NO. 93-020

MID-AIR COLLISION
AEROSPATIALE AS 355 F1 HELICOPTER
PIPER PA 28-181
ZK-HIT/ZK-ENX

AUCKLAND CITY

26 NOVEMBER 1993

ABSTRACT

This report explains the mid-air collision of a AS 355 helicopter with a PA 28 aeroplane, both on Police patrol flights over Auckland City on 26 November 1993. Safety issues discussed include the limitations of the "see and avoid" concept of collision avoidance, the use of radio contact between aircraft and the variety of radio frequencies in use.

AIRCRAFT:	Aerospatiale AS355F1 helicopter Piper PA 28-181	OPERATOR:	Airwork (NZ) Ltd
REGISTRATION:	ZK-HIT/ZK-ENX	PILOTS:	Mr R J Harvey Mr A A Connors
PLACE OF ACCIDENT:	Auckland City	OTHER CREW:	Sergeant L Grant Constable A Sampson/Nil
DATE AND TIME:	26 November 1993 1734 hours*	PASSENGERS:	Nil/Nil

SYNOPSIS:

The Transport Accident Investigation Commission was informed of the accident at 1820 hours on 26 November 1993. Mr J J Goddard was appointed Investigator in Charge and commenced the field investigation later that evening. ZK-ENX was on a routine Police road traffic patrol over Auckland City while ZK-HIT was climbing out after take-off for a Police patrol flight when a collision occurred. Both aircraft fell out of control onto the motorway area, and all crew members were killed.

1.1 History of the Flight:	1.2 Injuries to Persons:	1.3 Damage to Aircraft:	1.4 Other Damage:
See page: 3	Crew: 3 Fatal/1 Fatal Passenger: Nil/Nil Other: 1 Minor	Both destroyed	Minor damage to buildings, motorways and motor vehicles

1.5 Personnel Information:

	ZK-HIT Pilot in Command total Flight Times		ZK-ENX Pilot in Command total flight times	
	Last 90 days	Total	Last 90 days	Total
All Types	146	13589	221	1282
On Type	131	1247	181	754

1.6 Aircraft Information:
See page: 5

1.7 Meteorological Information:	1.8 Aids to Navigation	1.9 Communications:
See page: 5	Not applicable	See page: 5

1.10 Aerodrome Information:	1.11 Flight Recorders:	1.12 Wreckage and Impact Information:
See page: 7	Nil	See page: 7

1.13 Medical and Pathological Information:	1.14 Fire	1.15 Survival Aspects:
Post Mortem and toxicological investigations revealed no abnormalities which might have affected either pilot's ability to conduct his flight.	See page: 7	The accident was unsurvivable for the occupants of either aircraft.

1.16 Tests and Research:	1.17 Additional Information:	1.18 Useful or Effective Investigation Techniques:
See page: 9	See page: 11	Nil

2. Analysis:	3. Findings:	4. Observations:	5. Safety Recommendation
See page: 15	See page: 19	Nil	See page: 20

*All times in this report are NZDT (UTC + 13 hours)

1. History of the flights

1.1.1. ZK-ENX, a Piper Archer aeroplane, was operated on contract to New Zealand Police to provide a road traffic patrol service over Auckland on weekday mornings and afternoons during periods of peak traffic. The patrol flights used the radio callsign "Pact 1" (Police Airborne Control of Traffic). The routine flights, between 0700 and 0900, and 1600 and 1800 hours, departed from Ardmore Aerodrome then flew repetitive circuits of about 15 minutes duration covering the urban motorways and interchanges. The normal patrol altitude was 1500 feet. Normally the pilot would transmit a brief traffic bulletin to Police Control once on each circuit. This information was then made available to local radio stations for public broadcast.

1.1.2. In addition to the routine patrol, Police Control would, when advised of a road accident in the area, request Pact 1 to report on it. The pilot would then fly an orbit around the scene and report back on the accident and its effects on the traffic flow.

1.1.3. Pact 1 departed from Ardmore at 1559 hours on 26 November 1993, and was flown over Auckland on a normal patrol. RTF traffic with Pact 1 recorded at both Whenuapai Tower and Auckland Police Control indicated the general routes followed and the nature of road traffic monitored by the pilot. Several road accidents or breakdowns were addressed during the 1½ hours before the collision.

1.1.4 Shortly after 1732 hours, as Pact 1 was being flown south from North Shore towards central Auckland, Police Control advised of a road accident on the Southern Motorway near the Symonds Street on-ramp. The aircraft flew past this location about one minute later, heading south-east. It was then flown in a left turn around the location and was turning through a south-westerly heading when the collision with the helicopter occurred, at 1734:48 hours. The pilot of Pact 1 was making a RTF report to Police Control on the road accident which was interrupted at about this time.

1.1.5. ZK-HIT, an Aerospatiale Twinstar helicopter, was operated on contract to New Zealand Police to provide a crime patrol vehicle over greater Auckland on weekdays. It was positioned each day from Ardmore to Mechanics Bay Heliport, 1 NM east of the central city, where the Police Air Support Unit was based. Random patrols were flown over the area throughout the day, usually at an altitude of 1000 feet, and the helicopter, which used two radio callsigns—"Police One" with Air Traffic Control but "Eagle" with the Police—was often tasked by Auckland Police Control using the Police multiplex radio system. The Police radio system also enabled the crew to monitor other Police activity and to task themselves to assist.

1.1.6. The helicopter was crewed by a civilian pilot employed by the operator, and by two Police observers who were specially trained members of the Police Air Support Unit. The senior observer directed the Police support function of the helicopter and operated the Police radios, while the rear seat observer did the detailed navigation. The pilot was overall commander of the aircraft.

1.1.7. ZK-HIT had landed at Mechanics Bay at 1622 hours after a routine patrol. After a break of about an hour the crew prepared to depart on another patrol. The pilot made a RTF broadcast to "Mechanics Bay Traffic" that they were lifting off, and the departure time was logged in the office as 1733 hours. Shortly after, while the helicopter was climbing out, the Mechanics Bay office asked the pilot to call Auckland Information to inquire about another Company helicopter which they expected to arrive. The pilot did this, and reported back by RTF. These RTF exchanges probably occupied the pilot for 45 to 60 seconds. No other RTF traffic with either "Police 1" or "Eagle" was recorded from this flight.

1.1.8. Shortly after its departure to the north, over Waitemata Harbour, the helicopter was turned left onto a south-westerly heading. It was flown, climbing, across the city to near Queen Street where it was turned a further 30° to the left, at about 1734:30 hours. The helicopter then continued climbing in a straight line until the collision at 1734:48 hours.

1.1.9. After the collision the left wing of ZK-ENX separated from the aircraft. The aircraft rolled and dived steeply to collide with the elevated carriageway on the

interchange between the Northern and Southern Motorways. The left wing fell to lodge on the tower of a church near Queen Street.

