BASI
Bureau of Air Safety Investigation

Air Safety Report

INVESTIGATION REPORT
9703719

De Havilland Canada DHC-6 Series 320, VH-HPY
9 km SW of Simbai, Bismarck Ranges, Papua New Guinea

9 November 1997

COMMONWEALTH DEPARTMENT OF
TRANSPORT AND
REGIONAL SERVICES

Department of Transport and Regional Services

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SYNOPSIS

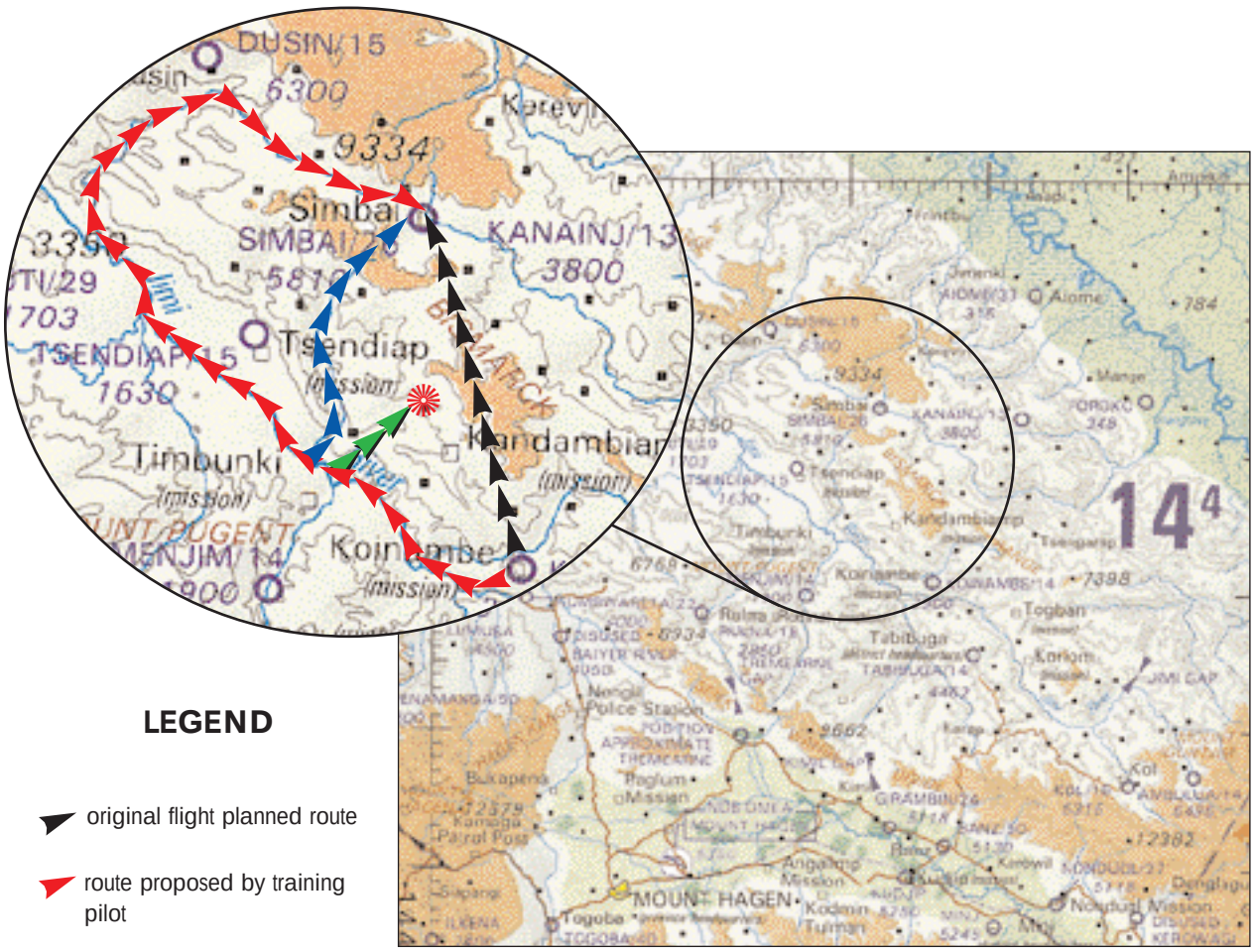
The crew were operating a de Havilland Canada DHC-6 Twin Otter aircraft in Exercise Highland Pursuit 2/97. The purpose of the exercise, which was conducted by No. 173 Surveillance Squadron, 1st Aviation Regiment, Australian Army, was to provide tropical mountainous flying training in Papua New Guinea. There were three trainees and one training pilot on board the aircraft.

On Sunday, 9 November 1997, the third day of flying operations in Papua New Guinea, the crew were conducting a flight from Madang and return via a number of airstrips in the central highlands. When haze and cloud prevented them flying the flight-planned direct track between the Koinambe and Simbai airstrips, they decided to fly north-west via the Jimi River valley and one of its tributaries.

Two of the trainees were occupying the cockpit seats, one as flying pilot and the other as navigating pilot using a 1:1,000,000-scale chart. When the crew turned the aircraft to follow a tributary off the Jimi River, the training pilot was in the aircraft cabin. A few minutes later, their discussion regarding the progress of the flight attracted the attention of the training pilot. By this time, however, the position of the aircraft in the valley, and its available performance, were such that an escape from the valley was not possible. The aircraft collided with trees before impacting steeply sloping ground.

It was subsequently established that when the crew turned from the Jimi River, they entered the wrong valley. Calculations based on the manufacturer's performance data showed that the aircraft did not have sufficient performance to outclimb the increase in terrain elevation from the Jimi River valley to cross the Bismarck Ranges via this valley.

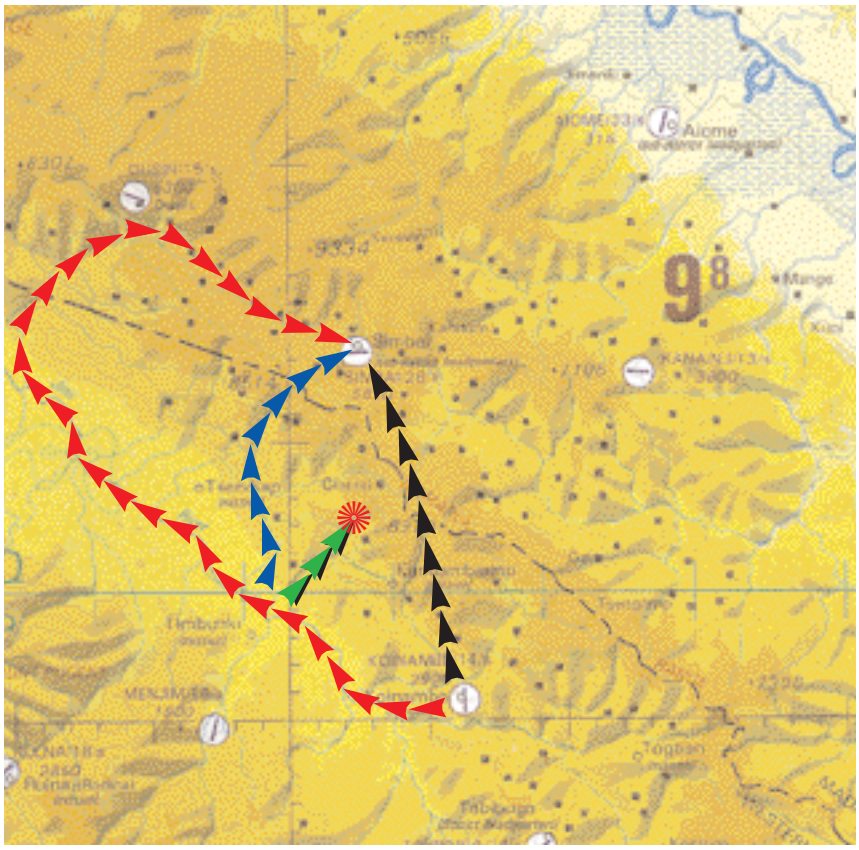
There was a low level of experience and corporate knowledge within the Army regarding the operations of fixed-wing aircraft such as the Twin Otter in tropical mountainous areas. Against this background, deficiencies were identified in the planning and preparation for the exercise, including risk assessment and the selection and briefing of the training pilot.



