No. 14

National Airways Corporation DC-3C, ZK-AYZ, accident in the Kaimai Range, New Zealand on 3 July 1963. Report No. 25/3/1338, dated 28 November 1963, released by the Minister in Charge of Civil Aviation, New Zealand.

1. Investigation

1.1 History of the flight

Flight 441 was a scheduled domestic flight from Whenuapai Airport, Auckland to Tauranga. The aircraft took off at 0821 hours local time from Whenuapai Airport and reported over the Browns Bay locator at 0826. At 0835 it reported at its cruising altitude of 5 500 ft and gave its ETA at Tauranga as 0914 hours.* The aircraft's heading at this time was estimated as 116°. At 0904 hours the crew called Tauranga and amended its ETA to 0908 hours. This was confirmed at 0906 when the flight requested permission to descent to 4 100 ft, the minimum safe altitude for the route Auckland to Tauranga. The request was granted by Tauranga Control. The wind velocity over the first 30 to 35 miles of the trip was assessed as 070°/30 to 35 kt. This would give a ground speed at cruising altitude of about 130 kt and a drift of 10° starboard, compared with the flight plan ground speed of 123 kt and drift of 13° starboard. It was believed that the aircraft initially drifted to port of its intended track and, when the stronger winds started to take effect, drifted back to be approximately on track when it crossed the southern coastline of the Firth of Thames, at 0849 hours with a ground speed of 137 kt. (A calculation at this point, based on a ground speed of 137 kt, would have resulted in an ETA Tauranga of 0908 hours.) The weather forecast could have led the crew to believe that the wind would decrease in strength over the remainder of the trip. However, from the Firth of Thames, the wind, though retaining roughly the same direction, became progressively stronger, reaching a maximum of between 70 and 80 kt, and the aircraft drifted starboard, while the ground speed diminished. At 0857 the aircraft was about 3 NM abeam Paeroa and was seen by ground witness within 3 miles of that position. The crew, at that time, would have expected to see Waihi. At 0904 the aircraft reported to Tauranga that it was at 5 500 ft and estimating Tauranga four minutes later. It was given the Tauranga weather picture and the altimeter setting (1 011 mb). (The setting of this pressure datum on the altimeter caused it to overread by at least 150 ft.) At 0906 hours the flight reported it was two minutes out and requested descent clearance to 4 100 ft. The aircraft was cleared to descend and the crew acknowledged the message. Shortly thereafter, the descent was commenced. Approaching 0908 a descending turn onto 056° was

* The flight plan time of 48 minutes for the trip appears to have been added to the set heading time of 0826 hours from the Browns Bay locator to give the ETA of 0914. The two-minute discrepancy is due to the following:

1) No allowance was made for the portion of the climb achieved at Browns Bay locator.
2) The distance from Browns Bay locator to Tauranga is 90 miles compared with 93 miles from Whenuapai to Tauranga.

initiated so as to track over the beacon and commence the let-down procedure. The turn was completed, and the aircraft probably encountered a severe down draught of the order of 2 000 ft/min, which caused a rapid and unavoidable descent. It was then subjected to severe turbulence. The aircraft was seen and heard by several witnesses as it tracked along the western side of the Kaimai Range until two witnesses (in the Gordon area) heard the noise of the engines cease abruptly. At approximately 0909 hours it crashed into a face of rock on the Kaimai Range 660 yds from the summit of Mount Ngatamahinerua and came to rest in a cleft at an altitude of 2 460 ft amsl at a point about 16 NM west of Tauranga Airfield.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	3	20	
Non fatal			
None			

1.3 Damage to aircraft

The aircraft was destroyed by the impact and subsequent fire.

1.4 Other damage

No damage was sustained by objects other than the aircraft.

1.5 Crew information

The pilot-in-command, age 35, held a valid airline transport pilot's licence and instrument rating. He had flown a total of 6 639 hours including 3 244 hours in command practice and as pilot-in-command. His DC 3 experience amounted to 5 687 hours, including 146 hours during the three months preceding the accident. This figure was well within the flight time limitations imposed by regulation. His last routine DC-3 training check was carried out on 26 February 1963 and a routine 180-day route check was completed on 19 March 1963. He was rated as satisfactory on both. At the time of his last medical examination in March 1963 he was physically fit.