1.1.10. After the collision the main rotor and transmission, and the rear tail boom, vertical stabiliser and tail rotor of ZK-HIT separated from the helicopter. The helicopter fell onto the on-ramp from Grafton Road to the North-western Motorway, under Symonds Street Bridge. A severe fire broke out on impact. The main rotor and tail section fell into a nearby cemetery by Karangahape Road.

1.1.11. The accident occurred in daylight at 1734:48 hours at a position close to the intersection of Queen Street and Karangahape Road, at an altitude of about 1400 feet amsl. National Grid Reference 675812, NZMS 260, sheet R 11 "Auckland". Latitude 36° 51.5'S, longitude 174° 45.5'E.

1.5. Personnel information

1.5.1. Ross Jeffree Harvey, 41, was pilot in command of ZK-HIT. He held Commercial Pilot Licences (Helicopter) and (Aeroplane), number 14592, with Agricultural, Chemical and Instrument Ratings for both licences, and a Helicopter Instructor Rating, categories C, D and E. He held Type Ratings for 13 helicopter types, including the AS 355 F1. Limitations on his CPL(H) were related only to his Instructor Rating.

1.5.2. His class 1 Medical Certificate was valid until May 1994, and included no restrictions.

1.5.3. His last Biennial Flight Review was completed satisfactorily on 19 July 1993.

1.5.4. His last proficiency check on the AS 355 type in accordance with Civil Aviation Regulation 76 was completed satisfactorily on 11 May 1993.

1.5.5. His total flying experience was 13588.6 hours, of which 9156.4 hours was on helicopters. His experience on the AS 355 type was 1246.6 hours.

1.5.6. During the previous 90 days he had flown 146 hours, of which 130.8 hours was on the AS 355 type.

1.5.7. During the previous 7 days he had flown 11.9 hours, of which 10.2 hours was on the AS 355 type.

1.5.8. He had first been employed part-time on Police operations in early 1989, then since January 1991 this had been his principal job.

1.5.9. On the day of the accident his duty period started at 1330 hours, and was preceded by a 19½ hour break. It was his fifth consecutive duty day since a two day break.

1.5.10. The Police observer crew members on ZK-HIT were Sergeant Lindsay Eion Grant, 39, and Constable Alastair Alan Sampson, 27. Sergeant Grant, the leader of the Air Support Unit, had five years experience of this role, while Constable Sampson had six months experience.

1.5.11. No formal licence related to their crew roles, but initial and recurrent training qualified them for their duties. In addition to the Police observer function, these included helicopter ground crew tasks, passenger briefing and safety, and keeping a lookout for aircraft traffic while airborne.

1.5.12. Allan Anthony Connors, 27, was pilot in command of ZK-ENX. He held Commercial Pilot Licence (Aeroplane) number 31181, with Instrument, category C Instructor and Glider Towing Ratings. His logbook Type Rating Certificate was endorsed for groups A,B,C,D and F, which included the PA 28 type. Limitations on his licence related only to his Instructor Rating.

1.5.13. His class 1 Medical Certificate was valid until 14 July 1994 and included no restrictions.

1.5.14. His last Biennial Flight Review was completed satisfactorily on 1 October 1993.

1.5.15. His last proficiency check on the PA 28 type in accordance with Civil Aviation Regulation 76 was completed satisfactorily on 30 November 1992.

1.5.16. His total flying experience was 1282.2 hours, of which 754.2 hours was on the PA 28 type.

1.5.17 During the preceding 90 days he had flown 220.7 hours, of which 180.9 hours was on the PA 28 type.

1.5.18. During the preceding 7 days he had flown 21.8 hours, of which 15.3 hours was on the PA 28 type.

1.5.19. He had flown 701.7 hours on Police traffic patrol operations, mostly in ZK-ENX, since 30 November 1992.

1.5.20. His duty period started at 1530 hours, and was preceded by a 11½ hour break. He was on duty on the previous day, flying traffic patrols in the morning and afternoon, and had also flown a night IFR flight from 2310 to 0400 hours.

1.6. Aircraft information

1.6.1. Aerospatiale AS 355 F1 helicopter ZK-HIT, serial number 5176, had a non-terminating Certificate of Airworthiness in the standard category, and a valid Maintenance Release. Maintenance documents recorded that normal maintenance had been carried out in accordance with the Maintenance Manual.

1.6.2. Piper PA 28-181 aeroplane ZK-ENX, serial number 28-7790212, had a non-terminating Certificate of Airworthiness in the standard category, and a valid Maintenance Release. Maintenance documents recorded that normal maintenance had been carried out in accordance with the Maintenance Manual.

1.6.3. Each aircraft was loaded below its maximum permitted weight, and within its approved centre of gravity range.

1.6.4. ZK-HIT was painted black with silver and blue trim colours, and had a red strobe light on the vertical stabiliser.

1.6.5. ZK-ENX was painted white with blue, red and grey trim colours, and had strobe lights on the wing tips and a rotating beacon on the vertical stabiliser.

1.6.6. Radio communications equipment in ZK-HIT included two aircraft VHF transceivers, two Police band UHF FM multichannel scanning transceivers, and a cellular telephone.

1.6.7. Radio communications equipment in ZK-ENX included two aircraft VHF transceivers, and one Police band single channel VHF AM transceiver.

1.7. Meteorological information

1.7.1. At the time of the accident the weather over Auckland City was fine with scattered cumulus cloud and excellent visibility. A light south-westerly breeze was blowing.

1.7.2. The ATIS at Whenuapai (7 NM north-west of the accident site) broadcast Information Bravo from 1705 hours, which included:

Surface wind 210°M at 5 knots
Cloud 3 octas at 2500 feet
Visibility 40 km
Temperature +17°C, dewpoint +10°C
2000 foot wind 250°M at 15 knots
QNH 1013 hPa

1.7.3. The position of the sun at the time of the accident was 247°M in azimuth and +32° in elevation.

1.9. Communications

1.9.1. Radio frequencies used by both aircraft were recorded on tape by Police Control and local Air Traffic Control facilities, but not at the Mechanics Bay office.