LEGEND

- original flight planned route
- route proposed by training pilot
- route proposed by navigating pilot and which the crew intended to fly
- actual route flown
- accident location

1:1,000,000 Operational navigation chart (ONC)



1:500,000 Tactical pilotage chart (TPC)

1. FACTUAL INFORMATION

1.1 History of the flight

The flight was one of a series being conducted by No. 173 Surveillance Squadron, 1st Aviation Regiment operating a de Havilland Canada DHC-6 (Twin Otter) aircraft as Exercise Highland Pursuit 2/97. The purpose of the exercise was to provide training for three No. 173 Squadron pilots in tropical mountainous operations in Papua New Guinea (PNG). All trainees were qualified on the aircraft type. The training pilot was the pilot in command. He had extensive experience in flying Twin Otter and other aircraft types in PNG as a civilian pilot and had also flown de Havilland Canada DHC-4 (Caribou) aircraft in PNG as a military pilot. Passengers were not carried on the flight.

The plan for 9 November 1997 was to fly from Madang and return via a number of airstrips where landing and take-off exercises would be conducted. A flight plan was submitted to Madang Flight Service. At 0915 PNG time, the aircraft arrived at Koinambe where each trainee conducted landing and take-off practice. During this time, the training pilot occupied the right cockpit seat while the trainees, in turn, flew the aircraft from the left cockpit seat.

The crew had flight-planned to track direct from Koinambe to Simbai. However, before departing Koinambe, they assessed that this would not be possible because of haze and cloud on track. The training pilot, who was still occupying the right control position, suggested that they could follow the Jimi River north-west from Koinambe and then one of its tributaries towards Simbai. This involved a right turn off the Jimi River about 37 km from Koinambe to follow the valley that passed about 2 km south of Dusin airstrip and then tracked south-east towards Simbai.

The navigating pilot, in the left cockpit seat, suggested that, instead of following the tributary off the Jimi River as suggested by the training pilot, they should follow the valley which extended north-east off the Jimi River from a position about 17 km north-west of Koinambe. This was a shorter route than that suggested by the training pilot. The training pilot agreed that the route could be attempted. Neither during this discussion, nor at any earlier time, was there any reference to the elevation of the Bismarck Range. (The increase in ground elevation from the Jimi River to the Bismarck Range, a straight-line distance of about 17 km, is approximately 7,400 ft.)

The crew was using an Operational Navigation Chart (ONC) 1:1,000,000-scale chart for in-flight navigation.

After departing Koinambe, the crew began following the Jimi River, flying at about 1,000 ft above ground level (AGL). The training pilot had intended to remain in the right cockpit seat for the short flight to Simbai. However, to gain the maximum benefit from flying time during the exercise, he had adopted the practice of having trainees occupy both cockpit seats during the en-route sectors of the exercise. He would then monitor the progress of the flight from either between the cockpit seats or the aircraft cabin. In this instance, he vacated the right seat for a trainee who then became the flying pilot for the sector.

The navigating pilot then made the required radio calls, one on VHF radio and the other (which was unsuccessful at the first attempt) on HF radio to Madang Flight Service to report the departure of the aircraft from Koinambe. A short time later, the navigating pilot became unsure of the aircraft's position. The flying pilot then conducted several left orbits while the navigating pilot obtained a Global Positioning System (GPS) fix and plotted the position on the ONC chart. He indicated on the chart, and received agreement from the training pilot, that

he had identified the aircraft's position. The flying pilot then resumed tracking along the river. During this time the training pilot was in the cabin of the aircraft. He was wearing a headset which was equipped with an extension lead to enable him to communicate with the cockpit crew. He was frequently checking the aircraft's position through the cabin side windows.

A short time later, the navigating pilot indicated what he believed to be the valley where the aircraft was to turn towards Simbai. The flying pilot turned the aircraft into this valley. He estimated that the aircraft was flying about 500 ft above the treetops at this time. The crew did not conduct a heading check to confirm that they were in the correct valley. When the aircraft was well into the valley, the training pilot heard over the intercom the flying and navigating pilots discussing the progress of the flight. He sensed some unease in their voices and moved forward from the aircraft cabin to a position between the cockpit seats. He immediately realised that the aircraft was at an excessive nose-high pitch angle and in a position from where it could not outclimb the terrain ahead or turn and fly out of the valley. The flying and navigating pilots ensured that the engine and propeller controls were set to full power and maximum RPM and selected 10 degrees flap. However, the training pilot assessed that impact with the trees was imminent. He ensured that the trainee seated in the cabin was strapped into his seat and then positioned himself on the floor aft of, and against, the cabin bulkhead. The stall warning activated at that time and, almost immediately, the aircraft crashed through the trees to the ground.

When the crew had not reported to flight service by 1004, communication checks were initiated. An uncertainty phase was declared at 1023 when there was no contact with the crew. At 1045, this was upgraded to a distress phase after the pilot of a helicopter operating in the area reported that the aircraft was not on the ground at Simbai airstrip. The pilot of the helicopter was tasked with tracking from Simbai to Koinambe in an attempt to locate the aircraft. At 1127, the helicopter pilot reported receiving a strong emergency locator transmitter signal and, shortly after, located the accident site in a valley about 9 km south of Simbai.

1.2 Injuries to persons

	Crew	Passengers	Other	Total
Serious	4	-	-	4

1.3 Damage to aircraft

The aircraft wings, cockpit, and nose sections were substantially damaged during the impact sequence. The cabin was distorted but retained its structural integrity.

1.4 Other damage

No damage to property was reported.

1.5 Personnel

	Navigating pilot	Flying pilot
Age	27 years	29 years
Licence category	ATPL	ATPL
Medical certificate	Class 1	Class 1
Instrument rating	Command (multi-engine)	Command (multi-engine)
Total hours	2,206	2,460
Total on type	576	900
Total last 90 days	164	160
Total last 24 hours	3	5
Last flight check	27 August 1997	28 August 1997

	Training pilot	Other pilot
Age	50 years	27 years
Licence category	ATPL	Commercial
Medical certificate	Class 1	Class 1
Instrument rating	Command (multi-engine)	Command (multi-engine)
Total hours	10,802	2,990
Total on type	706	180
Total last 90 days	195	195
Total last 24 hours	5	4
Last flight check	7 October 1997	23 August 1997

1.5.1 Previous 72-hour histories

The 72-hour histories for all crewmembers were reported to have been similar. The crew commenced duty at about 0700 each day, and began flying at about 0800. Flying activities were usually completed by about 1600, followed by a debrief of the day's flying, and a briefing for the following day. The crew reported that they dined together each night, consuming between four and six 375-mL bottles of beer each, before retiring by about 2200.

1.5.2 Relevant operational experience

Training pilot

See 1.17.2

Flying pilot

The flying pilot had no previous flying experience in PNG.

Navigating pilot

The navigating pilot had no previous flying experience in PNG.

Other pilot

The other pilot had flown Army Kiowa helicopters in PNG during a training deployment. He travelled to PNG to observe the operations of No. 35 Squadron RAAF and a local civilian operator as part of the preparation for Exercise Highland Pursuit (see 1.16.5).

1.5.3 Crew resource management training

Crew resource management (CRM) has been defined as the effective use of all available resources to achieve safe and efficient flight. Good CRM involves many components, including enhanced leadership skills, sharing of situational awareness, improved communications and a clear definition of each crew member's role.

The flying pilot had completed a 3-day CRM course with the RAAF in 1995. Neither of the other trainees, nor the training pilot, had received any CRM training.

1.5.4 Other information

The flying pilot and the navigating pilot had flown together on numerous occasions. However, the flying pilot had flown the aircraft almost exclusively from the left cockpit seat with the non-flying or navigating pilot occupying the right cockpit seat. Until the accident flight, the flying pilot had not flown the aircraft from the right cockpit seat since late 1996.

1.6 Aircraft information

1.6.1 Significant particulars

Registration	VH-HPY
Manufacturer	de Havilland Canada
Model	DHC-6-320
Common name	Twin Otter
Serial number	706
Country of manufacture	Canada
Year of manufacture	1980
Engines	Pratt & Whitney Turbo Prop, PT6A-27
Certificate of Airworthiness	No. AF/10669, Category Normal
Certificate of Registration	
Number	AF/10669/02
Issued	14 February 1997
Holder	Australian Army, 1st Aviation Regiment, Army Airfield, Oakey Qld 4401
Maintenance release	
Number	268855
Issued	18 September 1997

By	Hawker Pacific Pty Ltd
At	18,096.7 airframe hours
Valid to	18 September 1998 or 18,296.7 hours
Total airframe hours	18,208

The aircraft was being maintained in accordance with the manufacturer's procedures. No evidence was found of any fault in the aircraft which might have contributed to the accident.

1.6.2 Weight and balance

The weight and balance of the aircraft were within the limits specified in the aircraft flight manual.