Theco-pilot, age 38, held a valid commercial pilot's licence and instrument rating at the time of the accident. He had flown a total of 10 014 hours including 6 694 hours as co-pilot on DC-3 aircraft. On 17 April 1963 he satisfactorily completed a 180-day route check. On 2 July 1963 (the day before the accident) he successfully completed a routine DC-3 training check. At the time of his last medical examination in August 1962 he was physically fit.

The air hostess had been with the Hostess Section since 4 April 1963.

1.6 Aircraft information

The aircraft had flown a total of 18 629 hours which included 17 604 flown since it was in service with the airline (December 1953). Its last major overhaul was carried out on 29 March 1963 concurrently with the modification to "Skyliner" specifications. From that time it had been in continuous service and had flown 465 hours.

The aircraft's engines were well within their approved engine life at the time of the accident.

The aircraft was equipped with one magnetic compass, two altimeters, two radio compasses and distance measuring equipment (DME). Prior to the departure of the flight the co-pilot of the standby crew checked the radio compasses and distance measuring equipment (DME). However, maintenance records of the subject aircraft showed a disturbing number of unserviceability reports of the DME. Between 1 April 1963 and 2 July 1963 this aircraft carried out 96 flights. On 24 of these a defect report on the DME was made by the pilots. It is possible, therefore, that on the day of the accident the DME equipment was not operating satisfactorily.

The gross weight of the aircraft was 26 819 lb, slightly under the maximum authorized weight of 26 900 lb. The centre of gravity was not mentioned in the report.

The type of fuel being used on the subject flight was not stated in the report. It was estimated that the fuel tanks contained about 300 gal of fuel at the time of the accident.

1.7 Meteorological information

The area and zone forecasts for the period 0700 to 1400 hours were completed at 0540 by the duty forecaster at the Auckland meteorological office and were then transmitted by teletype to Whenuapai Aerodrome. The pilot-in-command and co-pilot of the duty standby crew arrived at the aerodrome at 0655 hours, checked the weather, obtained the flight forecast and prepared the flight plan for Flight 441, which was approved by the pilot-in-command of flight 441 when he arrived at 0735 hours. The salient features of the forecast for the zone, which included the route Whenuapai to Tauranga, were:

winds	3 000 ft	070°/35 kt
	5 000 ft	070°/40 kt
	7 000 ft	060°/40 kt
	10 000 ft	060°/35 kt

The height of the cloud base was forecast at 1 000 to 3 000 ft with patches down to 600 ft. The amount of cloud was estimated to be between 5/8 and 8/8.

Freezing level - estimated at 7 000 ft

Patches of light rain

Terminal forecast for Tauranga:

wind 090°/15 to 25 kt with gusts to 30 kt, intermittent light rain, visibility: 3 to 10 miles; cloud base: 1 000 to 2 000 ft.

The actual weather conditions existing over the route from 0800 to 1000 hours on 3 July were, briefly:

rain - continuous and moderate to heavy in and/near the ranges

cloud and visibility - cloudy to overcast over the whole route. In the area of moderate to heavy rain the cloud base was 500 to 1 000 ft, and the visibility on the ground was 1 to 2 miles. The top of the low cloud layers may have been higher than 6 000 to 7 000 ft over the Kaimai Range. Over all there was a higher layer of cloud, probably between 12 000 and 15 000 ft.

surface wind - from east to southeast about 15 to 20 kt except where this flow was considerably distorted by local topography.

upper winds - the average wind over the whole route was probably 050° to 070°/55 to 60 kt. The winds at 5 000 ft (cruising altitude of the flight) could well have been about 070°/30 to 35 kt over as much as the first 30 to 35 miles of the route from Whenuapai to Tauranga. If this were so, the average wind over the whole route at the time of the subject flight was probably 060 to 080°/55 kt. However, over the latter half of the flight the wind at 5 000 ft increased to about 75 kt, or possibly more.