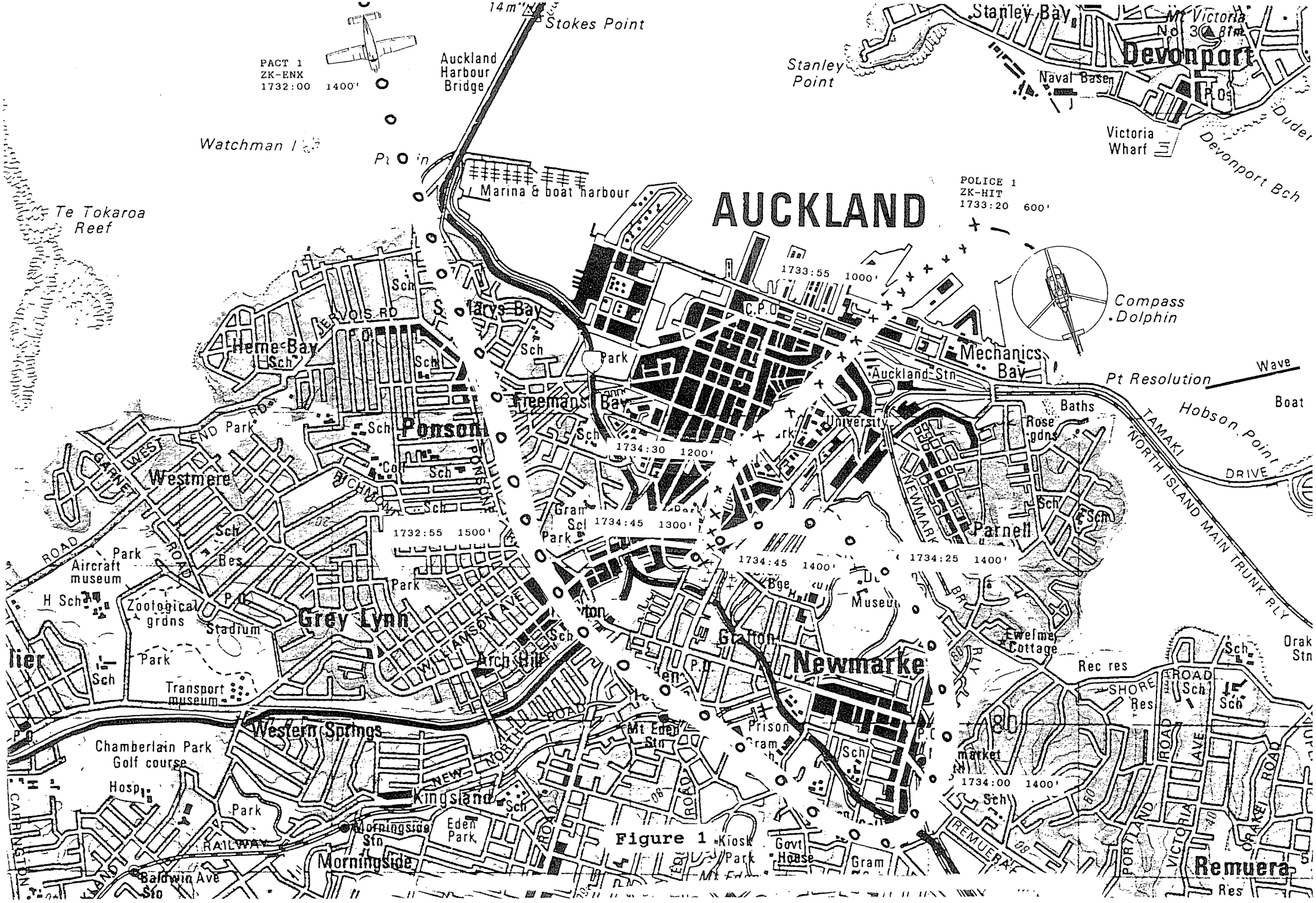
1.9.2. Normal communications were achieved with Police 1 (ZK-HIT) by the office at Mechanics Bay on 129.9 MHz, and by Auckland Information on 118.5 MHz. No other communications were found on the records of other aircraft or Police frequencies during the brief flight.

1.9.3. Normal communications were achieved with Pact 1 (ZK-ENX) by Ardmore Tower on 118.1 MHz, Whenuapai Tower on 134.5 MHz and by Police Control on a dedicated VHF frequency during the 95 minutes of the flight. Pact 1 had communicated with Whenuapai Tower at 1731:50 hours on vacating the Whenuapai CTR, and was subsequently communicating with Police Control just before the accident occurred.

1.9.4. Each aircraft was equipped so that its pilot could monitor two VHF frequencies at once, except when he was transmitting on either frequency. In addition the pilot of ZK-HIT could choose to monitor the Police radios as well as the crew conversation on the intercom system.

1.9.5. The accident occurred in uncontrolled (class G) airspace between Auckland CTR, 6 NM to the south, and Whenuapai CTR, 1.5 NM to the north-west, and below the Auckland TMA which was above 2500 feet amsl at that point. No specific position reporting procedures applied in this area, and pilots of radio-equipped VFR aircraft commonly listened out on the last Air Traffic Control frequency used, either Auckland or Whenuapai Tower. An alternative, more likely to be used by transitting aircraft on a VFR flight plan, was to use Auckland Information frequency. Mechanics Bay Heliport had an uncontrolled traffic advisory frequency specified, and helicopters arriving or departing would broadcast their positions on it.

1.9.6. The usual radio operating procedure for the pilot of Pact 1 was to have one radio permanently tuned to Police Control, and the other radio tuned to whichever ATC frequency was appropriate at the time. The normal patrol took the aircraft in and out of Whenuapai CTR, so Whenuapai Tower on 134.5 MHz was predominantly used.


PACT 1
ZK-ENX
1732:00 1400'
Stokes Point
Auckland Harbour Bridge
Watchman I
Marina & boat harbour
Te Tokaroa Reef
AUCKLAND
POLICE 1
ZK-HIT
1733:20 600'
1733:55 1000'
Compass
Dolphin
Stanley Bay
Mt Victoria
No 3
Devonport
Naval Base
Stanley Point
Victoria Wharf
Devonport Bch
Pt Resolution
Wave
Boat
Hobson Point
TAMAKI DRIVE
NORTH ISLAND MAIN TRUNK RLY
Mechanics Bay
Auckland Stn
Freemans Bay
University
Baths
Rose gdns
Parnell
Newmarket
Grafton
Museum
Ewelme Cottage
Rec res
Orak Stn
Arch Hill
Grey Lynn
Ponsonby
Westmere
Herne Bay
St Marys Bay
Aircraft museum
Zoological grdns
Stadium
Transport museum
Western Springs
Chamberlain Park Golf course
Kingsland
Morningside
Morningside Stn
Eden Park
Mt Eden Stn
Prison
Kiosk
Govt House
Remuera
1734:30 1200'
1734:45 1300'
1734:45 1400'
1734:25 1400'
1734:00 1400'
1732:55 1500'
Figure 1

1.9.7. There was no comparable usual procedure for Police 1, because of the random nature of the patrols flown, other than to call Mechanics Bay Traffic on 129.9 MHz on departure and arrival. Other ATC frequencies would be selected as required. The Police Control VHF frequency used by Pact 1 for traffic reports was not commonly monitored, but would be selected on occasions when the helicopter was approaching Pact 1's patrol area and altitude, and was then used to establish mutual positions. The Police band UHF radios were continuously monitored by the Police observers.

1.10. Aerodrome Information

1.10.1. Mechanics Bay Heliport was situated on the shore of Waitemata Harbour, 1 NM east of the city. An approach and departure sector to the north-east, away from the city, was promulgated. A discrete radio frequency of 129.9 MHz was published for position report broadcasts to "Mechanics Bay Traffic". An Aerodrome Traffic Zone surrounded the heliport, up to 1000 feet, to restrict traffic to that landing or taking off at Mechanics Bay.

1.12. Wreckage and impact information

1.12.1. The wreckage was removed to a storage depot before examination, because the closing of the various sites caused a serious obstruction to major public highways.