1.7 Meteorological information

The crew obtained the area forecast appropriate to the planned flying routes for the day. Visibility was forecast to be 25 km reducing to 3,000 m in smoke and haze, and 7 km in rain showers. The forecast cloud was scattered cumulus, strato-cumulus and isolated cumulo-nimbus from a base of 1,800–3,000 ft.

The helicopter pilot who located the wreckage 1.5 hours after the accident estimated that visibility in the area was about 5 km.

1.8 Aids to navigation

The aircraft was fitted with a Global Positioning System (GPS) receiver which provided aircraft positional information to the crew in the form of latitude and longitude. It was this information which the navigating pilot used to plot the aircraft's position in the Jimi River valley.

1.9 Communications

Satisfactory two-way communications via HF and VHF radio between the crew and local flight service units existed during the flight.

1.10 Flight recorders

The aircraft was not equipped with a flight data or cockpit voice recorder, nor were these required by regulation.

1.11 Wreckage and impact information

The aircraft entered the forest canopy at an angle of bank of about 90° left. The initial impact with the trees severed the left outer wing section. The fuselage then pivoted around the remaining section of the left wing so that it was heading about 90° left of the initial direction of travel. The fuselage struck the ground at an attitude of about 75° nose down. However, the terrain in the area sloped about 55° down in the direction the fuselage was travelling at impact. This effectively reduced the ground impact angle to less than 20°.

The nose section struck the ground first and folded back under the fuselage as the aircraft slid forward for about 5 m, before coming to rest against a tree. This prevented further movement down the slope.

1.12 Medical information

Each crew member received spinal injuries and bruising from the impact. In addition, the flying pilot received serious injuries to his right leg, and the navigating pilot serious facial and foot injuries.

1.13 Fire

There was no fire.

1.14 Survival aspects

During the impact sequence, the kinetic energy of the aircraft was absorbed initially by the wings as they struck trees. This, together with the low relative impact angle, limited the impact forces and the extent of injuries to the occupants, particularly those in the aircraft cabin.

The aircraft was fitted with an emergency locator transmitter (ELT) which activated during the impact sequence and was detected by the search helicopter pilot.

Following the accident, the crew reported the situation by satellite telephone to their base in Darwin. Rescue arrangements were initiated as a result of this call.

1.15 Overview of the PNG flying environment

In February 1997, the Directorate of Flying Safety—Air Force (DFS-AF), published the Third Edition of the DFS—AF Flying Safety Special *Operations in Tropical Mountainous Areas*. The foreword to this publication contained the following overview:

‘There is no unusual blend of flying skills required for flying in tropical mountainous areas, nor is there any special mystique about operating in these areas. A knowledge of why previous accidents happened, and the training to avoid accidents from the same causes will dispel any such notions. However, because so many of the more demanding aspects of flying—unpredictable and rapidly changing weather, rugged terrain, inadequate navigation aids, poor living conditions, marginal aircraft performance, demanding missions and long flying days—are often present (usually in combination), far higher standards of airmanship, supervision and plain professionalism are required. The margins for error are much narrower than in the relatively benign Australian mainland-flying environment. The valleys, ridge lines, airfields at high-density altitudes, visual illusions, and weather all become important considerations, often in the one sortie.

In every flight there is a requirement for sound decisions which are based on solid training and guarded by adequate supervision. This is especially so in tropical mountainous areas; where these factors are inadequate, the success of an operation in marginal conditions is jeopardised.

The importance of the human factors is emphasised. Fatigue, heat stress, crew relationships, and the standard of supervision become even more important when operating in these areas.’

During the investigation, discussions on the PNG flying environment were held with a number of pilots who had extensive PNG flying experience, including Army, RAAF and civil experience. A common view was that high-density altitude operations in PNG were unique and required specific training programs to develop the necessary levels of supervision and airmanship, as well as the flying and navigating techniques which such operations demanded. In particular, low-level valley flying required crew training and competency in maximum performance aircraft handling to cope with the difficult weather and terrain conditions.

The RAAF has published special procedures and criteria that apply to PNG/high-density altitude operations. These appeared in Air Lift Group Standing Instructions, Operations (ALG SI (OPS)) VOL2 DHC4, OPERATING PROCEDURES, OPS 8-3 (see 1.16.5).

1.16 Planning and preparation for Exercise Highland Pursuit

1.16.1 Evolution of Army fixed-wing aircraft operations

From the late 1960s until the early 1990s, No. 173 Squadron was equipped with Pilatus Porter and later, GAF Nomad aircraft which frequently operated in PNG. The Nomad and Porter were purpose-designed short take-off and landing (STOL) aircraft ideally suited to operating into the short, unsealed airstrips which existed throughout the highland areas of PNG. As a consequence of operating these aircraft, the Army possessed substantial corporate knowledge and experience in tropical mountainous flying operations in STOL aircraft.

In the late 1980s and the early 1990s, a significant number of experienced fixed-wing aircraft pilots resigned or retired from the Army. The Porter was withdrawn from service in 1992, and the Nomad in 1994/95. In 1995, the Army leased two civil-registered Embraer Bandeirante aircraft. These were replaced in 1996 by the lease of five civil-registered aircraft: three Beechcraft 200 Super King Air aircraft ('A' Troop No. 173 Squadron), which were based at Oakey; and two Twin Otter aircraft ('B' Troop No. 173 Squadron), which were based in Darwin.

The Beech 200—a turbine powered, pressurised, light transport aircraft—is distinct from the Porter and Nomad because of its higher operating altitudes and speed, and lack of STOL capability. It does not possess the manoeuvrability of the Porter or Nomad and could not be operated into many of the airstrips that could be used by these aircraft.

The Twin Otter is a purpose designed STOL aircraft with capabilities more aligned to those of the Porter and Nomad than the Beech 200. Thus, while there had been continuity in Army-fixed-wing aircraft operations after the withdrawal from service of the Porter and Nomad, there had been a hiatus in the operation of aircraft with performance capabilities similar to those of the Twin Otter.

No executive officer from No. 173 Squadron or 1st Aviation Regiment was endorsed on the Twin Otter. An officer of lieutenant rank was the 'B' Troop commander in Darwin.

1.16.2 Background to the exercise

Exercise Highland Pursuit had been the traditional means for maintaining a capability for operating in tropical mountainous areas. The exercise had involved, over many years, annual training in PNG for both the rotary and fixed-wing aircraft elements of Army Aviation.

The training requirements for 1st Aviation Regiment were approved on an annual basis by Headquarters 1st Division in response to training proposals submitted by the Regiment. The approved requirements were issued by 1st Division as a list of training objectives. In 1995 and 1996, training in tropical mountainous flying was submitted by the Regiment for inclusion in the training directives but was not approved by the Division. Hence, Exercise Highland Pursuit did not proceed in those years. In 1997, the Division approved the bid for training in tropical mountainous operations and Exercise Highland Pursuit was included in the training objectives.

Headquarters 1st Division indicated that tropical mountainous operations were considered an integral component of the operational capability of Army Aviation. From 1st Division's perspective, there were three reasons for the non-inclusion of the training in the 1995 and 1996 training directives:

1. the withdrawal from service of the Porter and Nomad aircraft;
2. the continuing loss of fixed-wing aircraft pilots from Army Aviation; and
3. aspects of the international relationship between Australia and PNG.

The training was reinstated in 1997 because the international situation had improved, suitable fixed-wing aircraft had been brought into Army service, and the number of fixed-wing aircraft pilots had increased.

By comparison, the perception within 1st Aviation Regiment was that the training requests for tropical mountainous operations training in 1995 and 1996 had not been approved because training resources were limited and, at that time, other training was considered by 1st Division to be of a higher priority. There was also the perception within the Regiment that 1st Division did not fully appreciate the unique aspects associated with tropical mountainous flying and was therefore not sufficiently knowledgeable to assess training needs in this area.

The requirement for tropical mountainous flying, and the maintenance of adequate skill levels, were discussed during the investigation with both 1st Division and 1st Aviation Regiment. These discussions indicated that the requirements had not been formulated by the Regiment, either as part of the submission of training proposals in 1997, or at any earlier time. This resulted in an incomplete awareness within 1st Division of the skill levels required for fixed-wing aircraft tropical mountainous operations and hence the priority which such training should be accorded.

The initial intent was for all elements of 1st Aviation Regiment to conduct training in PNG in September 1997. The A Troop No. 173 Squadron (operating Beech 200 aircraft) completed training in September in accordance with Operations Order Exercise Highland Pursuit 1/97. However, because of a lack of suitably qualified and experienced Twin Otter pilots, PNG training for B Troop No. 173 Squadron was deferred. Later, three pilots assessed as suitable to undergo PNG training were selected. Two of these pilots were from B Troop No. 173 Squadron, which was based in Darwin. The third trainee had only recently completed Twin Otter endorsement training and was based at Oakey. B Troop was given the task of completing all preparatory arrangements necessary for the exercise.