icing - Freezing level at noon was about 10 000 ft over Auckland and airframe icing at 5 000 ft was considered improbable.

down draughts - the conditions existing on 3 July suggest a maximum down draught of the order of 2 000 ft/min, about 1 000 to 2 000 ft above the crest of the ridge and some distance, possibly about a mile, downstream from it. The zone in which a down draught of this magnitude would occur appears to be quite limited in extent, and the magnitude of the down draught would drop off quite rapidly away from this zone. Evidence of local residents lent support to the existence of these conditions in the vicinity of the crash on the morning of 3 July.

turbulence - it did not seem likely that there would have been significant turbulence at 5 500 ft or even at 4 000 ft. Nearer to the level of the crest of the range, and particularly just in the lee of it, turbulence could have been severe.

1.8 Aids to navigation

There was a beacon at Whenuapai, 3 miles southwest of the airfield, one at Tauranga and a locator beacon at Browns Bay, which is 6 miles northeast of the field. The track between Whenuapai beacon and Tauranga beacon is 123°. Between Browns Bay locator and Tauranga it is 129°.

No DME equipment was available at Tauranga at the time of the accident.

1.9 Communications

The aircraft radio equipment was tested prior to take-off from Whanuapai and was functioning satisfactorily. The aircraft was in contact with Tauranga up until approximately 0906 hours and no difficulties were reported.

1.10 Aerodrome and ground facilities

Not relevant to the accident.

1.11 Flight recorders

No flight recorder was carried out.

1.12 Wreckage

The wreckage was contained within a narrow and nearly vertical U-shaped cleft about 30 ft wide at its entrance and extending inward for a distance of 50 ft. The side and rear walls of this cleft were precipitous and composed of rock and compacted earth.

Impact marks at the entrance to the cleft were compatible with the port and starboard mainplanes having been at relatively the same level. Moreover, the indentations in the port mainplane and tailplane appeared to be vertical. The conclusion, therefore, was that the aircraft was laterally level at impact.

The entry of the aircraft into the narrow opening had resulted in both mainplanes being forced simultaneously rearward, as the fuselage moved forward until it was brought to rest by impact with the rock face at the innermost extremity of the cleft. The entire wreckage, with the exception of the starboard engine, was resting within the cleft on a heading of 054°. A clearly-defined swathe in the undergrowth indicated that the missing engine had rolled down 200 yds away from the wreckage after impact. There was no discernible tree damage on the adjoining ridges, indicating that the aircraft had flown up the valley on a heading approximating that on which the wreckage lay.

1.13 Fire

The aircraft caught fire on impact, and it was apparent that the fuel tanks had ruptured and that fuel had been thrown onto the surrounding rock face. An intense fire resulted which was concentrated mainly in the cabin area and almost completely destroyed all cabin fittings and passenger seats.

1.14 Survival aspects

The wreckage was sighted from the air about midday on 4 July 1963 and was reached by a ground party on the morning of 5 July.

1.15 Tests and research

A post-mortem examination of the co-pilot revealed a severe degree of coronary disease, however, there was no evidence that this condition contributed in any way to the accident.

The magnetic compass was tested by the Dominion Physical Laboratory and was found to be serviceable.

1.16 Air flow over mountains - (Mountain waves)

Mountain waves are well known to pilots as phenomena to be avoided by aeroplanes; however, the magnitude of the disturbances they cause may not be so widely appreciated. The Court was concerned at the somewhat general lack of knowledge in aviation circles of the very real dangers of the dynamic effects which can be produced by the air flow over high ground and therefore extracts from the considerable amount of literature on this subject placed before the Court, are given hereunder.