1.12.2. The left wing of ZK-ENX had fallen, separate from the fuselage, with the outboard 50cm of wing and aileron further separated from it. Examination of the separation surfaces at the wing tip showed that it had been sheared through from the trailing edge in a forward direction. The shear plane was at an angle of +27° upward to the plane of the wing.

1.12.3. The severed surface was correlated with marks and damage on one main rotor blade of ZK-HIT. No evidence of any other contact between the two aircraft was found.

1.12.4. The left wing spar fracture surfaces, where it had separated inboard, by the main undercarriage leg attachment, showed evidence of overload failure in upward bending.

1.12.5. The major part of ZK-ENX had suffered a severe steep angle collision with the motorway surface. The fuselage and right wing had collapsed back to the main spar, while the rear fuselage and empennage had jackknifed forward. With the left wing, the wreckage was essentially complete.

1.12.6. Little useful evidence was available from the cockpit, but both VHF comm radios were selected "ON". COMM 2 was tuned to the Police Control VHF frequency, but the frequency of COMM 1 could not be determined. The audio selector panel selections were unreliable due to impact damage.

1.12.7. The main transmission, mast and main rotor of ZK-HIT fell as a separate unit from the fuselage, with the blue rotor blade further separating, probably on ground impact. The outboard 40 cm tip of the blue blade was also separated, and had fallen remotely on a city building.

1.12.8. The blue blade and its tip showed severe leading edge damage and angled/chordwise scoring on the lower surface. Some paint smears appeared similar to the zinc chromate primer inside the wing of ZK-ENX. The red and yellow main rotor blades showed no similar damage. All three blades had severe inboard end damage, consistent with the ground impact.

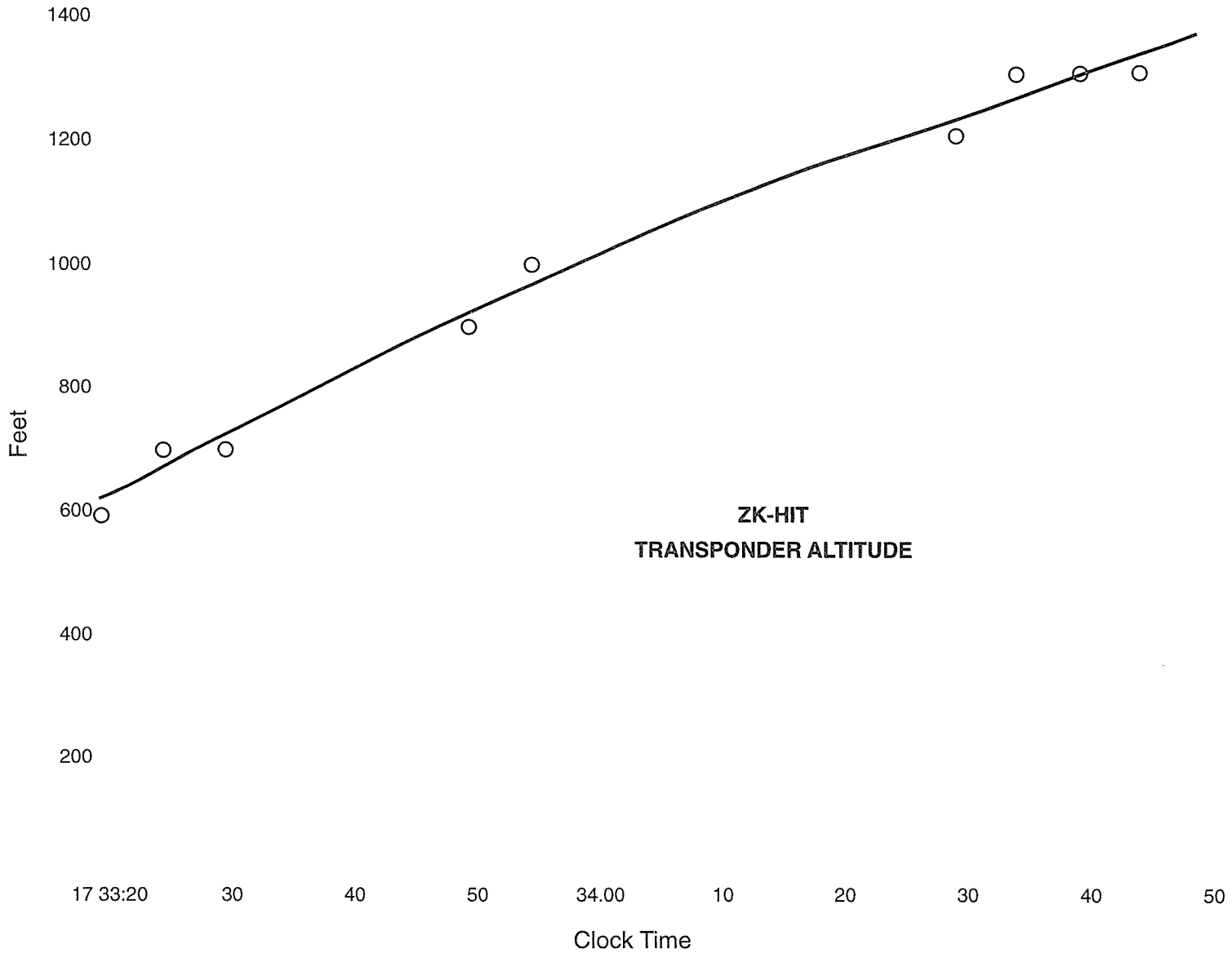
1.12.9. Damage to the upper cowls, which also fell separately about the city, indicated that the transmission had rotated rearwards and to the right while separating from the fuselage.

1.12.10. The rear of the tail boom, vertical stabiliser, tail rotor and gearbox also fell separately. Examination of the area of separation of the boom and driveshaft showed characteristic deformation typical of a main rotor strike, but at a position aft of the normal tip plane. The metal skin from aft of the spar of the left horizontal stabiliser was found, separated, and concertinaed from the root end outwards. This was also consistent with a main rotor blade exiting the tail boom to the left.

1.12.11. The fuselage of ZK-HIT was subjected to a severe fire which consumed most light alloy components. Most major items were accounted for, however. The burnt but straight tip rib and spar of the right horizontal stabiliser were found, suggesting that the main rotor had not struck it.

1.14. Fire

1.14.1. ZK-HIT was involved in a severe fire which broke out on or shortly after ground impact. It was fuelled by some 700 litres of aviation kerosene from the aircraft's


1400
1200
1000
800
600
400
200
Feet
ZK-HIT
TRANSPONDER ALTITUDE
17 33:20
30
40
50
34.00
10
20
30
40
50
Clock Time

tank. The ignition source was not determined, but numerous potential sources existed.

1.14.2. A witness video recording showed the helicopter falling after the collision. No evidence of pre-ground impact fire was recorded.

1.16. Tests and research

1.16.1. Radar data recorded at the Auckland Air Traffic Control Centre between 1730 and 1736 hours was obtained from the Airways Corporation of New Zealand. This was in the form of selected plots of secondary and primary radar returns. Both of the aircraft involved in the accident produced secondary returns which were identified by the transponder codes permanently assigned to them, and which displayed mode C altitude readouts.