1.16.3 Role specialisation

Department of Defence (Army Headquarters) Special Flying Instruction 2/97: Aircrew Categorisation, was issued in February 1997. It included the following paragraph:

> '23. Role Specialisations. A CO may define a system of role specialisations where the training implications of a category are complicated by specific types of mission. These role specialisations will be specified in the task list and the qualification and currency requirements will be defined in the workbook. Offshore search and rescue, aeromedical evacuation and certain special operations may, for example, be role specialisations with a degree of complexity that require a discrete training system. Theatre qualifications, such as those pertaining to PNG operations may also be defined as role specialisations. Role specialisations are to be entered in the member's Flying Log Book.'

At the time of the accident, tropical mountainous operations had not been defined as a role specialisation for Twin Otter pilots. However, the definition process was underway. Draft standard operating procedures were being developed (see also 1.16.5). However, no training needs analysis had been conducted and there was no syllabus in place for training in tropical mountainous operations.

1.16.4 Twin Otter operation and endorsement training

In addressing the operation of civil-registered aircraft, the Army determined that the carriage of Army personnel as passengers, the carriage of Army owned equipment and stores as freight, and the conversion training of Army pilots, all fell within the definition of private operations. As a result, the Army operated Twin Otter aircraft (and other leased, civil-registered aircraft) in the Private Category. The operation of aircraft in this category did not require the operator to obtain an air operator's certificate (AOC). However, the operation of aircraft in higher categories required an AOC and placed additional requirements over the private category, including the provision of a check-and-training manual acceptable to the Civil Aviation Safety Authority (CASA) (CAO 82.3 refers). Notwithstanding these provisions, 1st Aviation Regiment had in place a check-and-training manual. The manual was based on that of a regular public transport operator and had been approved by Headquarters Aviation Support Group. However, the endorsement training syllabus contained in the manual did not include training in maximum performance handling sequences (such as maximum rate/minimum radius turns) that would normally be included in typical military type conversion training. It also did not include any training in tropical mountainous operations.

Appropriately experienced and qualified Army pilots were not available to conduct check-and-training, type-endorsement training and on-going checking of Army Twin Otter pilots. Consequently, Twin Otter training was contracted to a civilian pilot who held the relevant CASA approvals to conduct such training. He conducted the training in accordance with the Regiment's check-and-training manual. Each trainee completed 5 hours dual instruction followed by 15 hours in command under supervision.

The on-going operation of the Twin Otter aircraft involved the transport of persons and freight. Operations of a more 'military' nature such as low flying, beach landings, and parachuting operations were not conducted. This was an intentional arrangement by the Regiment because of the experience levels of the pilots of B Troop. The pilots were aware of this arrangement and the reasons for it. At the same time, however, they were keen to extend the type of operations they conducted in the aircraft and viewed training in tropical mountainous operations as one such opportunity.

1.16.5 Exercise preparations

Pre-deployment reconnaissance to PNG

In preparation for Exercise Highland Pursuit 2/97, a Twin Otter pilot from No. 173 Squadron who was to participate in the exercise (and who was the pilot in the aircraft cabin on the accident flight) deployed to PNG with No. 35 Squadron RAAF. The purpose of the deployment was to observe the training operations and methods of No. 35 Squadron, as well as to gain experience with a suitable civilian operator of the aircraft type. However, no definite arrangements concerning particular operators and/or flights had been made before arriving in PNG. He spent one half-day observing No. 35 Squadron flying operations, and one full day observing the flying operations of a local Twin Otter operator before returning to Australia with No. 35 Squadron.

The pilot produced a report on the preparation for, and conduct of, flying operations in PNG. The recommendations of the report were as follows:

> 'a. 173 Squadron conduct PNG training on a more regular basis, in order to provide a greater experience level (and hence safety margin) for PNG operations;

b. 173 Squadron establish a closer working relationship with RAAF No 35 Sqn so as to achieve operational capability in PNG in a shorter time frame;

c. 173 Sqn establish 'Captaincy and Currency' requirements for PNG operations, based on the following proposed (minimum) criteria for authorisation to fly as a captain in PNG:

   i. 1000 hours total military aeronautical experience;

   ii. Category C captain;

   iii. 20 hours of 'in country' tasking (not transit to/from PNG);

   iv. Five departures and arrivals to strips likely to be used on tasking in PNG (based on aircraft type);

   v. Been awarded a PNG captaincy by OC 173 Sqn on recommendation from 173 Sqn Check and Training captain;

   vi. Retained currency in PNG operations by operating in country at least in the preceding 12 months.

d. Any opportunity be taken to increase general PNG experience through the use of activities such as the one just conducted;

e. All squadron aircrew be aware of the difficult nature of flying operations in PNG, and conduct operations 'in country' on a reasonably set itinerary so that pre-task planning may focus on necessary planning for both routes and intended landing areas;

f. As a result of current low PNG experience levels, preparation for operations in PNG should generally take approximately one to two hours per hour of flight;

g. 173 squadron prepare and hold a 'PNG Nav-Bag' per aircraft if possible.'

Both the Regiment and Squadron commanders read the report, as did the other two trainees on board the aircraft. The training pilot on the accident flight did not see the report.

Standard Operating Procedures (SOPs)

During the preparation for the exercise, the Regiment was unable to locate any Army Aviation documentation such as previously used SOPs or PNG qualification requirements which could have been used as a basis for planning and conducting Exercise Highland Pursuit 2/97. It was therefore necessary to start afresh in developing and documenting such procedures. This development was conducted at the direction of the Commanding Officer 1st Aviation Regiment and undertaken by the squadron commander, the squadron qualified flying instructor, and one of the trainees. The process included obtaining reference material from outside sources, including the PNG standard operating procedures (SOPs) for No. 35 Squadron RAAF, the Directorate Flight Safety—Australian Defence Force, Flying Safety Special: *Operations in Tropical Mountainous Areas,* and the pre-deployment reconnaissance report.

At the time of the accident, draft SOPs for tropical mountainous operations had been prepared. However, they had not progressed beyond the draft stage. This was deliberate as the Commanding Officer 1st Aviation Regiment was not satisfied with some aspects of the draft, particularly its requirements for PNG captaincy. He intended that the outcome of Exercise Highland Pursuit 2/97 would help clarify this issue, although how this was to be achieved was unclear. In this context, the draft SOPs listed the following qualifications for the award of 'PNG Aircraft Captain'.

'**PNG Aircraft Captain.** A PNG captain is defined as a pilot who has experience in high DA and mountainous terrain and is current within the following parameters:

a. Category 'C' captain;

b. Retained currency in PNG operations by operating in country at least once in the preceding 12 months;

c. Has completed a minimum of 20 hours task as pilot in command under supervision, in any aircraft type in PNG, before acting as pilot in command (not including transit to/from PNG);

d. Should have a minimum of 1,000 hours aeronautical experience with a minimum of 500 hours in command, 250 hours on type;

e. Has participated in a minimum of 5 navigational exercises through the highlands and made a minimum of five diversions to alternate routes;

f. Has conducted five approaches and departures from highland airstrips.'

Note: Army Flying Order 1.2.2c and 1.7.2 respectively included the following definitions:

'Category C. Category C may be awarded to a pilot assessed as being capable of carrying out tasks in the aircraft without supervision. A Category C pilot must hold an instrument rating. The pilot need not be capable of carrying out, without supervision, all operational tasks in the aircraft.

Captain. A pilot is only to be appointed as aircraft captain when he is a qualified first pilot on the aircraft and meets flying currency requirements.'

The draft also contained a paragraph titled 'Outcomes', which stated:

'The training outcomes sought from PNG training are proficiency in high DA (*density altitude*) and mountainous operations. As a general rule proficiency will not be gained from a single visit to the operating environment. Proficiency will be gained from experience in the environment and from gaining local knowledge.'

According to the draft, a pilot was deemed to be proficient in tropical mountainous operations when the requirements for a PNG captain, as listed above, were met.

Neither the training pilot nor the flying pilot had seen the draft SOPs.

By comparison, the No. 35 Squadron RAAF criteria for PNG captaincy (on Caribou aircraft), as detailed in ALG SI(OPS) VOL2 DHC4, OPERATING PROCEDURES, OPS 8-3, were as follows:

'3.2.2 Pilots who are authorised to fly as a captain in PNG must have:

a. completed at least three PNG trainers under the supervision of a PNG Check Captain and be a minimum of a Category C Captain in Australia,

b. been awarded a PNG Captaincy by CO No 35 SQN on recommendation by a PNG Check Captain and with the appropriate annotation to their categorisation records and

c. retained currency in PNG operations by operating in country at least once in the preceding 12 months.

