Resolution of Safety Concerns		■			□					

The PNG government response to the March 2009 USOAP audit had not been publicly released at the time of this report.

In an effort to determine the inherent safety risk in the operation from Jackson's International Airport Port Moresby to Kokoda Airstrip, the investigation sought historical accident and incident data relating to similar air safety occurrences in PNG. However, no accurate or reliable data was available.

The investigation was unable to establish if an effective mechanism existed in PNG to receive and record aviation accident and incidents notifications. That appeared to corroborate the findings of the March 2009 ICAO USOAP audit in that regard.

1.19 ADDITIONAL INFORMATION

1.19.1 Normalised pilot response to continuing alerts

Technology-based aircraft warning and alerting systems can be an important 'last line of defence' against human error. However, while of significant safety benefit, warning and alerting systems have limitations in practice.

Warning information provided to a crew may be intentionally ignored if the crew believe from past experience that an alert is likely to be a 'false alarm' given the particular circumstances. Alternatively, at a time of high workload or stress, the crew may be so focussed on some other aspect of flight operations that the alert does enter their conscious awareness.

Additionally, if the warning system generates many true alerts in certain situations, such as a terrain awareness warning system (TAWS) during a flight in the continuing vicinity of mountainous terrain, then the diagnostic value of the information provided to the crew may be diminished.

1.19.2 Threat and error management

There are two distinct skill sets required to fly an aircraft. The first is the technical skill of hand/eye coordination to manipulate the aircraft's controls to achieve the desired aircraft state. The second is the more difficult to teach and learn non-technical skill of managing safety risks.[33]

During flight, a pilot must manage situations that pose threats to that flight, involve errors, or result in undesired aircraft states in order for a flight to be concluded safely.[34] Threat and error management (TEM) is a relatively new approach to

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33 Flin, R., Martin, L., Goeters, K., Hoermann, J., Amalberti, R., Valot, C., & Nijhuis, H. (2003). Development of the NOTECHS (Non-Technical Skills) system for assessing pilots' CRM skills. *Human Factors and Aerospace Safety*, 3, 95-117.

34 Merrit, A. & Klinect, J., (2006), *Defensive Flying for Pilots: An Introduction to Threat and Error Management.*

managing those risks in the aviation environment that can be thought of as ‘defensive driving’ for pilots. The application of TEM provides a means to objectively observe and measure a pilot’s response to in-flight risks.

The three basic components of TEM include:

- **Threats.** Threats are ‘events or errors that occur beyond the influence of the flight crew, increase operational complexity, and which must be managed to maintain the margins of safety’. Examples of threats include high terrain, adverse weather conditions, aircraft malfunctions and dispatch errors. When undetected, unmanaged or mismanaged, threats may lead to errors or an undesired aircraft state.
- **Errors.** Errors are ‘actions or inactions by the pilot that lead to deviations from organisational or pilot intentions or expectations’, and can include handling, procedural and communications errors. When undetected, unmanaged or mismanaged, errors may lead to undesired aircraft states.
- **Undesired aircraft states.** Such states are defined as ‘an aircraft deviation or incorrect configuration associated with a clear reduction in safety margins’. Undesired aircraft states can include unstable approaches, altitude deviations, and hard landings and are considered the last stage before an incident or accident (ICAO, 2005) Thus, the management of undesired aircraft states represents the last opportunity for flight crews to avoid an unsafe outcome, and hence maintain safety margins in flight operations.

Whereas the components of TEM above refer specifically to the in-flight management by flight crew of threats and errors, it could be equally expected that TEM provides a tool for airline management and other operators to identify and mitigate risks and enhance operational safety. The mitigation of in-flight risks by the development of relevant operator procedures has the potential to minimise the exposure of crews to those risks, or to aid recovery from in-flight or other errors.

After the accident the operator provided guidance in their Exposition to address the threat of inadvertent IMC as follows:

> 119/Vol 1 5.2 Guidelines for Flight Operations within PNG
>
> ...A key to safety recovery to VFR conditions, should you inadvertently find yourself in IFR conditions, is prior to planning as to how you would handle this for different conditions. No advice in any manual can cover all the scenarios. However consideration should be given to:
>
> The use of terrain displays including EGPWS to retain situational awareness and assist in avoiding terrain.
>
> Monitoring the radar altimeter. Whilst a last resort it will give indications of closure with terrain.
>
> Ensuring the aircraft is flown at Vx (maximum angle climb speed)
>
> Consideration of the validity of putting the aircraft into a tight climbing turn.

1.19.3 Controlled flight into terrain

Controlled flight into terrain (CFIT) describes a situation in which an airworthy aircraft under the control of the flight crew is unintentionally flown into terrain, probably with little or no awareness by the crew of the impending collision. [35]

Controlled flight into terrain continues to be one of the leading causes of commercial aircraft accidents. While CFIT accidents are generally rare events, when a CFIT does occur, the likelihood of fatalities is high. Controlled flight into terrain accidents most commonly occur in the approach phase of flight.

The United States Flight Safety Foundation (FSF) has been a leader in efforts by the international aviation industry to reduce the incidence of CFIT. A number of CFIT reduction products have been developed by the FSF and are available to assist pilots and operators in mitigating the risk of CFIT. Those products are available at http://flightsafety.org/current-safety-initiatives/controlled-flight-into-terrain-cfit/cfit-reduction-products In particular, a *CFIT Checklist risk safety assessment tool* has been developed that can be used to:

> Evaluate specific flight operations and to enhance pilot awareness of the CFIT risk.

The FSF CFIT checklist risk factors that were pertinent to the approach into Kokoda included:

- in respect of the destination airport and its approach capabilities, the greatest risk was identified at destinations without an ATC service
- in regard to the expected approach type, the proximity to the destination of any mountainous terrain.

A review of public reports of aircraft accidents in PNG found only limited information and no specific CFIT reports in the last 10 years. Notwithstanding, the risk of CFIT in PNG could be expected to be higher than in Australia. PNG has extensive and generally higher mountainous terrain than in Australia and, as indicated in this case, the weather in some areas can change extremely rapidly.

Recognising the probable greater number of aircraft movements in Australia than in PNG, and the possible effect on the number of instances of CFIT, a search of the ATSB occurrence database revealed 11 CFIT accidents in Australia since 2000. Eight of those accidents resulted in fatalities and the remainder in serious injuries. One of the accidents, the crash of a two-crew, turboprop aircraft on a scheduled passenger service to Lockhart River, Queensland resulted in the loss of all 15 people on board.

1.19.4 Situational awareness

While CFIT accidents and incidents are often the product of a series of events, the investigation of CFIT over the years has identified the loss of situational awareness as a key contributing factor. More specifically, that factor can be described as the loss by the pilot(s) of vertical and/or horizontal situational awareness in relation to the terrain, obstacles or water.

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[35] ATSB (2007). *CFIT: Australia in context 1996 to 2005*. Canberra: Australian Transport Safety Bureau. Available at www.atsb.gov.au

In simple terms, situational awareness can be described as knowing what is going on around you.[36] More formally, situational awareness has been defined as:[37]

> ...the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future.

Maintaining a high level of situational awareness is essential to flight safety. In practice, that means that a pilot must continuously monitor his or her environment, and be alert for any significant changes and the possible effect they might have on flight safety.

Developing and maintaining situational awareness involves three aspects:

- perception - gathering relevant information
- integration - interpreting the information
- projection - anticipating future states.

For example, a pilot may receive information from an instrument scan, from looking out for conflicting traffic, from radio communications, and from other sources. He/she must then process that information to make sense of it, and then plan and prioritise any subsequent actions in order to maintain situational awareness.

Factors that can influence situational awareness

Situational awareness is very context specific, relating to a particular task and operating environment. The maintenance of situational awareness is dependent on a pilot's attention and working memory. Therefore, factors such as workload, fatigue, stress, and distraction can have a detrimental effect on situational awareness. Good task management is essential to minimise the effect of workload or distraction, and fitness for duty is essential to minimise the possible effects of fatigue or stress on pilot performance.