1.16.2 These altitude readouts derived from the encoder in each aircraft. Each encoder signalled the height of the aircraft digitally, in 100 foot increments, above the standard pressure datum of 1013 HPa. The calibration tolerance on each encoder was ±125 feet, but in practice ±100 feet was normally achieved. The signals from two aircraft at the same height could therefore be at variance by a maximum of 200 feet. The radar system applied a correction to the signals for the local QNH so that the radar displayed altitude information.

1.16.3. Because neither aircraft was under radar control the mode C altitude displays were not formally verified, but a position report from Pact 1 to Whenuapai Tower when vacating the CTR at 1650 hours had included an altitude report of 1500 feet. The mode C readouts were 1400 feet at 1649:40 and 1300 feet at 1650:10 hours. These verified the accuracy of the transponder as within the tolerance normally accepted by Air Traffic Control of ±300 feet.

1.16.4. Some smoothing and interpolation was used to produce the track plots derived from the primary and secondary radar plots, which are shown overlaid on a map of Auckland (Figure 1). A few secondary radar returns for each aircraft were missing, either as a result of terrain masking, or the aircraft turning and thus shielding its transponder aerial from the radar. The altitude information shown was that derived from each aircraft's encoder by ATC. The first radar return of Police 1 was at 600 feet, heading south-west, so the flight path to that point is an estimate only.

1.16.5. Each radar return occurred at 5 second intervals, and the plots indicated an intersection of the two flight paths at 1734:48 hours, the estimated time of the collision.

1.16.6. Measurement of the distances travelled on the plot over a 60 second period gave a ground speed for the PA 28 of 110 knots, and for the AS 355 of 65 knots.

1.16.7. Mode C radar data showed that the PA 28 was in level flight at 1400 to 1500 feet, while the AS 355 was climbing from 600 feet at the first radar return to 1300 feet at 1734:45 hours. Figure 2 shows a graph of the climb path profile of the helicopter.

1.16.8. Figure 3 shows the relative bearings of each aircraft for the last 45 seconds, as well as the bearing of the sun. Separation distances measured show that the closing speed was initially about 150 knots, reducing to about 80 knots just before the collision.

1.16.9. Figures 4 and 5 show the relative positions of each aircraft at the collision.

1.16.10. Table 1 lists the derived separation distances, altitude differences, vertical angles, relative bearings and magnetic bearings for the last 45 seconds. The derived vertical angles are not accurate to 0.1° because of the potential variance between encoder altitude data, but any such variance should be constant. The change in vertical angles indicates the likely trend in relative positions.

1.16.11. Radar data showed one other aircraft in the uncontrolled airspace area between the Auckland and Whenuapai CTR's over this time. This was an unidentified primary radar target, but its speed and position suggested that it was a microlight aircraft flying from Pike's Point microlight aerodrome 6 NM south-east of the accident site.

1.16.12. Measurement of the turn which ZK-ENX was performing in the 45 seconds before the collision gave a radius of 1100 metres and a heading change of 145°. These parameters required an angle of bank of 20° at 110 knots.

1.16.13. A cockpit field of view survey was conducted for the Commission by the US Federal Aviation Administration Technical Center, Atlantic City, New Jersey. A special binocular panoramic camera was mounted at the pilot's seat position of similar aircraft, at the design eye reference point (DERP). The resulting photographs showed the extent of the cockpit windows as seen by a pilot rotating his head from side to side. Monocular obstructions were

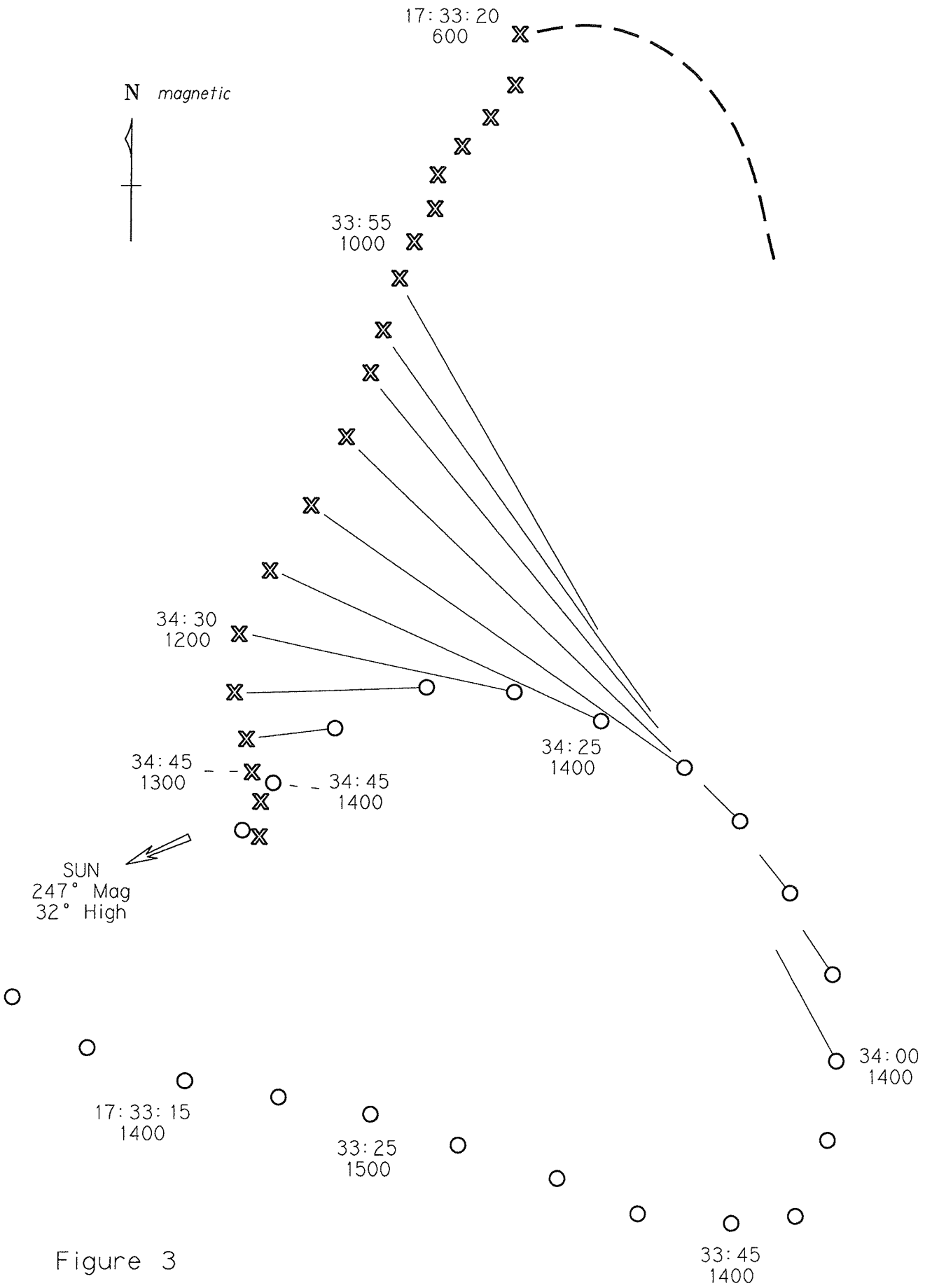

17:33:20
600
N magnetic
33:55
1000
34:30
1200
34:45
1300
34:45
1400
34:25
1400
SUN
247° Mag
32° High
34:00
1400
17:33:15
1400
33:25
1500
33:45
1400