3.2.3 The normal PNG captaincy progression involves a Restricted Captaincy route

check on the third trainer and the lifting of this restriction on the fourth trainer. This requirement is to meet a standard rather than complete a number of trainers, so the progression requirements can be altered at the discretion of CO No 35 SQN commensurate with the individual's experience level.'

Operations Order Exercise Highland Pursuit 2/97

Operations Order 23/97 for Exercise Highland Pursuit 2/97 was approved by the Officer Commanding No. 173 Squadron on 22 October 1997. It included the following:

1. Paragraph 1a (1)(a) stated the Commander 1st Division 'requires aviation units to maintain a capability to operate in high altitude conditions'.
2. Paragraph 2 stated that the Twin Otter squadron was 'to conduct HDA [high density altitude] training in PNG during the period 6–13 Nov 97 in order to qualify aircrew in tropical mountainous operations'.
3. Paragraph 3a stated that the 'intent is to train and qualify' selected aircrew 'in HDA ops in order to build expertise in deploying to tropical, mountainous areas'.
4. Paragraph 6 was titled 'Safety'and stated that an aviation risk management plan was attached to the Operations Order and, at sub-paragraph c., stated that 'risk management for each mission to be formally briefed during planning process'.

The Operations Order also contained an itinerary for the exercise, including a list of airstrips which could be visited each day. The list was arranged so that the level of difficulty of the airstrips increased as training progressed, beginning with operations in the lowlands before progressing to mountainous areas.

The Operations Order was drafted by the flying pilot. He made no reference in the Order to the draft SOPs because he was unaware of their existence.

1.17 Training pilot

1.17.1 Training pilot selection

The regiment advised that there was no Army pilot qualified as a check-and-training pilot on Twin Otter aircraft. This led them to conduct informal inquiries to RAAF and civilian sources for a suitable person to conduct the training in PNG. Only one pilot was located who was qualified as a check-and-training pilot on Twin Otter aircraft, who had PNG experience, and who was available to conduct the training. He had been recommended by a number of pilots outside the Army, including civilian pilots in Australia and PNG, and RAAF pilots, as having the necessary qualifications and experience. His reported experience in the RAAF, in PNG, and as a Twin Otter pilot, plus his availability during the planned period for the exercise were the predominant factors in his selection.

The selection process did not involve any formal interview other than a telephone discussion. No documentary assessment of the training pilot's training methods, qualifications, or experience was undertaken. Consequently, neither the regiment, the squadron, nor any of the trainees were fully aware of the training pilots qualifications, prior to the accident.

1.17.2 Experience

The training pilot had flown about 3,000 hours in PNG, as a military and civilian pilot. His military experience included about 30 deployments to PNG with No. 35 Squadron RAAF on

Caribou aircraft. For many of these exercises he performed check-and-training duties on the Caribou, although he did not conduct the initial training of military pilots who were new to fixed-wing aircraft operations in tropical mountainous areas. He was a member of the RAAF Reserve and his most recent deployment with No. 35 Squadron to PNG was in February 1995 as a check-and-training pilot. Since August 1994, the training pilot had been employed as a check-and-training pilot, and route and airfield endorsement pilot on Beech 200, Twin Otter, and Piper PA31 aircraft with a company based at Mt Hagen, PNG. The training pilot had the necessary qualifications and experience to conduct the training for the Army.

The training pilot was aware that one of the trainees had about 900 hours on type and another almost 600 hours. (This compared with 100–200 hours hours on type for RAAF Caribou pilots when they began training in PNG.) The training pilot said he believed that he had assumed a suitable level of expertise for the trainees because they were military pilots and because of their relatively high experience on type. He was not aware that they had not been exposed to basic tropical mountainous operating techniques. Further, he had not sought clarification of the trainees' experience or training in this area.

The training pilot indicated that he had extensive and recent experience in visual navigation throughout PNG. Although he had operated into Simbai from the west, he had not flown between Koinambe and Simbai direct or via the Jimi River.

1.17.3 Availability

The training pilot was employed by a local operator based at Mt Hagen in PNG. His employment arrangements there included 2-months operations in PNG followed by a 1-month break in Australia. His most recent 2-month employment period in PNG prior to the exercise had ended on 31 October 1997 when he returned home to Townsville. He had a commitment in Australia on the night of 13 November. He was therefore available to conduct training between 1 and 12 November only.

When he initially discussed the exercise with the training pilot, the squadron commander stated that he wanted three pilots to receive training. The training pilot indicated that, because there was only a limited time available for the exercise, he preferred to train only two pilots: if there was to be a third trainee, then he should be as an observer only. The training pilot agreed to take three trainees, but advised that if they were to be given an equal amount of training then this would mean less training for each of the participants.

1.17.4 Expected exercise outcome

The Commanding Officer 1st Aviation Regiment viewed the exercise as an introduction to flying operations in PNG. He stated that he held no expectation that any of the trainees would return from PNG with an in-country captaincy rating, but relied on the recommendations of the training pilot.

The Officer Commanding No. 173 Squadron believed that one of the trainees might qualify as a PNG captain during the exercise but not the other two. His expectation was that the training pilot would provide a recommendation at the completion of the exercise as to the award of any PNG captaincy. He informed the training pilot of this during a telephone conversation with him.

Until the training pilot met the trainees in Townsville, and following his acceptance of the task, his involvement in the exercise had been limited to telephone conversations and correspondence via facsimile between himself and the trainees. He understood that the purpose of the exercise was to expose the trainees to the PNG environment. He knew that

the trainees were keen to gain a PNG captaincy, and believed that the squadron and regimental management would have liked at least one of the trainees to be recommended for PNG captaincy. His own view was that he would not make a decision on any individual until the exercise was completed.

After the exercise began, there was discussion among the crew concerning the high level of suitability of the Twin Otter for Army air support in PNG. This led the trainees to agree that it would be advantageous to achieve PNG captaincy during the deployment. As the exercise progressed, they queried the training pilot as to their progress and their prospects of gaining PNG captaincy. The training pilot indicated that he would not make any decision until the completion of the exercise.

1.17.5 Pre-deployment training

Pre-deployment training was conducted in Townsville on the day before the aircraft departed for PNG. It consisted primarily of a series of classroom briefings by the training pilot. The topics covered included flying and navigation techniques, flight planning, weather, and aircraft operations in PNG. The training pilot conducted a flight with one of the trainees. Its purpose was for him to become familiar with the Army operating procedures for the Twin Otter aircraft.

The training pilot indicated that during the pre-deployment briefings, and as the exercise progressed, he repeatedly stressed the importance of having an escape route planned at all times during PNG operations. However, he had not demonstrated, nor had the trainees practised, valley escape manoeuvres. In the aftermath of the accident, the trainees felt that they had not received adequate training in valley escapes—either in terms of recognising when a turn-around should be conducted, or the technique for conducting the manoeuvre.

1.18 Additional information from the crew

Additional information provided by the crew included the following:

1. The aircraft was flown from Townsville to Port Moresby on 6 November, remaining there overnight. The following day, the group conducted 7.2 hours flying in the lowland areas of south-east PNG, and returned to stay overnight at Port Moresby. On 8 November, the crew planned to fly from Port Moresby to Madang via Goroka and Mt Hagen. However, they were unable to continue the flight due to poor visibility caused by smoke haze, and diverted to Nadzab. After refuelling, the crew attempted to reach Mt Hagen via the Bundi Gap but again had to return because of smoke haze. They then elected to fly direct to Madang under the instrument flight rules. Total flying time for the day was about 5 hours;
2. Two of the trainees indicated that, before departing Madang on the morning of the accident, they felt a lack of motivation towards flying that day. They attributed this to a level of fatigue and the local weather, which was overcast with poor visibility;
3. The trainees indicated that they had a good rapport with the training pilot and that they believed him to be the best qualified person for the task. However, his practice of not occupying a cockpit seat was new to them (see 1.19.5). The training pilot had not explained who was responsible for decision making in these circumstances, nor had the trainees sought such information;
4. The training pilot had completed a 2-month tour of duty flying in PNG. He then spent 2 days in Australia before commencing pre-exercise briefings on 4 November; and

5. Two of the trainees flew the aircraft from Darwin to Townsville (approximately 8 hours flying) on 3 November.

1.19 Other aspects affecting the accident flight

1.19.1 Aircraft en-route climb performance

The crew members had not compared, either during the pre-exercise briefings or as part of the pre-flight preparation, aircraft climb performance against terrain elevation profiles. One trainee indicated that 'the aircraft had plenty of power, and [climb] performance was not an issue'. The normal Twin Otter operations the trainees had been exposed to in the Northern Territory were such that terrain versus aircraft climb performance was not a consideration. None of the trainees had previously been in a situation where aircraft performance was insufficient to outclimb rising terrain.