A pilot's level of experience can also affect their ability to maintain situational awareness. More experienced pilots are better able to recognise what information is important to seek or to attend to; to integrate various pieces of information to understand the 'big picture'; and to anticipate likely outcomes and hence stay 'ahead of the aircraft'.[38] In addition, more experienced pilots need to devote less conscious effort to the primary flight tasks, freeing up mental resources that can be used to maintain situational awareness.

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[36] Endsley, M., & Garland, D. (2000). *Situation Awareness: Analysis and Measurement*. Mahwah, NJ: LEA.

[37] Endsley, M. (1995). Towards a theory of situation awareness. *Human Factors*, 37, 32-64.

[38] Endsley, M., Garland, D., Shook, R., Coello, J., & Bandiero, M. (2000). *Situation Awareness in General Aviation Pilots*. NASA-Ames Research Center Contract NAS2-99073 Report SATECH-00-01. Marietta, GA: SA Technologies.

1.19.5 International travel warnings and advisories

Throughout the world, aviation safety standards can vary greatly. In general, those variations are due to differences in weather, terrain, aviation infrastructure and the ways in which a country regulates its aviation industry.

International travellers can access travel advisory information from organisations such as the International Civil Aviation Organization (ICAO), the United States Federal Aviation Administration (FAA) and the International Air Transport Association (IATA). In addition, the European Union (EU) publishes a list of airlines that are subject to operating bans or restrictions within the EU (see http://ec.europa.eu/transport/air-ban/list_en.htm).

In Australia, travellers can access much of that information from the Australian Department of Foreign Affairs and Trade *Smartraveller* website, at http://www.smartraveller.gov.au/ In relation to air travel in PNG, at the time of the accident, that website did not include specific advice about the risks associated with aircraft operations in PNG.

2 ANALYSIS

2.1 OVERVIEW

When the crew commenced the descent through the Kokoda Gap in the reported rapidly changing weather conditions, they committed themselves to a course of action that they could not be assured of completing safely.

If the crew decided for whatever reason to discontinue the approach, they would have either had to manoeuvre the aircraft to keep it clear of cloud, or to accept the increased risk of temporary operations in instrument meteorological conditions (IMC) below the relevant lowest safe altitude (LSALT). Without the benefit of a published instrument approach or other radar-based procedures, flight in IMC below the LSALT cannot assure terrain clearance.

The reported previous serviceability of the aircraft, witness and on-site physical evidence, indications of the production of engine power at impact, and lack of an emergency call from the crew indicated that it was highly unlikely that a mechanical problem contributed to the accident.

Given the surrounding mountainous terrain, the evident cloud in the Kokoda Gap, as in this instance, had the potential to severely limit the crew’s escape options, increase their workload, and test their situational awareness. A reduction in situational awareness and the presence of mountainous terrain during an approach are known risk factors in instances of controlled flight into terrain (CFIT).

The investigation concluded that it was probable that during the descent, the crew were required to manoeuvre the aircraft to remain clear of cloud, or regain that status, and in so doing, impacted terrain. This analysis will examine the operational factors that contributed to that CFIT.

2.2 CONTROLLED FLIGHT INTO TERRAIN

Although there was no regulatory requirement for the installation of on-board recorders in the aircraft, the lack of both flight data and cockpit voice recorders adversely affected a full understanding of the accident by the investigation. However, some understanding of the last minutes of the flight was possible by examining the combined information that was recovered from the S100 Global Positioning System (GPS) tracking and telemetry device and from the recorded radio transmissions. That reconstruction showed that, between the time of the last S100 recording and the unsuccessful Port Moresby ATC radio call, the aircraft would have travelled about 3 NM (6 km) at an average groundspeed of 120 kts. The descent from the last S100-recorded altitude of about 8,100 ft to the accident site elevation of 5,780 ft in that time suggested an average rate of descent of about 1,500 ft/min.

The witness reports of cloud obscuring the eastern side of the valley in the vicinity of Misima village, and photographic evidence of a solid bank of cloud in the junction of the Kokoda Gap and Valley just north of the accident site, meant that the crew would not have been able to continue visual flight towards Kokoda. The impact with terrain at a right bank angle of about 25°, and on a heading of 110° was consistent with the crew turning right to avoid entering the cloud that blanketed the Kokoda Gap.

The investigation concluded that the accident was probably the result of controlled flight into terrain.

A more reliable mandatory occurrence reporting arrangement would ensure a fuller understanding of the risk of CFIT in PNG. It could be expected that an enhanced accident and incident data set would allow a more informed response to PNG-specific safety risks.

2.3 WEATHER

Witness and photographic evidence of the weather at the junction of the Kokoda Gap and Valley at about the time of the accident suggested that the conditions were not conducive to visual flight. The cautionary radio transmission from the pilot of KST as MCB descended into the Kokoda Gap might have been expected to have elicited a request for clarification from the crew of MCB. Had the crew of MCB requested an indication of the weather that affected KST's departure and climb, they would have better understood the weather risk to the remainder of their planned flight.

The investigation could not determine the extent to which the ability of the pilot of KST to successfully depart Kokoda may have influenced the pilot in command (PIC) of MCB to continue the approach to Kokoda in the worsening conditions.

The investigation was unable to establish if the aircraft's weather radar was being used by the crew during the descent or of the usefulness of that equipment once the aircraft was manoeuvred below the surrounding terrain.

2.4 OPERATIONAL CONSIDERATIONS

The conduct of the instrument flight rule (IFR) flight with one IFR-rated pilot was in accordance with the clarification that was provided to the operator by the then Civil Aviation Authority PNG (later re-designated the Civil Aviation Safety Authority Papua New Guinea (CASA PNG)). That clarification allowed for operations under the IFR with one instrument-rated pilot, despite the aircraft not having an autopilot. However, clarification from CASA PNG late in the investigation was that, the public availability of the amended Rule 91.112 meant that the operator should have been operating in accordance with the current CASA PNG Rules. In that case, at the time of the accident and given that the aircraft did not have an autopilot, both pilots should have been instrument rated.

The copilot had been assessed for instrument approach procedures; however, he was not qualified for flight under the IFR, meaning that his ability to reliably assist the PIC during operations in IMC could not be assured.

Although the crew had planned to fly under the IFR with visual procedures, the forecast cloud in the area ought to have alerted them that, under those procedures, visual flight in the Kokoda Gap could prove problematic. The visual descent into the Kokoda Gap required 5 km visibility, which was not the case to the north of the accident site. In that case, the crew should have discontinued their approach in sufficient time to be able to safely avoid the cloud. The provision by the operator of an effective inadvertent IMC recovery procedure would have offered a final defence that could have facilitated the recovery of the aircraft to above the LSALT, reversion to IFR procedures, and recovery to Port Moresby or other suitable alternate destination.

2.5 PILOT INCAPACITATION

Despite the limited information possible from the PIC's postmortem, all of the remaining evidence indicated that the PIC, who was the handling pilot, was in good health and appeared to be well prior to the flight. The investigation concluded that it was unlikely that the PIC's health was a factor.

Although the investigation was unable to determine whether the copilot held a valid Class 1 medical certificate, the copilot's relatives reported that they were not aware of any significant pre-existing medical condition affecting the copilot. Against that, the finding at postmortem of the copilot's critical coronary artery heart disease, and the examining pathologist's observation that the copilot could have had a medical event at any time, was cause for concern. Any incapacitation of the copilot as the aircraft approached the cloud to the north of the Kokoda Gap would have instantly increased the PIC's workload and likely distracted her from the primary task of flying the aircraft. Both those factors are known to increase the risk of CFIT.

On that basis, while considered unlikely, the investigation was unable to discount the possible incapacitation of the copilot as a factor in the accident.

The appointment of a qualified Director (or similar) of Aviation Medicine in PNG could be expected to enhance the administration of the PNG aviation medical regime, including of pilots' aviation medical certificates.

2.6 AIDS TO NAVIGATION

The lack of ground-based navigation aids at the Kokoda Airstrip meant that the only potential navigation assistance for the crew during their approach to Kokoda was from the GPS, or via the ground-based non-directional beacon/distance measuring equipment (NDB/DME) located at Girua.