Figure 3

TABLE 1

TIME	SEPARATION	ALTITUDE DIFF	VERT ANGLE	REL BRG from: HIT	REL BRG from: ENX	MAG BRG from: HIT	MAG BRG from: ENX
	metres	feet					
1734:00	2998	370	2.2°	311°	331°	151°	331°
:05	2618	340	2.3°	304°	341°	146°	326°
10	2215	300	2.4°	300°	353°	142°	322°
:15	1853	270	2.5°	293°	355°	234°	314°
:20	1521	250	2.9°	283°	356°	126°	306°
:25	1200	200	3.0°	271°	358°	115°	295°
:30	936	170	3.2°	263°	360°	103°	283°
:35	632	140	3.9°	270°	009°	089°	269°
:40	300	100	5.7°	276°	022°	082°	262°
:45	93	60	11.2°	295°	070°	107°	287°

also defined, and horizontal and vertical grid lines at 5 degree intervals were superimposed on the photographs.

1.16.14. Diagrams were made from each survey photograph, with slight modifications to allow for the most likely eye points of pilots of the stature of the pilots of ZK-HIT and ZK-ENX. The PA 28-181 diagram was rotated and the reference grid modified to represent the 20° left bank of ZK-ENX. Supplementary local measurements were made in a PA 28-181 cockpit to establish the lowered position of the pilot's sun visor.

1.16.15. The relative angular positions (Table 1) of each aircraft from 1734:20 to 1734:45 hours were plotted on the diagrams of the other aircraft. The positions of the sun were similarly plotted. (Figure 6)

1.16.16. The study revealed that for the pilot of ZK-ENX the helicopter would have been located low in his central windscreen, beneath the horizon and just above the nose of his aircraft, at 1734:20 (28 seconds before the collision), which was when the aircraft first closed sufficiently to be identifiable. It would have moved steadily right to become obstructed by the aircraft's nose about 10 seconds later. The study also showed that at about the same time the sun appeared in the top left of his windscreen, to move across to the right as the aircraft turned left. The dark transparent sun visor, if used, could have screened him from direct light from the sun.

1.16.17. For the pilot of ZK-HIT, at 1734:20 the aeroplane would have been located in the top left corner of the left windscreen, above the horizon and within his monocular view for a few seconds only. It would have been moving aft, to go out of his view behind the windscreen and above the left window. After he turned the helicopter, at 1734:30, the aeroplane would have moved forward but would have remained out of his view above the window and windscreen. The sun was outside his field of vision above the right side of his windscreen.

1.16.18. Local measurements were made in a AS 350 helicopter with similar left doors and windows to ZK-HIT, to determine the fields of view to the left of the observers seated in the left front and rear seats. These measurements showed that the top of each adjacent window was 14° above the horizon from a normal seated position. From the front seat the adjacent window gave a lateral view from 60° to 130° left, while the rear seat provided a view from 40° to 140° left. These fields of view would have presented no obstruction to either Police observer on ZK-HIT to prevent him from seeing the approaching aeroplane from 1734:20 to 1734:45.

1.17. Additional information

1.17.1. Several hundred witnesses on the ground gave evidence about the two aircraft, their flight paths and the ensuing collision. While there was some variation in details reported, probably resulting from individual locations or circumstances, the consensus supported the evidence of the radar data.

1.17.2. A video recording made by a witness on Mount Eden, 1.3 NM south of the accident site, showed both aircraft falling shortly after the collision, but did not record the collision itself or the paths of the aircraft beforehand, which had been above the frame of the camera. The trajectories of the aircraft supported the evidence of the radar data, and the general scene showed the prevailing clear, bright weather conditions, with no cloud shadows in