According to en-route climb data provided by the aircraft manufacturer, at the aircraft operating weight of 11,000 lb (4,990 kg) (assuming an ambient air temperature of ISA plus 20° C), the distance required for the aircraft to climb from 2,500 ft to 8,500 ft (i.e. from an altitude of 1,000 ft above the Jimi River to cross the Bismarck Range) was as follows:

a. Low-speed climb (90 kts) 10.5 NM (19.4 km)

b. High-speed climb 17 NM (31.5 km)

These distances compare with the ground distance from the Jimi River to cross the Bismarck Range on the route flown by the aircraft–7 NM (13 km), and via the route the crew had intended to follow–10 NM (18.5 km).

The distance from the Jimi River to the accident location was 4.5 NM (8.3 km). That distance, and the increase in elevation from the position of the aircraft above the Jimi River, coincided with the low-speed climb profile of the aircraft.

1.19.2 Use of charts

The flight navigation package carried on the aircraft included a 1:1,000,000-scale Operational Navigation Chart (ONC) and a World Aeronautical Chart (WAC), a 1:500,000-scale Tactical Pilotage Chart (TPC) and a 1:250,000-scale Joint Operations Graphics Air Chart (JOGAIR). The training pilot stated that he preferred the ONC for planning and navigating in PNG. He considered that the strong yellow colouring of the 1:500,000-scale chart (which was referred to by some pilots as the 'yellow peril') made map reading difficult. On that basis, he suggested that the trainees use the ONC.

The trainees indicated that they accepted the advice of the training pilot and used the ONC for all the PNG flights they conducted. They used WACs for all Twin Otter operations they conducted in Australia. The draft No. 173 Squadron Standard Operating Procedures (SOPs) and the RAAF procedures for Caribou operations in PNG stated that 'TPC are more recent (than WAC) and have a better level of relief and navigation detail, however it is noted that their scale makes it difficult to cross country navigate, usually entailing frequent crossing of map joints'. The RAAF procedures stated that the standard practice was for the flying pilot to use the 1:1,000,000-scale ONC while the navigating pilot used the 1:500,000-scale TPC. The draft No. 173 Squadron SOPs did not contain this advice, and stated that the navigating pilot should use 'the appropriate maps'. There was no reference to the chart the flying pilot should use.

Although the ONC charts provided a general overview of terrain, the level of detail was

limited. For example, the area of the Bismarck Range where the accident occurred was marked on the chart by brown shading to indicate that the elevation was between 7,000 ft and 12,000 ft AMSL. However, the chart displayed limited spot height information. This contrasted with the TPC and JOGAIR charts that displayed more comprehensive terrain information. Further, the river that led to the valley in which the accident occurred was about 1.8 km south-east of the intended route and was clearly evident on the larger scale TPC and JOGAIR charts but not marked on the ONC.

1.19.3 Navigation

The training pilot indicated that he closely observed the navigation skills of the trainees during the initial flights in PNG. He was aware that each had considerable helicopter experience and, given their background, he expected their navigation skills to be sound. His observations on earlier flights confirmed this expectation. The trainees had also demonstrated sound decision-making skills during the exercise. As a result, the training pilot was confident that he could monitor their activities by standing at the cockpit entrance or from the aircraft cabin.

However, the trainees required close supervision and prompting when operating into the more demanding airstrips the crew visited. Short take-off and landing (STOL) techniques were used at these airstrips. The result was that most of the training emphasis was directed towards operations into and out of the different airstrips that the crew visited each day.

1.19.4 Pre-flight planning and briefing

The trainee who was seated in the aircraft cabin on the last flight of the day normally completed the flight plan for the next day's activities. The flight plan for 9 November included detail of the direct track and distance for each sector, along with an estimated time interval (ETI). To allow for possible diversions, a reduced true airspeed was used when calculating ETIs. The flight plan indicated that the sector from Koinambe to Simbai was to be flown at an altitude below 5,000 ft. This compared with the aerodrome elevation for Simbai (5,810 ft) and the terrain en route which extended to 9,000 ft AMSL near Simbai. Although all crew members were aware of the elevation of Simbai, none knew until after the accident that the terrain elevation en route extended to 9,000 ft AMSL.

The training pilot indicated that the flight-planned altitude (5,000 ft) was used for the flight plan document only. It did not imply the expectation that they could fly from Koinambe to Simbai at that altitude. However, it was not practicable to fly at a significantly higher altitude because of the visibility. In practice, the terrain elevation only exceeded 5,000 ft in the vicinity of Simbai. It was never the firm expectation that a direct track would be flown on any of the sectors, including from Koinambe to Simbai. The prevailing smoke and haze conditions had caused a number of changes to planned routes on the previous day and similar conditions existed on the day of the accident.

The training pilot said that it was not practicable to pre-brief all possible routes for each sector because of the variability of the weather and visibility. He described flexibility as the key to flying operations in PNG and had emphasised this to the trainees throughout the exercise. At the same time, he repeatedly emphasised the necessity of having escape routes available at all times.

The trainees stated that the planned flying for the following day was discussed each evening. However, these discussions were of a general nature and did not involve detailed consideration of routes to be flown, possible alternate routes in the event that the direct track could not be flown, or terrain elevation. The trainees were told who would occupy the

cockpit on the first sector of the following day's flying. However, there was no pre-briefing regarding the role of each trainee on subsequent sectors.

1.19.5 Seating

The duration of the exercise was to be a maximum of 7 days in PNG. To give each trainee an equal amount of flying time at a control position, the training pilot employed a system of cockpit position rotation. The usual procedure was for him to occupy a control seat while one trainee flew an arrival, circuit and landing. Another trainee would then fly one or more circuits, after which the third trainee would fly the take-off and departure. En route between airstrips, two trainees occupied the cockpit, one to fly the aircraft, and the other to navigate, while the training pilot monitored their activities by standing at the cockpit entrance, or from the aircraft cabin. The sequence and timing for cockpit position changes were decided by the training pilot as the flying activities progressed each day to ensure that each trainee received an equal amount of time as the flying pilot. This resulted, in some instances, in the trainee occupying the right cockpit seat being allocated the role of the flying pilot.

Although not a requirement of Army Flying Orders, it was normal practice in all Army flying operations for the pilot in command of the aircraft to occupy a cockpit seat during flight. None of the trainees had previously operated an aircraft where the pilot in command did not occupy a cockpit seat. In some RAAF operations, including Caribou training exercises in PNG, the practice was for the pilot in command not to always occupy a cockpit seat during en-route flying. The training pilot on the accident flight had participated in a number of RAAF PNG training exercises where this procedure was followed.

1.19.6 Training management package

A comprehensive training package had been developed by 5th Aviation Regiment (which operated Blackhawk helicopters) detailing the ground and flying training program aircrew were required to complete to qualify for PNG operations as pilot in command and co-pilot. The package specified the content and duration of each lesson/flight, the learning outcomes and performance criteria, and assessment requirements. It was used by A Troop, No. 173 Squadron (operating Beech 200 aircraft) when it completed lead-up training for Exercise Highland Pursuit 1/97 in September 1997. However, the package was not provided to B Troop. Neither the training pilot, nor any of the trainees involved in Exercise Highland Pursuit 2/97, were aware of its existence.

1.20 Risk assessment

As a result of the inquiry into the accident involving Army Blackhawk helicopters near Townsville in June 1996, a risk management process was developed for Army Aviation. It was published as a draft Corps Training Note in early 1997 and formalised in December 1998. The process was designed to 'provide commanders and supervisors with the clear and comprehensive guidance in a deliberate process to conduct risk management'. The process was introduced at two levels:

1. as part of the planning process for operations; and
2. as a part of the authorisation procedure before each flight.

The Regiment attempted to put the process into practice when the draft training note was issued. Neither the squadron commander, nor any of the trainees, had received any training in the risk assessment process.

1.20.1 Risk assessment for the exercise

A risk management plan was included in the Operations Order. The plan listed a number of 'control measures' that were to be employed to minimise risk. One control measure was that 'thorough briefings are to be conducted before each flight'. The plan concluded that, 'with adherence to the control measures the cumulative risk level for the whole exercise is assessed as low'.

The trainee who prepared the Operations Order stated that the risk management plan was a copy of that used for an earlier training exercise in PNG undertaken by rotary-wing and Beech 200 elements of the Regiment. The trainee did not conduct an independent risk assessment.