The pre-programming and display of the flight-planned route during the flight, and the last position information that was broadcast by the crew, indicated that the crew were most likely using the GPS to assist with navigation. The crew may also have been using the GPS to assist them in maintaining a general awareness of the position of the aircraft relative to the surrounding terrain. The investigation could not determine the possible impact of the pilots' lack of formal GPS training on their use of that equipment.

Although in ideal conditions the aircraft was marginally within the published range of the Girua NDB/DME, it could not be determined whether, given the altitude and position of the aircraft, and nature of the surrounding terrain, the Girua navigation aid would have been a reliable source of information for the crew. The investigation concluded that it was unlikely for the crew to have used the Girua NDB/DME to determine an effective escape route from the Kokoda Gap. However, had the crew decided in sufficient time to avoid the cloud at the Kokoda Gap and to recover visually, or had a recovery from inadvertent IMC been carried out successfully, the Girua NDB/DME may have provided the opportunity for the crew to reorientate themselves and continue to Girua, or to return to Port Moresby.

2.7 TERRAIN AWARENESS AND AIRCRAFT SEPARATION

The application of visual procedures by the crew to the descent below the LSALT required the navigation of the aircraft by visual reference to the ground. The conduct of the flight below the height of the surrounding terrain meant that the terrain awareness database in the aircraft's GPS would probably have displayed the surrounding terrain in red on the GPS and/or multi-function display leading up to the accident. Any indication of the rising terrain immediately prior to the impact would similarly have been coloured red and therefore not been separately noticeable to the crew.

The extent to which the crew's response to any ongoing red terrain display in such conditions had been normalised, by their perhaps routine application of visual procedures during approaches to Kokoda, could not be determined.

Despite the lack of a capability in radar altimeter equipment (RADALT) to 'look' ahead of an aircraft, the display of an aircraft's constant barometric altitude can, in combination with the display of its diminishing radar altitude, provide an indication of rising terrain below the aircraft. In this instance, the action by the crew to set the RADALT decision height 'bug' to the zero position deprived them of a visual alert to any critical risk of rising terrain under the aircraft. Similarly, the likely manoeuvring, including in height, to remain visual would have diminished the relevance of the combined barometric altimeter/RADALT information as a means to understand the nature of the terrain below the aircraft.

2.8 ASSISTANCE AVAILABLE TO THE CREW

The operator's methods and procedures for safe flying operations were described in the operator's exposition, which was amended every 2 months. That amendment cycle ensured the operator's ability to regularly promulgate any changes or enhancements to the operator's procedures, including those affecting flight in mountainous terrain and in reduced visibility.

The lack of a requirement for the operator's personnel to certify that they had read and understood successive expositions meant that it was only when personnel underwent scheduled company training and checks that the operator could assure itself that staff had assimilated and were applying any amended procedures.

It was not possible to determine if either the PIC or copilot of MCB had received, read or understood the operator's most recent exposition. However, the most recent pilot line checks indicated that when assessed, both pilots had a satisfactory understanding, and were in possession, of the current company documents.

2.9 THREAT AND ERROR MANAGEMENT

There is a growing international consensus on the validity of threat and error management (TEM) as a tool for flight crews to manage safety risks. TEM training was not required by regulation or included in the operator's exposition at the time of the accident. That said, the application of TEM principles to the flight to Kokoda might have influenced the decision by the flight crew to conduct a flight for which the copilot was not qualified and to continue the approach via the Kokoda Gap in the prevailing weather conditions.

The application of TEM by an operator also has the potential to assist in the identification and mitigation of operational risks, thereby setting the context for safe operations. For example, in isolation the operator's exposition (Appendix A) could be interpreted to suggest that, given the availability of sufficient fuel and a destination airstrip for the flight, and that the attempted flight to Kokoda was conducted in daylight, the weather on the day could have been 'explored with some latitude'.

The risk of rapidly changing weather conditions in the Kokoda Gap, and the mountainous terrain in that area would suggest that the application of TEM might identify the need in the exposition for an effective emergency inadvertent IMC recovery procedure.

While such a procedure should not be seen as routinely applicable to such operations, nor as a replacement for sound pre-flight planning and in-flight decision making, in the PNG context it appears to offer a final safety defence against CFIT. Similar procedures may have application to other operators and operations in PNG.

3 FINDINGS

From the evidence available, the following findings are made with respect to the collision with terrain, 11 km south-east of Kokoda Airstrip, Papua New Guinea, involving a de Havilland Canada DHC-6-300 Twin Otter aircraft, registered P2-MCB, and should not be read as apportioning blame or liability to any particular organisation or individual.

3.1 CONTRIBUTING SAFETY FACTORS[39]

- Visual flight in the Kokoda Gap was made difficult by the extensive cloud coverage in the area.
- The crew attempted to continue the descent visually within the Kokoda Gap despite the weather conditions not being conducive to visual flight.
- It was probable that while manoeuvring at low level near the junction of the Kokoda Gap and Kokoda Valley, the aircraft entered instrument meteorological conditions.
- The aircraft collided with terrain in controlled flight.

3.2 OTHER SAFETY FACTORS[40]

- The copilot was assessed during normal proficiency checks for instrument approach procedures but was not qualified for flight in instrument meteorological conditions.
- The operator did not have a published emergency recovery procedure for application in the case of inadvertent flight into instrument meteorological conditions. *[Minor safety issue[41]]*
- The Civil Aviation Safety Authority Papua New Guinea surveillance of the operator did not identify the operations by the operator in contravention of Rule 91.112.
- The lack of a reliable mandatory occurrence reporting arrangement minimised the likelihood of an informed response to Papua New Guinea-specific safety risks. *[Minor safety issue]*

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39 For the purposes of this report, a safety factor is an event or condition that increases safety risk. A ***contributing*** safety factor is one which, had it not happened or existed, then either:

- the occurrence would probably not have occurred
- the adverse consequences associated with the occurrence would probably not have occurred or been as serious
- another contributing safety factor would probably not have occurred or existed.

40 Other safety factors are those factors which increase safety risk without directly affecting the accident.

41 A safety issue is a safety factor with the potential to adversely affect the safety of future operations.

- There was no qualified Director (or similar) of Aviation Medicine in Papua New Guinea (PNG). *[Minor safety issue]*
- The lack of both flight data and cockpit voice recorders adversely affected a full understanding of the accident by the investigation. *[Minor safety issue]*

3.3 OTHER KEY FINDINGS

- The investigation was unable to discount the possible incapacitation of the copilot as a factor in the accident.
- Although not required by the aviation rules at the time of the accident, the adoption of threat and error management training for flight crews, and of the methodology by operators would provide a tool to identify and mitigate operational risk as follows:
  - by flight crews, when flight planning and during flight; and
  - by operators, when developing their operational procedures.

4 SAFETY ACTION

The safety issues identified during this investigation are listed in the Findings and Safety Actions sections of this report. The Accident Investigation Commission of Papua New Guinea (AIC PNG) expects that all safety issues identified by the investigation should be addressed by the relevant organisation(s). In addressing those issues, the AIC PNG prefers to encourage relevant organisation(s) to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

All of the responsible organisations for the safety issues identified during this investigation were given a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

4.1 CIVIL AVIATION SAFETY AUTHORITY OF PAPUA NEW GUINEA

4.1.1 Administration of the Papua New Guinea aviation medical regime

Minor safety issue

There was no qualified Director (or similar) of Aviation Medicine in Papua New Guinea (PNG).

Action taken/response by the Civil Aviation Safety Authority of Papua New Guinea

In response to this accident, the Civil Aviation Safety Authority of PNG (CASA PNG) advised that:

> Pilot Medical Administration. CASA PNG has in place an appointed Principal Medical Officer (PMO) for this purpose who is appropriately qualified. Proper oversight guidelines and accountability of the PMO will be implemented to enable an effective Aviation Medicine Policy in PNG is in place to support Civil Aviation Rule Part 67. The CASA PNG is also embarking on recruiting an in-house Medical Officer to enable proper oversight and monitoring of aviation medicine.