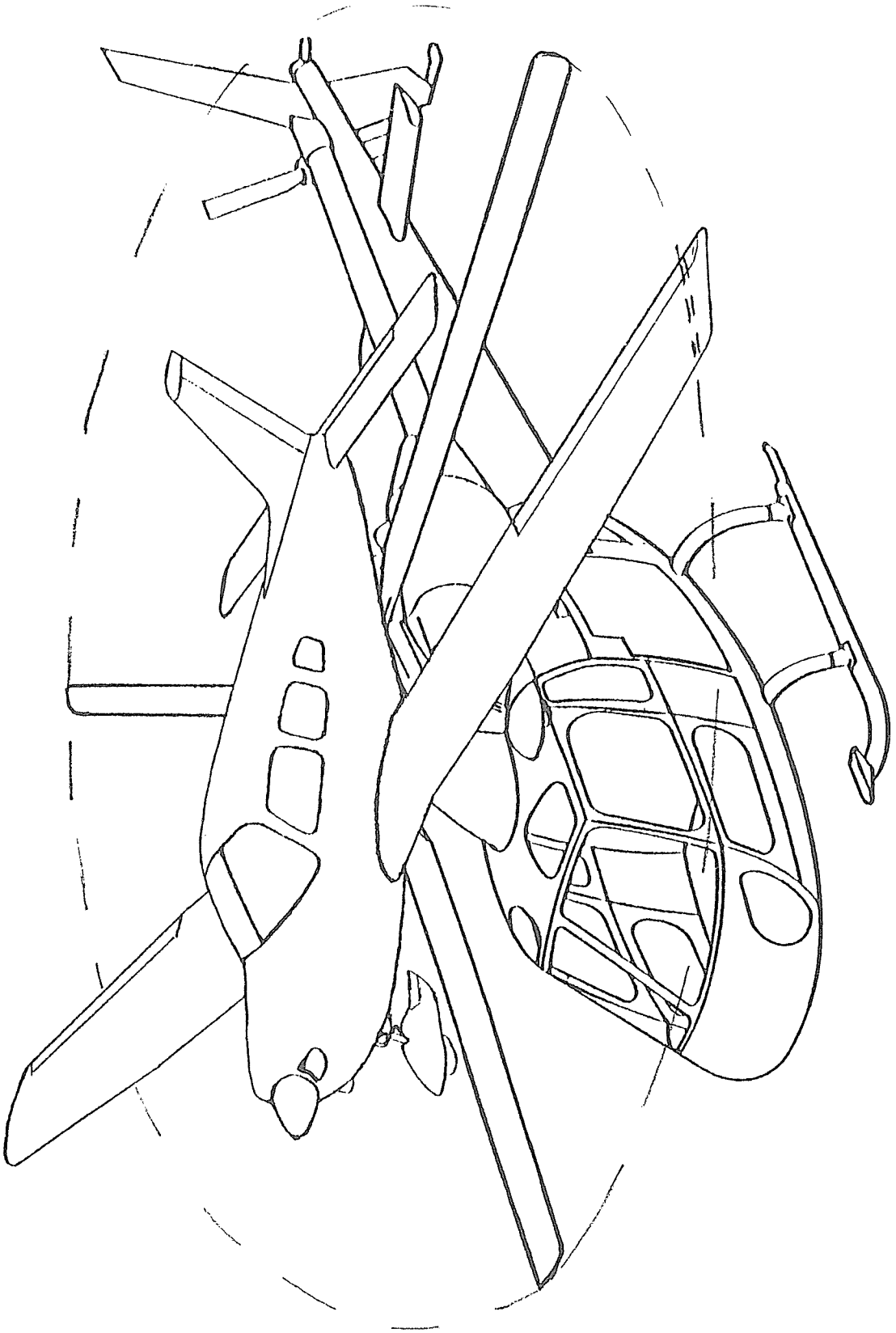


Figure 4

the accident area. Only distant scattered cumulus were shown, beyond North Shore and to the south of Auckland.

1.17.3. The Airwork (NZ) Operations Manual included under:

"5—Police Traffic Patrol

4. Heights at which the patrol is to be carried out at.

4.1. 1500' or lower depending on

— weather conditions

— required by ATC

— or in accordance with Reg 38 of the Civil Aviation Regulations.

4.2. NB The Police Eagle Helicopter also operates in the same areas, and the pilots have agreed to carry out their operations at 1000' where possible."

and

"12. Miscellaneous

12.4 Under no circumstances is the Traffic Patrol aircraft to operate in close proximity to the Eagle Helicopter while the Helicopter is engaged on an incident.

A good lookout is imperative and shall be maintained at all times."

1.17.4. Section 6 of the same Operations Manual titled "Police Helicopter—Operation Eagle" did not contain any complementary information similar to the above, with reference to the Police Traffic Patrol aircraft. This section did state:

"7. Noise Abatement

Unless absolutely necessary the helicopter shall remain at a minimum altitude of 1000 ft above the terrain."

1.17.5 Regulation 4 of Civil Aviation Regulations (1953) defined:

"Altitude" means the vertical distance of a level, a point, or an object considered as a point, measured from mean sea level.

"Height" means the vertical distance of a level, a point, or an object considered as a point, measured from a specified datum; and includes the vertical dimension of an object.

1.17.6. Discussions with other pilots of each aircraft, and with Police crew, did demonstrate that they had good awareness of the operational altitudes and procedures of each other. The Police Traffic Patrol aeroplane was normally flown at an altitude of 1500 feet, and the Police Eagle helicopter was normally flown at an altitude of 1000 feet.

1.17.7. The New Zealand Aeronautical Publication—Planning Manual, in RAC 5, Airspace, Appendix 1, listed the applicable rules and air traffic services for different classes of airspace. It showed that for uncontrolled (class G) airspace, separation (between aircraft) was not provided, but a flight information service was available.

1.17.8. RAC 6, Air Traffic Services, page 43, included:

"Flight Information Services (FIS)

FIS will be provided whenever practicable to all aircraft which are known to be affected by the information.

In the case of aircraft in flight, flight information is normally confined to information concerning the route being flown.....

FIS will include the provision of pertinent:

•

•

• On request collision hazard information to aircraft operating in class G airspace;

•

Note: The collision hazard information above includes only known aircraft which might constitute a collision hazard and will sometimes be based on data of doubtful accuracy and completeness and ATS units cannot assume responsibility for its issuance at all times, nor for its accuracy."

1.17.9. RAC 7, Radar Services, page 48, included:

"Radar services to VFR flights

within radar coverage in.....class G airspace:

Radar services are not normally provided to VFR flights operating in these types of airspace. When requested, however, every effort will be made to provide service but it will be limited to:

• assisting aircraft experiencing an emergency.

• giving navigational assistance and

• supplying information to assist pilots to avoid areas of adverse weather."

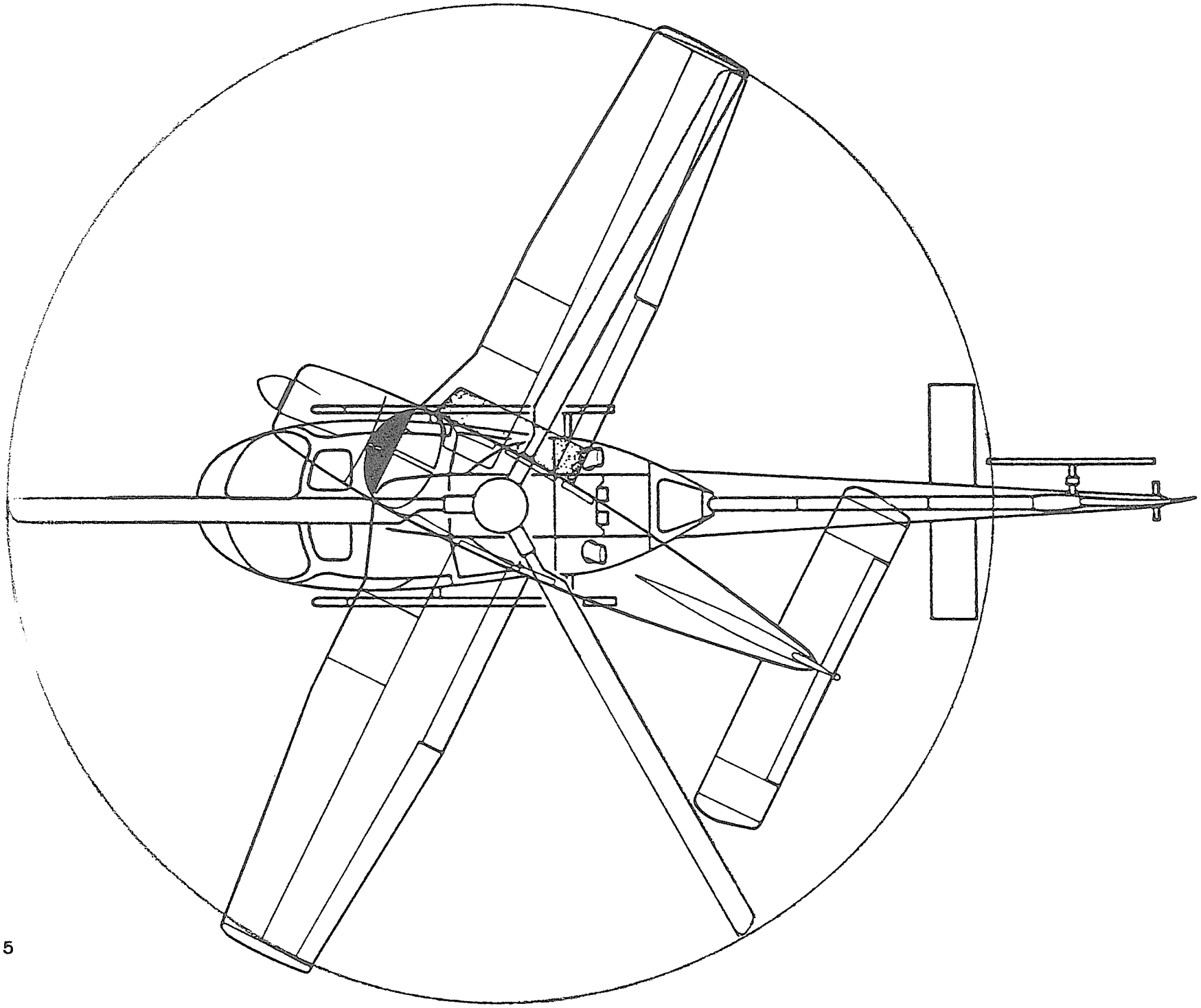


Figure 5

2. ANALYSIS

2.1. Both the AS 355 helicopter and the PA 28 aeroplane were equipped and maintained to the appropriate standards. There was no evidence that a deficiency in the airworthiness of either had contributed to the collision.