The squadron commander indicated that he initially held some concern at the level of risk the planned exercise involved. However, after he had met and spoken with the training pilot about the exercise (2 days before the aircraft departed Townsville for PNG), he was confident that the risk level was low.

Other Army pilots interviewed during the investigation considered that risk assessment and management were an integral part of the flying culture. They considered that an adverse effect of the risk management program had been to separate it as a process from the flying task. The result was that risk management had become a 'tick and flick' exercise in which the formal process of completing written assessments of risk, both before operations and individual flights, had become a mechanical process and did not enhance safety.

1.21 Human performance aspects

1.21.1 Optical Illusions

The inherent risk associated with optical illusions while operating in mountainous areas is well documented in the DFS-ADF publication, *Operations in Tropical Mountainous Areas*. In particular, the publication advises 'that false horizons caused by sloping terrain can cause disorientation and variations in airspeed to the point of unintentional stall'.

1.21.2 Fatigue

The crew assembled on 3 November and was engaged in flying or ground duties each day until the accident on 9 November. The exercise itinerary scheduled about 10 hours duty per day.

Members of the crew indicated that their performance had been affected by fatigue. The training pilot indicated that, in hindsight, having only two rest days in Australia before commencing preparation for the exercise may not have provided him with adequate rest.

When aircrew are operating away from their home base, the quality and duration of their sleep patterns are typically less than normal. This is caused by several factors including:

1. changes to personal and work routines;
2. the quality and novelty of their sleeping accommodation; and
3. a tendency for alcohol consumption to increase.

2. ANALYSIS

2.1 Introduction

The investigation identified a number of factors or latent conditions that influenced the organisational and operational environment in which exercise Highland Pursuit 2/97 was established. These latent conditions were present throughout the planning and preparation for the exercise and established the parameters within which the crew conducted the accident flight. They resulted from management decisions, most of which were distinctly separated from the crew, both in an organisational sense, and over time. They involved organisational processes including planning, communicating, policy-making, managing safety, and checking. This analysis will initially address these systemic issues before discussing the performance of the crew.

2.2 Corporate Knowledge

There was a low level of corporate knowledge, within the Army Aviation system, of the operation of Twin Otter type aircraft in tropical mountainous areas. This situation had evolved over a number of years and was the result of:

1. a substantial reduction in the extent of fixed-wing aircraft operations in PNG after the phase-out of the Porter and Nomad aircraft;
2. the continuing loss of pilots with Porter and Nomad experience;
3. the absence of records concerning the procedures and techniques for the operation of Twin Otter type aircraft in tropical mountainous areas; and
4. the level of priority allocated by 1st Division to training in operations in tropical mountainous areas involving Twin Otter type aircraft.

This lack of corporate knowledge acted to limit the level of experience, knowledge, and effective oversight that could be applied to Exercise Highland Pursuit 2/97. This resulted in:

1. an incomplete appreciation of the unique nature of fixed-wing aircraft operations involving Twin Otter type aircraft in PNG, and the need to maintain skills and experience levels necessary to ensure safe operations in this environment. This manifested itself as irregular inclusion of training in tropical mountainous operations in the annual training directives; and
2. the omission of any Army-specific requirements for operating techniques and procedures concerning maximum performance handling to be included in the endorsement training of Twin Otter pilots. This, in conjunction with (1.) above, meant that the trainee pilots lacked exposure and expertise in skills that were relevant to the circumstances of the flight.

2.3 Management and oversight responsibilities

2.3.1 Divisional and regimental responsibilities

At the divisional and regimental levels management deficiencies included:

1. the operation of aircraft with a training and checking system in place which did not include skills and knowledge which were pre-requisites to the exercise; and

2. the use of a risk assessment process before all pilots had been trained in its operation.

2.3.2 Regimental and squadron responsibilities

At the regimental and squadron levels, management was characterised by:

1. the expectation that an appropriate risk analysis could be completed by the trainees;
2. the acceptance of the risk analysis attached to the operations order, which was a copy from another operations order relating to another aircraft type and did not necessarily bear any relevance to the task;
3. the absence of a training-needs analysis for Twin Otter type operations, including PNG qualification requirements and standard operating procedures. The limitations placed on the Twin Otter operations in Australia indicated that management informally recognised that the Twin Otter crews had not received training in military-specific operations. This assessment was not reflected in the exercise planning because no formal needs analysis was conducted and therefore a benchmark for planning the exercise, selecting a training pilot and identifying areas where skill levels were deficient was not established. There was also no basis for considering the cost and benefit outcomes of variables such as the exercise duration, and the flying hours achievable, against the number of trainees;
4. the absence of documentation concerning the selection of the training pilot prevented a full examination of the selection process being conducted during the investigation. While the Army was confident that the training pilot was 'the best man available for the job', there were no supporting documents to substantiate his selection. The Army had an incomplete and unsubstantiated picture of the background, experience, qualifications and currency levels of the training pilot;
5. the absence of any written communication or formal briefing, apart from the Operations Order, between the regimental and/or squadron management and the training pilot to set exercise criteria. Consequently, the training pilot lacked information important to the exercise process. This forced him to assume the type of training necessary and to conduct the training according to his own assessment of needs. Consequently, aspects of the training provided, including the level of pre-flight planning, the use of charts, and maximum performance handling and supervision, were not appropriate; and
6. the geographical separation of the Twin Otter troop from squadron management and the absence of any management pilot qualified on Twin Otter aircraft. The operations of the troop lacked close supervision. The perception of the trainees was that they were left to plan and conduct the exercise with little support from management.

2.4 Flight crew performance

The training pilot and trainees made several errors during the exercise and the accident flight that contributed directly to the accident. The primary errors were:

1. incomplete planning, before the exercise began, of intended and alternative routes and aircraft en-route climb performance;
2. pre-flight planning which did not adequately consider the terrain and aircraft en-route climb performance;

3. the use of a chart for navigation which provided insufficient terrain information for accurate visual navigation;
4. twice changing the planned route from Koinambe to Simbai without adequate appreciation of vital terrain elevation information;
5. the absence of the training pilot from the cockpit at a critical stage of the flight;
6. the failure to conduct a heading check when the aircraft initially entered the wrong valley;
7. the failure to recognise that they had turned into the wrong valley; and
8. the failure to recognise when a turn-back should have been conducted.

The following factors probably contributed to these errors: deficits in trainees' skills and knowledge; operating practices; crew relationships and crew resource management; difficulties with weather and terrain; and fatigue.

2.4.1 Trainees' skills and knowledge

Preparation for the exercise

Notwithstanding their level of experience on the aircraft type, the trainees lacked skills and knowledge in four important areas—low level navigation in mountainous terrain, maximum performance handling, appreciation of aircraft en-route climb performance, and operation of the aircraft from the opposite control position to which they were accustomed. As indicated previously, these deficiencies were not recognised by the training pilot because, in part at least, no formal training needs analysis for the exercise had been conducted.

Training management

The training pilot's expectation that the trainees would have well-developed visual navigation skills was confirmed by his observations during the early, but less demanding, stages of the exercise. This reinforced his assumption concerning the capabilities and experience of the trainees. In turn, it led to a lower level of vigilance on his part during en-route phases of the exercise. This culminated in his absence from the cockpit from when the aircraft turned into the wrong valley until he became aware of the trainees' concern about the progress of the flight.

2.4.2 Operating practices

Charts

The lack of terrain detail on the 1:1,000,000-scale ONC chart prevented an accurate appreciation of the terrain along the route the crew was flying. Thus, the sole use of this chart for flight planning and en-route navigation was inappropriate and contributed directly to the crew:

1. not being aware of the elevation of the Bismarck Ranges at the intended crossing point; and
2. turning into the wrong valley.

Unfamiliar crew seating positions

The cockpit position rotation system adopted by the training pilot was intended to provide each trainee with an equal amount of experience in the time available for the exercise. However, because the trainees were not aware in advance of which sectors they would be flying or navigating, the amount of pre-flight preparation they could conduct for a particular

sector was limited. This lack of preparation may have contributed to the navigating pilot's uncertainty regarding the aircraft's position in the Jimi River valley and, ultimately, the turn into the wrong valley.

The practice of the occupant of the right cockpit seat acting as the flying pilot placed the trainees in an operating environment with which they were not familiar. This created the potential for uncertainty and confusion during decision making by the crew, particularly in high workload situations such as existed after the aircraft entered the wrong valley (see also 2.4.4).

2.4.3 Crew relationships.

Although the trainees felt unsettled by the cockpit position rotation system, they did not raise their concerns with the training pilot even though they perceived that the social climate was appropriate to do so. The high regard the trainees held for the training pilot may have led them to accept his techniques and suggestions without question.