AIC assessment of response/action

The AIC PNG is satisfied that the action proposed by CASA PNG will, once in place, adequately address the safety issue.

4.1.2 Mandatory occurrence reporting system

Minor safety issue

The lack of a reliable mandatory occurrence reporting arrangement minimised the likelihood of an informed response to PNG-specific safety risks.

Action taken/response by the Civil Aviation Safety Authority of Papua New Guinea

On 2 March 2011, CASA PNG advised that they were preparing amendments to the Civil Aviation Act to require industry to notify occurrences to the Accident Investigation Commission of PNG.

AIC assessment of response/action

The AIC PNG is satisfied that the action proposed by CASA PNG will, once in place, adequately address the safety issue.

4.2 Accident Investigation Commission of PNG

4.2.1 Fitment of cockpit voice recorders in aircraft certified to carry 18 or more passengers

Minor safety issue

The lack of both flight data and cockpit voice recorders adversely affected a full understanding of the accident by the investigation.

Action by the Accident Investigation Commission of PNG

As a result of the identified minor critical safety issue, the AIC PNG issues the following safety recommendation to CASA PNG.

Safety recommendation

The Accident Investigation Commission of Papua New Guinea (PNG) recommends that the Civil Aviation Safety Authority PNG review the requirements affecting the installation of cockpit voice recorders in PNG-registered aircraft that are certified to carry 18 or more passengers, with the intent of implementation.

Action taken/response by the Civil Aviation Safety Authority of Papua New Guinea

In response to the AIC PNG recommendation, CASA PNG advised that:

> Amendment to Rule Part 125 effective from 1 January 2011 now requires that a holder of an air operator certificate must ensure that each of the certificate holder's multi-engine turbine powered aeroplanes is equipped with a flight data recorder (FDR), although this requirement does not apply to de Havilland DH6 aeroplanes, and aeroplanes registered on or before 1 January 2004 with a MCTOW of less than 5700 kg:

> Furthermore, CASA PNG has mandated the fitment of the following equipment in CAR 125:
>
> (1) Terrain Awareness and Warning System (TAWS) Class A -for turbine powered aeroplane with a MCTOW greater than 5700 kg and under IFR.
>
> (2) Each turbine powered aeroplane with a MCTOW of 5700 kg or less and with a certificated sealing configuration of more than 5 seats being operated under the AOC certificate is equipped with TAWS Class B.
>
> (3) A rule requirement requiring an AOC holder that operates each turbine powered aeroplane operating under that certificate is equipped with Ground Proximity Warning System (GPWS).
>
> (4) A rule requirement requiring an AOC holder that operates each turbine powered aeroplane that has a MCTOW greater than 5700 kg to be equipped with Airborne Collision Avoidance System (ACAS II).
>
> (5) An amendment to the rule to require an AOC holder to ensure that each turbine powered aeroplane with a certificated passenger seating configuration of more than 9 seats is equipped with a cockpit voice recorder (CVR).

AIC assessment of response/action

The AIC PNG is satisfied that the action proposed by CASA PNG will, once in place, adequately address the safety issue.

4.3 AIRCRAFT OPERATOR

4.3.1 Emergency recovery from inadvertent flight into instrument meteorological conditions

Minor safety issue

The operator did not have a published emergency recovery procedure for application in the case of inadvertent flight into instrument meteorological conditions. *[Minor safety issue]*

Action taken/response by the aircraft operator

In response to this accident, the aircraft operator advised that additional guidance to pilots has been incorporated into the company's Exposition in respect of the risk of inadvertent flight into instrument meteorological conditions as follows:

> A key to safely recovering to VFR [visual flight rules] conditions, should you inadvertently find yourself in IFR [instrument flight rules] conditions, is prior planning as to how you would handle this for different conditions. No advice in any manual can cover all the scenarios. However consideration should be given to;
>
> • The use of terrain displays including EGPWS [enhanced ground proximity warning system] to retain situational awareness and assist in avoiding terrain.

• Monitoring the radar altimeter. Whilst a last resort it will give indications of closure with terrain.

• Ensuring the aircraft is flown at Vx.

• Consideration of the validity of putting the aircraft into a tight climbing turn.

AIC PNG assessment of response/action

The AIC PNG does not consider that, in isolation, the operator's additional guidance fully addresses the safety issue. However, when considered in conjunction with the requirement under Rule 91.112 for two instrument-rated pilots for flight under the instrument flight rules in the absence of an autopilot, the planned EGPWS upgrades in the operator's aircraft and the other operator safety action, the AIC PNG is satisfied that the overall response by the operator adequately addresses the safety issue.

4.3.2 Operations to and from Kokoda Airstrip

Although the investigation did not identify any systemic factor with the potential to adversely affect the safety of future operations into Kokoda, the aircraft operator has undertaken proactive safety action to amend their operations to and from Kokoda Airstrip as follows:

> Flight Standing Order (FSO) NO: 02/09
>
> DHC-6 General
>
> Date: 30th September 2009
>
> Please ensure you sign the FSO folder as having read understood and agreed to abide by this FSO.
>
> SUBJECT: Operations to/from Kokoda
>
> Background
>
> Pending a risk review, operations to Kokoda were suspended following the accident involving DHC-6 P2-MCB. The Company has requested the resumption of regular flights to/from Kokoda airfield. This FSO details the requirements [the aircraft operator] has adopted to mitigate risk operating into this airfield.
>
> Policy
>
> General
>
> Kokoda is re-c1assified as Category D. A copy of the experience requirements is attached below. Captains must ensure they meet these requirements prior to operating to Kokoda.
>
> Flight to/from Port Moresby must be operated under full procedural IFR conditions, unless clear of cloud and with forward visibility of not less than 15km.
>
> Approach Phase Due to the visual nature of the approach phase, the following conditions are placed on the Captain;

Descent from LSA of 13,700ft is only approved either via a procedural instrument arrival to Girua, and/or visually with visibility of not less than 15km.

Any visual descent must not be commenced until established within the Kokoda/Girua valley and must be made along the Kokoda/Girua valley.

Descent via the Kokoda Gap is not approved.

Failure to meet all of these requirement[s] must result in the aircraft returning to either Port Moresby or Girua (subject to fuel/ Notams/ weather) (unless a greater emergency exists)

Landing Phase, including pedestrian and crowd control and airfield specific.

The agent and/or local police must ensure pedestrian traffic remains outside the strip area, and preferably on the track running up the side of the airfield.

Departure Phase

Due to the visual nature of the departure phase, the following conditions are placed on the Captain;

Takeoff is only approved where at least 15km visibility is assured for the entire segment until the aircraft either reaches cruise, or the flight is able to be conducted in accordance with the procedural Instrument Departure from Girua.

The visual departure may be made, in either direction, along the Kokoda/Girua valley. However the Captain must be able to undertake an initial visual climb at least 10km down the valley towards Girua.

The Captain must be assured of their ability to re-land at either Kokoda or Girua in the event of an engine failure prior to reaching cruise altitude.

Failure to meet all of these requirements must result in the aircraft remaining on the ground at Kokoda until all requirements are meet.

Category D Captain experience requirements. Requires either;

a minimum of five takeoffs, five landings at that airfield, as pilot occupying a control seat which must be included as part of normal route operations, and not specifically as circuit training; and a minimum of five takeoffs, five landings at that airfield, as a Captain which must be included as part of normal route operations, and not specifically as circuit training;

or

Have not less than 1,000 hours flight time in PNG, including not less than 250 hours as a DHC-6 Captain, and have operated there at least twice in the past in either control seat of any aircraft type ,or as an observer occupying a jump seat.

Authored by Approved by

[Deleted]

Manager Line Operations General Manager, Flight Operations.

Review of changes to DHC-6 Operation

<u>Background</u>

A review of the performance of the industry identifies a large number of CFIT accidents involving Part 135 and Part 125 aircraft (effectively those under 5,700kg) whilst none involving civilian passenger carrying two crew aircraft over 5,700kg (effectively Part 121 aircraft). This is despite the fact that;

- DHC-6-300 aircraft have similar equipment to their Part 121 peers.