In unstable air, vertical air currents associated with convection are liable to be more intense over mountains than over level terrain, especially in strong transverse air streams, but in these cases the distribution of vertical currents is irregular. In stable air conditions, however, the disturbance of a transverse air flow by a mountain range can set up an organized flow pattern comprising waves and/or large-scale eddies in which strong vertical currents and turbulence can occur. These effects are sometimes manifest to a considerable height above the level of the crest, and the train of waves may extend for many miles downwind. Thus, whether the air be stable or unstable, mountains and ridges of hills may rise to strong vertical air currents.

With transverse winds of about 20 kt, down currents of 800 ft/min have been experienced on the lee side of mountains rising only 1 500 ft above the surrounding terrain. Stronger winds can give rise to higher vertical velocities, especially over higher ground with a steep lee slope. Indeed, vertical currents of 2 000 ft/min have been recorded on rare occasions in the lee of mountains only 3 000 ft in height, whilst in the Sierra Nevada region of California (U. S. A.) velocities have been known to exceed 5 000 ft/min.

When lee waves are operating, the strongest surface winds are commonly found sweeping down the lee slope. These winds may carry the cap cloud down the lee slope during the process of dispersal by adiabatic warming, so that the cloud resembles a waterfall known as the "cloud fall" or "fohn wall".

If the waves are of large amplitude the flow may contain rotors in the crests of the waves at about the level of maximum amplitude. Because of the large vertical wind shear in the region, the characteristic rotor or roll cloud which may form commonly has the appearance of rotating about a horizontal axis. The low-level winds beneath rotors are much lighter than elsewhere and may indeed even be reversed. Violent turbulence is liable to be encountered in the vicinity of rotor clouds.

If a ridge of substantial high ground has to be crossed when transverse winds are strong and waves are likely, much greater hazard is likely to be encountered when doing so against the wind than for downwind flights. There are two reasons for this:

1) when flying into wind the aircraft's ground speed is reduced, and it will, therefore, remain in the down currents longer;

2) where no attempt is made to counteract height changes, the aircraft's height variations when flying into wind are out of phase with any airstream waves, so that the aircraft is liable to be at its lowest height when actually over the highest ground.

Above the friction layer, which may extend to a considerable height above the crest of the high ground, flight through mountain waves is likely to be very smooth.

Within the friction layer, however, and particularly in the rotor or roll cloud zone, the turbulence encountered may be more violent than that occurring in the most violent thunderstorms. Thus, a region of severe turbulence may be suddenly encountered when height clearance above the terrain has become marginal. If there are reasons to expect strong effects, e. g. from the forecast, appearance of the clouds, or from the pilot's experience, the cruising flight level should be at least one and a half times the height of the mountains above surrounding terrain, and preferably higher.

From the point of view of navigation, the largest tracking (and timing) errors are likely to occur when an aircraft is flying parallel to a long ridge lying across the general wind. When mountain waves are operating the pilot must expect marked departures to occur, both from the forecast winds and from those recently measured in flight. In mountainous regions, therefore, where the available navigational aids do not provide constant and accurate track and ground speed checks, the cruising height selected must allow for maximum deviations from the intended track.

In determining safety heights for each sector of a route, account should be taken of the configuration of the terrain, the alignment of any high ground relative to the intended track, the maximum wind velocity normal to the high ground, and the cruising speed and climb performance of the aircraft. Where the route forecast or the pilot's past experience of the route indicate a possibility of lee waves operating over high ground, an adequate safety margin should be added to the normally accepted terrain clearance heights to ensure that any height fluctuations caused by wave phenomena will not bring the aircraft dangerously close to the high ground.

2. Analysis and conclusions

2.1 Analysis

Examination of the wreckage indicated that no structural or engine malfunction or failure occurred prior to impact of the aircraft within the cleft. Both hydraulic flap-jacks and hydraulic landing gear jacks were found in the fully retracted position and although the starboard flap and landing gear were too badly damaged to ascertain their respective position, it was considered that both flaps and landing gears were retracted at the time of impact. Evidences were found indicating that the aircraft was sinking at a high rate of descent and that the attitude of the aircraft was 7° nose up at the time of initial impact.