When the navigating pilot expressed uncertainty regarding the aircraft's position after the flight departed Koinambe, the training pilot intervened and resolved the situation. Events such as this may have led the trainees to believe that the training pilot was closely monitoring their activities and would intervene whenever necessary. On the other hand, the training pilot had been impressed by the trainees' ability, particularly with respect to navigation. These assessments may have led to the training pilot overestimating the ability of the trainees in this and other areas.

The trainees' perception of the training pilot and vice versa is an example of the 'halo' effect. This occurs when one person's positive perception of a particular characteristic of another person is generalised to other characteristics. The influence of such effects would probably have been reduced with more rigorous exercise planning, training pilot briefing, trainee preparation, and pre-flight planning.

2.4.4 Crew resource management

As well as flying and navigating from seating positions opposite to which they were accustomed, both the flying pilot and the navigating pilot were unclear as to who was 'in command'. This lack of clear role definition probably influenced the behaviour of both trainees when the aircraft was flying in the wrong valley. They later indicated that they expected the person in the other cockpit seat to make a decision as to what should be done. Also, the flying pilot thought that the training pilot was monitoring the flight while standing behind the cockpit seats.

The seating positions would not have been important, provided that each trainee had a clear understanding of their role and was adequately prepared. However, the frequent changes during the exercise, and the ad hoc change on the accident flight, are likely to have adversely affected the trainees' performance due to role confusion and inadequate preparation time. The need for frequent ad hoc seating changes also indicates that the exercise had been inadequately designed and that insufficient time had been allocated.

2.4.5 Weather and terrain

The weather conditions influenced the crew to attempt to fly an unplanned route from Koinambe to Simbai at relatively low level. The trainees had minimal experience in such conditions, and the associated hazards were not emphasised in pre-flight briefings or during the accident flight.

The broad visual similarities between the valley in which the accident occurred and the valley the crew had intended to follow, may have delayed or prevented the crew from

realising they were in the wrong valley. However, the use of a 1:500,000-scale chart, on which differences between the valleys were clearly evident, should have either prevented the error, or significantly improved the prospect of it being detected at an early stage.

The terrain and haze may also have contributed to a 'false horizon' illusion. The aircraft was flying at 2,000–2,500 ft AMSL (500–1,000 ft AGL) when it turned into the wrong valley. The elevation of the ridgeline in the distance, which was barely visible due to extensive haze, was 8,900 ft AMSL. Given the aircraft attitude and performance noted by the training pilot when he entered the cockpit, it is possible that the ridgeline had become a false horizon to the trainees in the cockpit. In response to this illusion, the flying pilot would have raised the nose of the aircraft, causing a reduction in airspeed and ultimately, a stall.

2.4.6 Fatigue

The crew made several errors during the flight which were not detected or corrected. It is possible that fatigue contributed to these errors.

This fatigue could have been the result of several factors including:

1. different environment;
2. different sleeping quarters;
3. changed personal work routines;
4. consumption of alcohol;
5. successive duty days without a recovery day; and
6. flying in conditions of reduced visibility and unfamiliar terrain.

3. CONCLUSIONS

3.1 Findings

3.1.1 The aircraft

1. The aircraft was on the Australian civil register, and operated under lease by the Army in the Private Category.
2. The aircraft had been maintained in accordance with the required procedures, and was functioning normally at the time of the accident.

3.1.2 The flight

1. The crew navigated with the aid of a 1:1,000,000-scale ONC topographical chart of the area.
2. Before departing Koinambe, the crew assessed that the haze and cloud precluded them flying the planned direct track from Koinambe to Simbai.
3. The crew, at the suggestion of the training pilot, decided to track north-west via the Jimi River valley and then east via one of its tributaries.
4. Shortly after departing Koinambe, the training pilot vacated the right cockpit seat for one of the trainees whom he nominated as flying pilot for the remainder of the sector. The trainee in the left seat then became the navigating pilot.
5. At the suggestion of the navigating pilot, the crew decided to track via a different tributary of the Jimi River without any detailed consideration of the route.
6. As the crew followed the Jimi River valley, flying 500–1,000 ft above the valley floor, the navigating pilot became unsure of the aircraft's position. He plotted the aircraft's position using GPS while the flying pilot flew a number of left orbits.
7. While the training pilot was in the cabin, the flying pilot turned the aircraft into a valley that was about 1.8 km south-east of the valley the crew intended to follow.
8. The aircraft reached a position in the valley where a collision with terrain was unavoidable.
9. The accident site was on steeply sloping, tree-covered terrain, approximately 9 km south of Simbai.
10. The crew were not aware that, from the height at which the aircraft was operating in the Jimi River valley, its en-route climb performance was insufficient to outclimb the terrain, either via the route proposed by the navigating pilot, or via the route actually flown.

3.1.3 The crew

1. All crew members were appropriately licensed and medically fit to undertake the flight.
2. The training pilot had significant PNG flying experience as a Twin Otter pilot and check-and-training pilot, and as a training pilot with No. 35 Squadron RAAF.
3. Neither the flying pilot, nor the navigating pilot, had previous PNG flying experience.
4. The training pilot did not obtain detailed information concerning the trainees' skills and experience.
5. The flying pilot was the only crew member who had received any CRM training.

6. Two of the trainees indicated that they felt fatigued on the morning of the accident.
7. The training pilot considered that he may have had inadequate rest prior to commencing preparations for the exercise.

3.1.4 Aircraft operation

1. The training pilot adopted a system of cockpit position change for the trainees during the exercise.
2. During the final flight of each day, the trainee in the aircraft cabin prepared the flight plan for the following day.
3 Most training emphasis was on airstrip operations, rather than navigation.
4. The trainees did not have adequate knowledge of the en-route climb performance of the aircraft.

3.1.5 The weather

1. The weather forecast indicated that visibility could reduce to 3,000 m in smoke and haze.

3.1.6 Organisational

1. Specific training programs in tropical high-altitude flying operations were required to develop the unique skills and techniques such operations involved.
2. There had been a significant loss of corporate knowledge within the Army concerning the operation of Twin Otter type aircraft in tropical mountainous areas.
3. The level of appreciation within 1st Division concerning the skill levels implicit in tropical mountainous operations was inadequate.
4. Exercise Highland Pursuit had not been included in 1st Aviation Regiment's Training Directives in 1995 and 1996.
5. 1st Aviation Regiment was unable to locate records concerning the training requirements for the operation of Twin Otter type aircraft in tropical mountainous areas.
6. No training needs analysis for tropical mountainous operations in Twin Otter type aircraft was conducted.
7. Before the exercise began, draft standard operating procedures for Twin Otter tropical mountainous operations, including proposed minimum requirements for a PNG aircraft captaincy, had been developed but were not made available to the training pilot.
8. The process for the selection and briefing of the training pilot was informal, incomplete, and not documented.
9. The risk assessment analysis for the exercise was an unmodified (except for aircraft type) copy of that undertaken for Exercise Highland Pursuit 1/97, involving Beech 200 aircraft, and was not appropriate for Exercise Highland Pursuit 2/97.
10. The trainees had not received any training in the risk assessment process.
11. Other personnel who had used the risk assessment procedure considered that it did not enhance safety in the manner or to the extent intended.

3.2 Significant factors

1. There had been a significant loss of corporate knowledge, experience and risk appreciation within the Army concerning the operation of Twin Otter type aircraft in tropical mountainous areas.
2. No training needs analysis for the exercise had been conducted.
3. The tasking and briefing of the training pilot were incomplete.
4 The training pilot did not adequately assess the skill development needs of the trainees.
5. The supervision of the flight by the training pilot was inadequate.
6. The scale of chart used by the crew was not appropriate for the route they intended to fly.

4. SAFETY ACTION

4.1 Recommendations

As a result of the investigation into this occurrence, the Bureau of Air Safety Investigation makes the following recommendations:

R980215

That 1st Aviation Regiment develop a procedure detailing the phases of aircraft operation during which the pilot in command must occupy a control seat.

R980219

That the Army include, as an on-going component of 1st Aviation Regiment Training Objectives, sufficient resources to maintain a core of expertise in tropical mountainous operations for each type of aircraft which may be required to operate in such conditions.

R980220

That 1st Aviation Regiment review operational standards and procedures to ensure that maps and charts appropriate to the performance and type of aircraft involved, and the nature of the operation being conducted, are used for the planning and conduct of flying operations.

R980221

That the Army formalise the skill and experience requirements for tropical mountainous operations for each aircraft type and develop training programs to meet these requirements.

R990051

That the Army develop and promote an appropriate aviation risk management culture at both operational and management levels.

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