- DHC-6-300 aircraft have similar performance capabilities to their Part 121 peers, to the extent of enabling procedural IFR operations (albeit are more restricted in engine out performance)

- Both are now flown two crew.

- Part 121 aircraft have also been flying to and from highlands aerodromes at least as geographically challenging, and with the same lack of procedural arrival and departure procedures as the smaller aircraft, for much the same period of time.

It is viewed that somewhere within the two operations, one (or more likely a number) of factors have kept one of the operations safe to-date, whilst seeing a number of CFIT's in the other. The crux of the review has been to attempt to identify what these difference are/might be, and mould them into the DHC-6 operation. The easiest way of doing this was to elect to make the DHC-6 operation exactly the same as the DHC-8 operation, unless it could be demonstrated that an operational constraint or safety consideration made this inappropriate.

Where an operational constraint made it not possible, [the aircraft operator] then needed to assess if this was a constraint that was inherent in all DHC-6 operations within PNG (such as engine out performance constraints in the highlands), or one that [the aircraft operator] could elect to alleviate by reducing/restricting operations to a location(s). An example of this was the decision to only operate to aerodromes where the geographical characteristics allowed an average pilot to make at least one error and recover from this, without that error inherently resulting in damage to the airframe (as a constraint of the demands of the aerodrome)

Additionally it was acknowledged that notwithstanding what additional skills training we provide to crew, the non-procedural demands of arrivals and departures within PNG are likely to result in these phases of flight continuing to be assessed as high risk (based on Flight Safety Foundations guidelines). Consequently, continued review of technological aids to mitigate this risk is also required. From approximately 2004, [the aircraft operator] has been assessing the options of installing EVS (Enhanced vision System) and had been in discussions with Kollsman. However the requirement for this equipment to be installed on heads-down displays (HUD's had been assessed and found to be extremely expensive and difficult to keep operational for this type of operation), but the new rollout of synthetic vision products warranted assessment.

<u>Equipment</u>

<u>Avionics' fitment</u>

The Garmin 1000 and associated TAWS-B fit was flight trialled using an SIL Kodiak aircraft. This included flying down the Kokoda Gap to assess whether the equipment would have given the crew the tools to avoid CFIT, in a high workload/stress environment. It was also flown in the Goilala's highlands area.

The conclusions were;

- The equipment gave the crew the tools to avoid CFIT in end to end valley environments in the event of loss of visual guidance.

- Where an aircraft was turning into high ground (i.e. flying at it) the equipment lacked depth perception to give guidance as to how far from the terrain the aircraft was. However the moving map display identified the expected point of impact, and the distance to run. Consequently two crew procedures could be developed to allow the PM to call distances to go to impact in these circumstances, which would allow the PF to manage the flight profile to avoid the impact. Additionally the visual shading of the terrain to reflect TAWS warnings also gave ready guidance to the risk of CFIT. In the worst case, where CFIT could not be avoided (due performance constraints), the equipment would give information to allow a low energy impact.

- With a good reporting culture and two crew operations, the risk of use of the equipment to develop a culture of pushing on into reduced visibility conditions could be mitigated.

- A software bug caused terrain in front of higher terrain (i.e. foothills) in the background to be poorly shaded resulting in it being difficult to see. Garmin has replicated this in the laboratory and identified a fix date.

- The TAWS-B aural function was found to be flawed to the extent that selecting override whilst in the circuit in good weather (due to close terrain proximity) did not automatically deselect in the event of a go-around, or unless the equipment was powered down. The override deselected both the aural and visual warnings. Consequently (as actually occurred during the testing) there was material risk that an aircraft could depart the circuit without the pilot remembering that TAWS-B was still overridden. Consequently, and in the absence of a fix by Garmin (specifically that it could not be overridden unless the aircraft was, and remained in, the landing configuration) , it was proposed to utilise the TAWS-B function within the Garmin 600 to provide visual alerting, and a separate TAWS-A (or TAWS-B) system to provide aural alerting.

It is also acknowledged that in an environment where the number of ground based Navaids has continued to reduce over time (at present there are no state operated Navaids functioning between Port Moresby and the Indonesian border) GPS-NPA's remain the only viable option to allow for procedural instrument arrivals and departures. As noted, generally the more procedural an operation can be made, the safer it becomes.

However there are a number of issues associated with this, especially around the engine out performance requirement of Part 135 and Part 125 aircraft and their ability to presently legally conduct these approaches. Associated with this is both a discussion as to the relative risks of approving IFR approaches for aircraft with acknowledged limited engine out performance characteristics, and specifically the options of treating them the same therefore as SEIFR, with the associated risk mitigators.

The avionics will also be upgraded to include dual TSO-146 Garmin 430 GPS's

<u>EGPWS</u>

The historical fitment of TAWS-A, or TAWS-B has been effectively derailed by the lack of aerodromes within the Honeywell or Jeppesen databases. By early 2010 only some 35 of the 400 aerodromes were in the database. Since then some 10 additional aerodromes have been added, giving a sufficient number, at sufficient varied geographical locations to allow [the aircraft operator] to assess the fitment of TAWS-A (EGPWS) or TAWS-B across the entire DHC-6 fleet.

In approximately 2005, [another operator] trialled EGPWS in a DHC-6, however this was (I understand) removed due to the lack of aerodrome information in the databases, and the consequent false aural warnings at almost all aerodromes they went to.

[The aircraft operator] has also been able to ascertain from PNG CASA what the survey integrity requirements are to allow it to have third party surveys conducted on the runway ends of all aerodromes [aircraft operator] normally uses, and then provide this data to PNG CASA for inclusion in the terrain databases.

[The aircraft operator] has sourced a Honeywell EGPWS unit, and raised an EO for the fitment of this to P2-MCD and flight trialling expected to be completed by 30th July.

Quick Access Recorders to allow rollout of FOQA

[The aircraft operator] is in final discussions with [a service provider] to allow analysis of QAR recorder information from the DHC-8 fleet, as part of a FOQA program.

Trends tracked will include;

- Stable approach and departure data (airspeed high or low, above/below 3 degree glide-slope, pitch angles on takeoff and landing)
- Descent rates on finals, and including evidence of descending through holes
- Flap settings and extension/retraction points.
- Runway aiming point
- Airspeed on departure and landing
- EGPWS alerts
- GPWS alerts

[The aircraft operator] is also in final discussions with Appareo Limited on the fitment of the GAU-3000 QAR once it is introduced to the market, across the DHC-6 fleet. This will allow the same FOQA assessment as for the DHC-8.

<u>Other Equipment Changes</u>

A review of the operation has also identified a number of potential hazards which have resulted in the following additional equipment changes.

1. Engineering Order raised to allow the DHC-6 First Officer to sight the centring markings for the nose wheel tiller.

2. Engineering Order raised for a central storage box on the control yoke, to allow rollout of checklists, speed tables, and central storage of QRH.

The [aircraft operator's] Board has approved an investment of up to K6 million to fit this new equipment to the DHC-6 fleet.

Procedures, Training and Personnel Training and Checking procedures

A review of the operation identified that the DHC-6 continues to operate in some of the most demanding environments in the world, and consequently not all pilots have the capabilities to be selected for, or subsequently checked to line. One of the indicators of a possible lack of capability is a pilot who requires line training far in excess of that stated in Volume 5a. Associated with this is evidence that these pilots will often continue to perform in the bottom quartile of crew.

Consequently [the aircraft operator's] Training and Checking procedures have been amended to put a cap on maximum line training hours for Captains of the stated minimum hours required plus 25%

Additionally, it is not possible to provide a culture and operation reflective of that of the DHC-8, unless the standards pilots on the fleet know what this looks like. Therefore all DHC-6 Check Captains who have not flown a Part 121 aircraft before, will operate as DHC-8 First Officers for at least four months, to ensure they are cognisant of airline standard and procedures. [Deleted] has already completed the DHC-8 ground school.