Forecasts, although designated by routes, apply to a zone or area, and the wind velocities given are the averages for that area. It was established that the predicted average velocity of winds for an area can be quite misleading as to a particular locality within that zone.

Based on the material available to him, it was believed that the conclusions reached by the Whenuapai forecaster regarding the weather situation were as accurate as could reasonably be expected, however it was considered that the forecast issued at Whenuapai could have given more information for the zone covering the flight of the subject aircraft. No warning was given of the possibility of turbulence and down draughts in the Kaimai area, although a storm commenced to rage during the night of 2 July, and power supplies were cut off in the early hours of 3 July due to poles being blown down in the vicinity of Gordon.

According to Regulation 38 (4) of the Civil Aviation Regulations (1953): regarding minimum terrain clearance altitudes -

> "No aircraft, unless landing or taking-off, shall be flown in accordance with instrument flight rules at a lower height than 1 000 ft above the highest obstacle located within 5 NM of the estimated position of the aircraft in flight:
>
> "Provided that in areas of mountainous terrain a clearance of at least 2 000 ft shall be maintained."

To determine the minimum safe altitude for the route from the Browns Bay locator to Tauranga beacon, Mount Te Aroha, which is 3 126 ft, was used as a basis for calculation. Following consideration as to whether the route terrain clearance area contained terrain which should be classified as mountainous, it was the unanimous opinion of the Operations Planning Section, Civil Aviation Administration, that mountainous terrain clearance was not required, and the minimum safe altitude for the route was fixed at 4 100 ft, i.e. 3 126 + 1 000 ft, rounded off to the nearest 100 ft.

It appeared that the aircraft was flying in accordance with this regulation.

It was considered that when the subject flight was over the Thames coastline, the crew probably obtained an accurate position by visual reference to the ground. Failing such a ground sighting, a DME reading from Whenuapai would have made possible a ground speed calculation, and a back bearing on the radio compass on Browns Bay locator would have given a track check. Having considered many combinations of wind strength, headings, tracks, and ground speeds, the Court concluded that at the halfway point in the flight the aircraft was probably on track and ahead of time. Judging from the weather forecast provided, the crew might have expected the wind would decrease in strength over the last part of the trip, since the wind velocity south of Tauranga at 5 000 ft was given as 060°/25 kt compared with 070°/40 kt from Whenuapai to Tauranga. However, the wind actually increased up to a maximum of 70 to 80 kt, resulting in a drift to starboard and in a reduced ground speed. Based on the evidence of 29 witnesses, who heard or saw the aircraft between Kerepehi and Gordon, together with a knowledge of the wind velocity, it was possible to plot the track of the aircraft with reasonable accuracy. Evidence of the weather in the area, combined with the testimony of experienced pilots, led the Court to conclude that for the greater portion of the last 15 minutes of flight the radio compasses were affected by terrain and precipitation static, and were not giving adequate tracking guidance. At 0904 the flight reported that it would be reaching Tauranga four minutes later. Although the changed ETA had probably been calculated 15 minutes earlier, it was felt that Tauranga was not advised of the amendment, because the crew believed that satisfactory communications were unlikely until the flight had passed to the east of the Kaimai Range. Also, they may have been waiting for another position check. If the radio compass was operating satisfactorily it probably started to settle down around 0904 hours, and this would have indicated to the crew that the aircraft was approaching Tauranga on the starboard side of the beacon. The crew unaware of the displacement of the aircraft to the west, would have believed they were close to the Tauranga beacon and in a good position to turn onto 056°, the bearing of the outbound leg of the let-down procedure. Shortly thereafter the aircraft made its descending turn, encountered the severe down draught and turbulence then crashed. As there was evidence that additional power was applied during the last few seconds of flight, it was believed that an abortive attempt had been made to regain height at that time.

2.2 Conclusions

Findings

Both pilots were satisfactorily certificated and had considerable experience on DC-3 aircraft. During their latest medical examination they were found to be physically fit. Although a post-mortem examination revealed that the co-pilot had a severe degree of coronary disease, there was no evidence that it contributed in any way to the accident.