In assessing our Check program across both types, it is identified we have a range of pilots who are great mentors and teachers, but wish not to be Check Captains. PNG CASA has approved the new position of Flight Instructor (as distinct from that of a Line Training Captain) qualification to allow for pilots highly capable in training, but for whatever reason not apt to be Check Captains, to conduct training based sessions during type ratings LOFT sessions etc.

CRM and Threat and Error Management

Whilst the PNG Rules do not presently have a requirement for CRM training, [the aircraft operator] continues to conduct a 2 day initial CRM training, and thence 1 day recurrent CRM training every second year. In addition we have entered a contract with [a service provider] to complete online training for all pilots in TEM (Threat and Error Management). This company is owned by [Deleted], a leading expert in TEM, who was hosted by CASA in an around Australia, Error Management Road show in June 2009 (which [the aircraft operator] arranged for all pilots on reserve to attend). A précis of the subject matter for this course and background information is attached.

The CRM course has also been updated to ensure the following scenarios are covered, and crew are equipped with the skills to manage these;

1)Crew scenarios involving both male and female pilots and/or flight attendants

2)Crew scenarios involving both PNG National and expatriate crew and also crew from differing parts of PNG.

3)Crew scenarios where the FO may have similar, or even greater hours (or experience), than the Captain.

The updated operating procedures also include requirements for the DHC-6 (Vol 5a Chapter 7.14) include both requirements for briefings to include TEM principles, and examples of TEM based briefing for different scenarios.

Hypoxia Training

[The aircraft operator] has purchased GO2Altitiude equipment from [an equipment supplier] in Australia to allow onsite training on the effects of hypoxia. This is scheduled for installation on 28th July, and all pilots and FA's will be trained using this.

<u>GPS Training</u>

In addition to the GPS generic and GNS-430 training module that has been provided to date to all pilots via CD, the following additional Garmin 430 specific training is being provided;

1)Jeppesen Garmin 430/530 VFR and Core IFR Procedures-Computer Based Training Module

2)Jeppesen Garmin 430/530 Advanced IFR Procedures-Computer Based Training Module

3)Jeppesen Garmin 430/530 WAAS Procedures-Computer Based Training Module.

<u>Aircraft Operating Procedures</u>

The DHC-6 standard operating procedures have been amended to reflect DHC-8 present procedures, and are in use on line. A copy of these is attached.

It is also the view of [the aircraft operator] that you will not change the underlying culture of an operation without making deep and systemic changes across it. Consequently, the present SAFEGO tab-type checklist provided on the control column has been removed and replaced with laminated card checklists. Additionally the DHC-6 reference speed placard that were above the Captain, and outside the view of the First Officer have been removed, and replaced with "turn-over" speed tables, per the DHC-8.

<u>Other- Documentation Changes</u>

A view of all the DHC-6 documentation identified that it was silent in a number of areas both regards policy, and also training required. The following reflect additional documented procedures or polices that have been added.

1. Inclusion of requirement for Flap 15 takeoffs as part of initial and recurrent training.

2. Inclusion of requirement for Flap 30 landings and go-arounds as part of initial and recurrent training. Specific policy on Flap usage for takeoff and landing, and specific windshear procedures have been included, including bans of Flap 20 takeoffs and Flap 37.5 landings.

3. Inclusion of present stabilised approach policy to also include DHC-6 operations, and new stabilised window at 5NM from threshold.

4. Amended aiming point information to also include "bush" airfields.

Other- Personnel, and Policy Changes

1. Amended minimum aerodrome standards, and associated withdrawal from any aerodromes that do not meet this standard (as attached). As stated it is not possible to have a culture of a regional airline operation if you elect to continue to operate in an environment that goes entirely counter to this culture. It remains a reality that much of the environment within PNG remains unconducive to this as an outcome, but in both areas [the aircraft operator] can mitigate against the impacts of this. Additionally, where these influences are not pervasive across the entire industry [the aircraft operator] can also choose not to operate to an area. The selection of updated minimum aerodrome standards is an example of this.

2. Whilst PNG CAA advice has been that Part 91.401 implied that the First Officer of an aircraft did not require to hold an Multi-engine Instrument Rating (MEIR) (one assumes this view was a hang-over from the prior rule set, which specifically required the FO to hold a type rating, but not an instrument rating), [the aircraft operator] has;

- Sent the two other [aircraft operator] DHC-6 First Officers who did not hold MEIR's to Coff's Harbour, and they have been issued with Australian MEIR's.

- Updated employment minimums to require all new pilots to hold a MEIR.

3. Appointment of [Deleted] (who is full time) to replace [Deleted] (who was tour based) as Manager DHC-6 fleet.

4. Appointment of [Deleted] (who is full time) as new Manager Flight Standards to replace [Deleted] (who was on tours). [Deleted]

5. Introduction of full loadsheets (rather than presently approved use of the FRDR) for DHC-6 operations to further formalise the culture of a regional airline.

APPENDIX A: AIRCRAFT OPERATOR'S FLIGHT OPERATIONS EXPOSITION

At the time of the accident the operator's flight operations exposition, Flight Operations Exposition119 / Vol. 1 Ver. 3.0 May 2009, dedicated several chapters to safe flying during operations similar to that in which the accident occurred. The operator stated that compact Discs (CD's) were distributed to pilots on the 15th of every second month containing the following manuals:

Crew were required to contact the document control manager should they not receive a new CD every second month.

The investigation was unable to determine if the crew had received, read and understood the operator's most recent flight exposition.

The operator did not have a system in place that ensured that the staff had actually read and understood current flight operations expositions and any amendments therein.

Exposition119 / Vol. 1 Ver. 3.0 May 2009

Chapter 5.1 Safety

Safety is the most important aspect of any line activity. [The aircraft operator] has a firm policy of placing safety before any other consideration and this policy includes safety both on the ground and in the air.

It is the responsibility of every employee and contractor of [the aircraft operator] to take full account of the health and safety of themselves, their co-workers, our passengers and the public.

Safety is more important than customer services and maintenance of the schedule.

Safety is the paramount part of good operating practice and is a management priority.

Safety requires the adherence to the requirements of the company exposition, operations manual, adherence to standard Operating procedures and the exercise of sound and mature judgement. Deviation from these principles will not be tolerated'.

Guidelines for Flight Operations within PNG, Chapter 5.2

The ability to operate safely within PNG is based on a set of skills developed over a number of years. These skills include professionalism within the airline industry, but also require local knowledge, knowledge of mountain flying, and an understanding of the "culture' and how [the aircraft operator] wishes its aircraft to be flown.

The experience of PNG aviation is that almost all fatal accidents have been a result of CFIT, often as a consequence of pilots striking terrain while operating at low levels, and generally associated with reduced weather conditions.

Based on the relatively high performance of the DHC-6 and DHC-8, [the aircraft operator] aims to develop an operating culture in which flight crew's preference will be to operate at higher altitudes with the intent of descending close to the destination. Specifically [the aircraft operator] is extremely adverse to its flight crew operating at low level (less than 1,000ft AGL) in conditions of reduced visibility (less than 10 km visibility) other than for the express purpose of landing or taking off.

General guidelines which reflect "[the aircraft operator's] best practices" for operations within PNG are denoted below. There are a myriad of scenarios that a crew will experience on line, which no policy could ever completely cover. Indeed there can never be enough written rules to cover every situation that might arise. Commonsense, good judgement and experience must take over where the rules end. However whilst these are issued as guidelines, the Company expectation is that unless greater imperatives exist, they should in general be followed.

Naturally the guidelines shall never impinge on the authority of the captain to operate the aircraft in what they consider the safest method possible, especially in circumstances following an abnormal occurrence, or where there is difficulty is climbing visually to LSA at the originating aerodrome. Likewise these guidelines should never be construed as operationally limiting the crew in operating the aircraft as required to ensure the safe outcome of the flight.

Never mix IFR with VFR outside the legal parameters of IFR operations. Almost all CFIT accidents are a mix of this and pushing the weather beyond the pilot's or the aircrafts limits.

For operations on longer sectors (in excess of approximately 70NM) crew should where practical operate the aircraft at appropriate IFR altitudes, unless the weather is CAVOK. Descent below the relevant IFR altitude / step should not normally be conducted in forward visibility of less than 10km, until within approximately 7NM of the destination aerodrome, and where applicable, within the valley or basin where the airfield is located.

For operations at low levels a distinct horizon should always be obvious. During "normal "operations, other than for the express purpose of landing or taking off, the crew should not operate the aircraft below 500ft AGL, or, 1,000ft AGL when visibility is less than 10 km.

Always plan ahead. This includes always be looking for, and planning, alternatives and escape routes. When on descent, always plan the best climb out path while you still have the altitude to see things clearly. Equally, by the time a map or approach chart is needed it is too late to start searching in a flight bag for it.

Never leave yourself without an escape route if you do, statistics show it only a matter of time before you have an accident.

Where performance is not guaranteed, always be aware of the area around you (especially on takeoff) should a forced landing be required in the event of an engine failure. Equally plan flights at altitudes that allow you to drift down out of high terrain.

When crossing ridges, two of three items are needed. These are excess altitude, excess airspeed and an approach to the ridge at 45 degrees angle (Also known as the three A's). If uncertain as to whether you have enough altitude, circle until confident that has been obtained. Generally if you are seeing more of the terrain behind the ridge appearing, you are out climbing it. If the terrain is disappearing you do not have the altitude to safely cross the ridge. Additionally never commit yourself to crossing the ridge unless you can see into the next valley and are sure you can operate safely in the valley.

Crew should be aware of the visual illusion during turns that the aircraft may appear higher than in relation to the ridge than you actually are. Likewise be aware of false horizons resultant of sloping terrain and / or cloud base.

Altitude is golden, once sacrificed it can only be regained at the cost of fuel and time.

Never commit yourself to descend through a hole in a cloud that you cannot ascend through again, unless you are assured you can land or manoeuvre below the base. This generally means having either the airfield in sight, with sufficient manoeuvring room to land, or that you are assured the cloud base and visibility will allow you to proceed to your destination. Be very wary about descending at a faster rate in this scenario than possible subsequent climb rate when forced to recover the situation. Be especially mindful of the risk of descending through a hole to find that the terrain surrounding the hole rises into the cloud base.

Unless three of the following four factors are available the trip must not be started. The factors are fuel, available airstrips, weather, and daylight (or legal night lighting). As long as three of them are in your favour, the forth can generally be explored with some latitude. Remember, once airborne it is much harder psychologically to turn back, than to avoid the flight in the first place.

From training or experience, have a predefined committal point for landing on one way strips. Beyond this point you will almost always be better of damaging the aircraft in a heavy landing, than destroying it in a misjudged and ill-fated attempt to go-around.

Be aware of, and practice in a safe environment the effect of altitude, weight and temperature on an aircraft's performance, including best angle of climb, and turning radius with varying groundspeeds. Understand the effect of wind and flap on the turn radius. It is considerably safer to know how an aircraft will perform in varying scenarios prior to needing this knowledge in an real operational situation.

Be aware of the trap of climbing towards sloping strips in low cloud base conditions. Aircraft have crashed previously, having discovered the aircraft is unable to out climb the terrain on final approach.

Learn to pick winds and their effects from signs other than wind direction indicators. Educate yourself to the up / down drafts and turbulence that can be expected to produce alternate up and down drafts. A pilot also needs to be aware of the effect of valley shadows, cloud shadows, windscreen blackout, early twilight and the sun on airfield lighting.

Never enter a valley in reduced visibility unless you are guaranteed it is the valley you want. Prior to entering the valley, establish the aircraft in the bad weather configuration, ensure access to your maps, and brief the First Officer on your escape plan.

Study the natures of cloud development. Grey cloud indicates rain and reduced visibility, whilst sunshine through cloud can indicate an available hole. Cloud extent can often be estimated from cloud shadows on the ground. Less active areas of build –up can often be recognised by the spread of cirrostratus sometimes allowing VFR transition of the area without significant off track diversions.

When operating in valleys, aim to operate on the side of the valley that best allows you to turn back, taking into account your seat position (and hence vision during the turn), the effect of winds and naturally the weather conditions in the valley. Additionally always presume you may have an engine failure and plan your operations on this premise. To operate on the basis that safe flight requires the continued operation of both engines is likely to eventually let you down.

Landmarks and topographical details at 5000ft on a CAVOK day bear no resemblance to the same points at 500ft in a 4,000m visibility. Operate at bad weather altitudes, and learn the important landmarks, before you need to recognise them in anger.

An aborted flight is a sign of prudence, not of cowardice.

Exposition119 / Vol. 1 Ver. 3.0 May 2009

Minimum Experience on Type Chapter 5.8

Crew members of company aircraft types shall normally have the following minimum experience / qualifications:

DHC-6

First Officer – DHC6

CPL

200 hours total time.

Captain

CPL

Multi-engine instrument rating.

1,200 hours total time.

500 hours multi-engine time.

Captains Upgraded from Company first officers

CPL

Multi-engine instrument rating.

1,200 hours total time.

500 hours multi-engine time.

Exposition119 / Vol. 1 Ver. 3.0 May 2009

Chapter 5.18, Alcohol and drug usage

While the CARs do not detail the legal prohibition on the use of alcohol and drugs, including prescribed pharmaceutical medicines, by crew members, the following describes the company policy on these issues.

It is contrary to company policy for crew members to perform any duties associated with operation of an aircraft if they are affected by the consumption of alcohol, drugs, pharmaceutical or medicinal preparations.

Because all medication has side effects to varying degrees it is important that the use of any medications, not prescribed by a doctor experienced in aviation medical matters, should be cleared by a DAME or aviation medical practitioner before undertaking flying duties. It is important to remember that some medications can have a serious reaction with only a small consumption of alcohol.

Some medications which cause concern are:

Blood pressure medication (must be approved by CAA)

Antibiotics

Tranquillisers

Anti-depressants

Pain relievers (analgesics)

Sleeping pills

Sedatives

Antihistamines

Steroids

Stimulants

Natural remedies

[The aircraft operator] requires that a crew member shall not act as an operating crew member, or perform any duties or functions preparatory to acting as an operating crew member, if the crew member has, during the period of 8 hours immediately preceding “sign on” for the departure of an aircraft consumed any alcoholic liquor. In addition [the aircraft operator] requires that crew shall not act as an operating crew member, or perform any duties or functions preparatory to acting as an operating crew member, if the crew member has a blood / alcohol level of in excess of 0.02 BAC, (or 20 milligrams of alcohol per 100 millilitres of blood).

[The aircraft operator] reserves the right to test Flight Crew, using calibrated breath testing equipment, and if found to have a breath alcohol amount in excess of 0.02 BAC to terminate the services of the relevant crew members.

Likewise should a person refuse to undertake a alcohol breath test, the company reserves the right to terminate the services of the relevant crew member.

Similarly, any crew member allowing another to perform his / her duties whilst under the influence of any intoxicant shall be subject to severe disciplinary actions.

In addition to the foregoing requirements, company policy prohibits the consumption of alcohol while wearing the company uniform as follows:

In any public place.

In any passenger section of a company aircraft or that of another airline.

In any vehicle being utilised for the transport of crew members to or from a port associated with any operation of an aircraft.

Crew members shall not perform flying duties within 48 hours of having a general anaesthetic or 24 hours of having local anaesthetic (including dental).

APPENDIX B: RELEVANT CIVIL AVIATION SAFETY AUTHORITY RULES

In Papua New Guinea (PNG), the Civil Aviation Safety Authority (CASA) of PNG, Civil Aviation Rules (CAR) were developed as a result of the PNG ACT. Relevant sections of the rules that relate to this report are included in this appendix:

Part 1: VFR Flight

Definitions and Abbreviations

VFR flight means a flight conducted in accordance with the visual flight rules:

Part 91 – General Operating and Flight Rules

Subpart B – Operating Rules

91.112 Requirement for licence and ratings

(h) Instrument rating: Each pilot of a Papua New Guinea registered aircraft, or of a foreign registered aircraft within Papua New Guinea, operating under IFR, must hold—

(1) an appropriate current instrument rating issued under Part 61; or

(2) an appropriate current instrument rating attached to a foreign licence recognised by the Director.