The aircraft was airworthy and no failure or deficiency of the engines contributed to the accident. Its gross weight was within the authorized limits. The centre of gravity was not mentioned in the report. The aircraft was equipped with various aids to navigation, including distance-measuring equipment (DME). Maintenance records indicated a number of unserviceability reports of the DME and this equipment might not have been operating satisfactorily on the day of the accident. Furthermore at that time Tauranga Airfield was not equipped with DME. Also the aircraft radio compasses were probably affected by terrain and precipitation static during the last 15 minutes of the flight.

The area weather forecast induced the crew to believe that the wind strength would diminish during the last part of the flight whereas it actually increased considerably. This resulted in a drift to starboard and in a reduced ground speed of which the crew was unaware. Believing they were close to the Tauranga beacon and in good position to start the let down procedure, a descending turn to 065 was initiated. The aircraft then encountered turbulence and a severe down-draught of the order of 2 000 ft/min and crashed in a cleft of the Kaimai Range, 327 ft below the summit of Mount Ngatamahinerua

Cause or Probable cause(s)

The main cause of the accident was a strong downward current in the lee of the Kaimai Range close to the Gordon quarry. This downward current carried the aircraft below the level of the crests of the range where, under the conditions prevailing at the time, the aircraft encountered an area of extreme turbulence in which it was impossible for the pilot to regain effective control and recover height.

Contributory causes of the accident were:

a) The pilot-in-command of the aircraft was unaware of his true position and initiated a premature descent. However, it must be appreciated that he decided to descent only to the level officially designated as the minimum safe altitude in the area of his descent.

b) The decision of the Civil Aviation authorities to classify the Kaimai Range as non-mountainous terrain for the purpose of determining the safe altitude for the route.

c) The misleading forecast of the upper winds between Whenuapai and Tauranga.

3. Recommendations

Following this accident the Court recommended that:

- the installation of DME at aerodromes used by air transport operators be accorded priority and that reliable airborne DME equipment be provided on passenger aircraft operating on scheduled flights;

- a critical examination be made of existing minimum safe altitudes for air routes in New Zealand, and that such an examination be made in conjunction with meteorological experts and those who have made a specialized study of vertical air currents (such as the gliding fraternity);

- where the forecast wind velocity is 30 kt or greater at planned cruising level, the minimum safe altitude for DC-3 aircraft on any route be increased by 1 000 ft and where the forecast wind velocity is 55 kt or greater DC-3 flights be cancelled;

- a climbout procedure be initiated for instrument flight rules departures from Tauranga so that aircraft set heading at the Tauranga beacon at not less than 3 000 ft;

- when DME equipment is not available, or is suspect for any reason, aircraft flying under instrument flight rules, arriving at Tauranga, remain at the en route cruising altitude until overhead the beacon. Other routes which involve high terrain and lack of positive fixing should also be examined with this precaution in mind;

- ballpoint pens be used by air traffic control officers and no superimposed alterations to figures be permitted;

- a forecaster be made available at Whenuapai Airport to brief and de-brief crews;

- where possible and practicable, specific winds be furnished rather than an average for the route and forecasters be encouraged to comment on any suspected unusual weather phenomena along the route;

- an investigation be carried out into the feasibility and cost of fitting a crash-proof radio beacon to aircraft which would operate on impact and be available to guide searching aircraft to the accident site;

- the possibility of installing flight recorders on turboprop and jet aircraft should be promptly and carefully investigated particularly in the light of recent practice and compulsory requirements in certain other countries. (The Court was not disposed to recommend the fitting of flight recorders to DC-3 aircraft because it doubted the expense was justified.)

4. Action taken

Following the accident, the complementary ground equipment required for the use of DME was installed at Tauranga Field.

On 8 July 1963 (i.e. 5 days after the accident) the minimum safe altitude of the Whenuapai/Browns Bay - Tauranga route was raised to 5 126 ft, an addition of 1 026 ft, as a precautionary measure, due to the possibility of excessive down draughts around the Kaimai Range.

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