Part 91 – General Operating and Flight Rules

Subpart D – Visual Flight Rules

91.301 VFR Meteorological minima

Each pilot-in-command of—

(1) an aircraft may operate in Class F airspace over areas with terrain rising to more than 5000 feet AMSL clear of cloud and in sight of the surface and with a flight visibility of not less than 5 km

Part 91 – General Operating and Flight Rules 91.401 Minimum flight crew

A pilot-in-command shall not operate an aircraft under IFR without another pilot, unless-

(1) the aircraft flight manual authorises operation of the aircraft with one pilot; and

(2) the aircraft is equipped with-

(i) communication equipment that can be operated by the pilot without releasing the aircraft flight controls; and

(ii) an operative autopilot or stabilisation system capable of operating the aircraft controls to maintain flight and manoeuvre the aircraft about the roll and pitch axes with an automatic heading hold

91.405 IFR alternate aerodrome requirement

(a) A pilot-in-command of an aircraft operating under IFR shall list in the flight plan at least one alternate aerodrome unless—

(1) at least 30 minutes before and 30 minutes after the estimated time of arrival at the aerodrome of intended landing the meteorological forecast, or meteorological reports, or a combination of the two indicate that—

(i) the ceiling and visibility are at or above the alternate minima prescribed under Part 95; and

(ii) there is no probability of reduced visibility due to fog, mist or dust; and

(2) if the aerodrome of intended landing only has an instrument approach procedure based on GPS, at least 30 minutes before and 30 minutes after the estimated time of arrival at the aerodrome of intended landing the meteorological forecast, or meteorological reports, or a combination of the two indicate that—

(i) the ceiling is at least 500 feet above the lowest safe altitude prescribed under Part 95 for the final route segment; and

(ii) the visibility is at least 8 km; and

(3) if the aerodrome of intended landing does not have an instrument approach procedure prescribed under Part 95, at least 30 minutes before and 30 minutes after the estimated time of arrival at the aerodrome of intended landing the meteorological forecast, or meteorological reports, or a combination of the two indicate that—

(i) the ceiling at the aerodrome is at least 500 feet above the lowest safe altitude prescribed under Part 95 for the final route segment or the lowest MSA; and

(ii) the visibility is at least 8 km; and

(4) if the meteorological conditions are forecast to deteriorate intermittently (INTER) or temporarily (TEMP), in addition to the requirements of 91.403, sufficient fuel based on holding speed is carried for an additional—

(i) 30 minutes for intermittent deteriorations; and

(ii) 60 minutes for temporary deteriorations.

(b) A pilot-in-command of an aircraft required to make provision for an alternate aerodrome under paragraph (a) shall not list any aerodrome as an alternate unless the meteorological forecasts at the time of submitting the flight plan indicate, at the time of planned arrival at the alternate aerodrome, that—

(1) if the alternate aerodrome has an instrument approach procedure prescribed under Part 95 based on a navigation aid other than GPS, the ceiling and visibility are at or above the alternate minima prescribed under Part 95; and

(2) if the alternate aerodrome does not have an instrument approach procedure or only has an instrument approach procedure based on GPS prescribed under Part 95—

(i) the ceiling is at least 500 feet above the lowest safe altitude prescribed under Part 95 for the final route segment; and

(ii) the visibility is at least 8km.

(c) A pilot-in-command of an aircraft required to make provision for an alternate aerodrome under paragraph (a) shall not list any aerodrome as an alternate unless that alternate aerodrome is equipped with a secondary electric power supply for—

(1) the electronic navigation aids required to be used for an instrument approach procedure; and

(2) for night operations, the aerodrome night lighting.

91.423 Approach to land under IFR

(h) Visual approach procedures. Each pilot-in-command may, subject to ATC authorisation in controlled airspace, conduct a visual approach under IFR, from the applicable minimum altitudes prescribed under Part 95, provided that—

(1) if the visual approach is to be commenced en route, the aircraft is within 30 nm from the aerodrome of intended landing; and

(2) the visibility is at least 5 km; and

(3) the approach can be conducted with continuous visual reference to the surface; and

(4) at night, the aircraft is-

(i) within the circling area; or

(ii) aligned with the runway centreline at a distance of 7 nm if conducting an ILS

approach otherwise at a distance of 5 nm; and

(5) at night, the runway approach or runway lighting is in sight throughout the approach;

and

(6) until the aircraft is continuously in a position from which a descent to a landing on the intended runway can be made at a normal rate of descent using normal manoeuvres that will allow touchdown to occur within the touchdown zone of the runway of intended landing, the visual approach is not conducted below the minimum heights—

(i) prescribed for VFR flight under 91.311(a)(2) and (3); and

(ii) where applicable, for noise abatement procedures prescribed by the Director—

91.517 IFR instruments and equipment

Powered aircraft issued with an airworthiness certificate and operating under IFR, shall be equipped in accordance with 91.509 and 91.511 and have the means of indicating—

(1) aircraft attitude, by gyroscopic or inertial means; and

(2) magnetic heading, by gyroscopic or inertial means; and

(3) that the power supply to any gyroscopic instruments is adequate; and

(4) sensitive pressure altitude, in feet, adjustable for barometric pressure in hectoPascals or millibars; and

(5) outside air temperature; and

(6) time in hours, minutes, and seconds; and

(7) airspeed in knots, with a means of preventing malfunctioning due to either condensation or icing; and

(8) rate of climb and descent.

and IFR communication and navigation equipment under PNG CAA rule 91.519

(a) Each aircraft operating under IFR shall be equipped with communication equipment that meets level 1 standards specified in Appendix A, A.9 and is capable of providing continuous two-way communications with an appropriate ATS unit or aeronautical telecommunications facility.

(b) Each aircraft operating under IFR shall be equipped with a navigation system which—

(1) meets level 1 standards specified in Appendix A, A.9; and

(2) will enable the aircraft to proceed in accordance with—

(i) the flight plan; and

(ii) the designated RNP airspace where applicable; and

(iii) in accordance with the requirements of ATC.....

Part 125 Air Operations — Medium Aeroplanes

125.1 Purpose

Subpart A — General

(a) Subject to paragraph (b), this Part prescribes rules governing air operations using an aeroplane—

(1) having a seating configuration of 10 to 19 seats, excluding any required flight crew member seat, or

(2) having a payload capacity of 2200 kg or less and a MCTOW of greater than 5700 kg; or

(3) powered by a single engine for the carriage of passengers under IFR.

(b) If either the seat numbers or payload capacity of the aeroplane falls into the applicability for Part 121, then the operation shall be conducted under Part 121.

APPENDIX C: SOURCES AND SUBMISSIONS

Sources of information

The sources of information during the investigation included the:

- pilots of a number of other aircraft
- Civil Aviation Authority Papua New Guinea (CAA PNG), subsequently re-designated the Civil Aviation Safety Authority of Papua New Guinea (CASA PNG)
- Department of Transport Papua New Guinea (DoT PNG)
- PNG Accident Investigation Commission (AIC)
- PNG air traffic services (ATS) provider
- operator of P2-MCB
- International Civil Aviation Organization (ICAO)
- Royal Melbourne Institute of Technology (RMIT)
- Australian Maritime Safety Authority
- Transportation Safety Board of Canada(TSB)
- SkyNet
- Latitude Technologies
- engine manufacturer.

Submissions

The Accident Investigation Commission (AIC) may provide a draft report, on a confidential basis, to any person whom the AIC considers appropriate under the *Civil Aviation ACT 2000.*

A draft of this report was provided to the TSB, the aircraft operator, the engine manufacturer, a Twin Otter pilot, the Australian High Commission in PNG, CASA PNG, the air traffic service provider, the Australian Federal Police, the Victorian Institute of Forensic Medicine, the trekking company and DoT PNG.

Submissions were received from the Australian High Commission in PNG, CASA PNG, the aircraft operator and the TSB. Those submissions were reviewed and, where considered appropriate, the text of the report was amended accordingly.