2.2. The pilots of both aircraft were appropriately qualified for the flights, and there were no known medical problems which might have affected their ability to avoid the collision.

2.3. The weather at the time was good, with clear visibility and little or no cloud in the area, and thus would not have restricted either pilot's ability to see the other aircraft.

2.4. The airspace in which the aircraft were operating was uncontrolled (class G) airspace, and thus no air traffic control service was provided, or applicable. As a result the responsibility for safety from collision hazard fell directly on the pilots in command of the aircraft involved, and was not in this case shared with any other party.

2.5. This responsibility for collision avoidance was a basic pilot duty which depended on the "see and avoid" concept whenever aircraft were being flown in VMC. The aircraft involved in this collision were not only flying in VMC but were operating under VFR, which required them to remain in VMC, thus mandating a vigilant lookout throughout their flights.

2.6. The geometry of the approach paths of the aircraft to the collision was studied in order to determine their visibility and relative positions in the fields of view of the pilots. The cockpit field of view survey of each aircraft, prepared by the US FAA for this investigation, was also studied in order to determine to what extent either pilot's view was obstructed. (Figure 6)

2.7. The radar data showed that the PA 28 was flying at altitudes of 1400 to 1500 feet. The earlier mode C readouts of 1400 and 1300 feet before and after the time of an altitude report to ATC of 1500 feet suggested that the aircraft was maintaining an actual altitude of 1500 feet within reasonable margins. The available mode C readouts from the AS 355 helicopter showed that it was climbing, from the first radar contact at 600 feet to the collision at 1300 feet. The difference between the radar altitudes of the two aircraft at the collision, when they must have been at similar altitudes, is probably a result of the tolerances of each encoder. The graph in figure 2 was used to derive the probable climb profile of ZK-HIT.

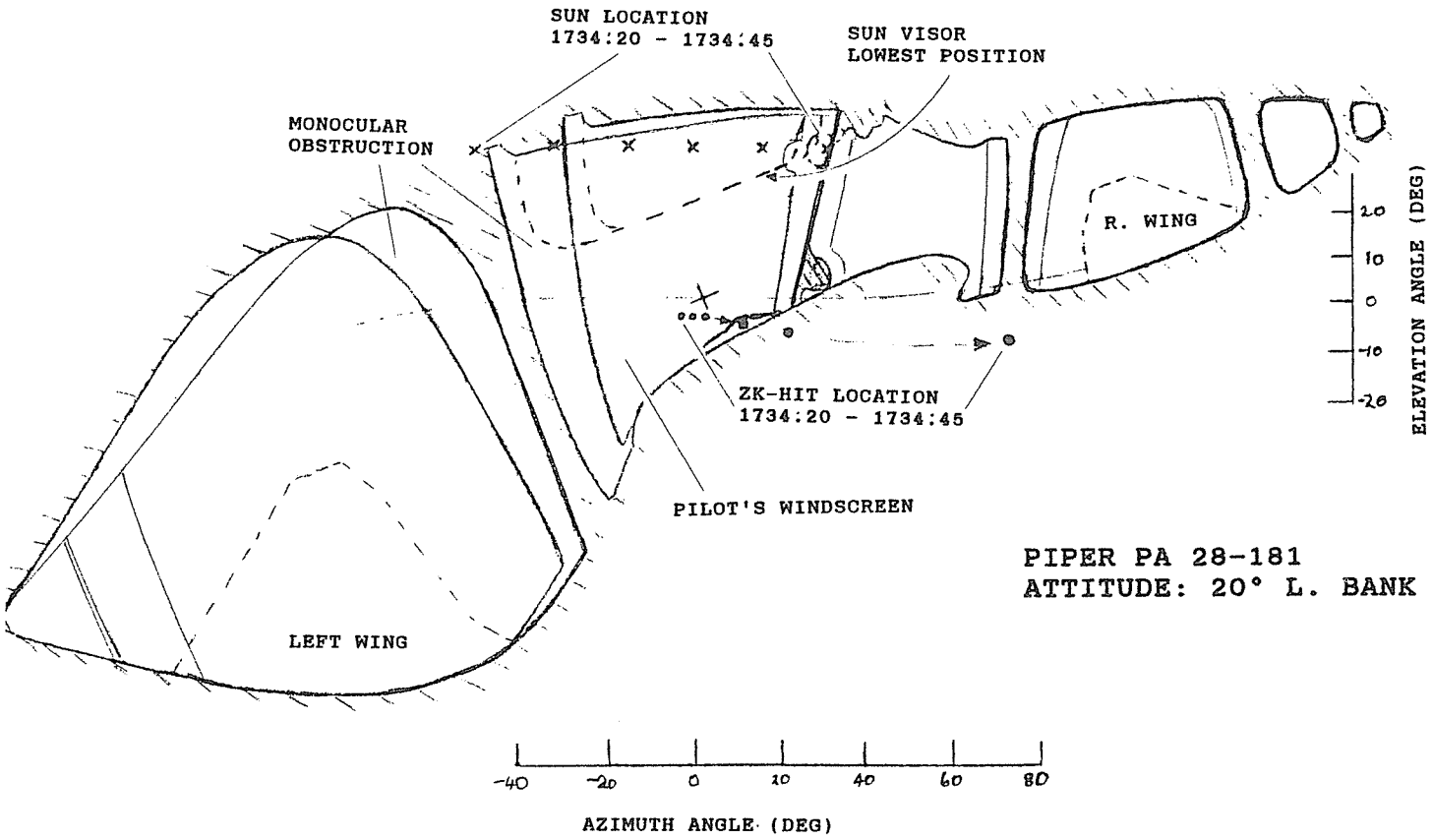
2.8. The calculated angle of bank of ZK-ENX of 20° was supported by the shear plane angle of 27° through its wing tip. As the PA 28 has a dihedral angle of 7°, a relative angle of 20° between the main rotor blade and the aeroplane was indicated. The helicopter was in straight flight, and the collision was with an advancing blade.

2.9. The track plot, figures 1 and 3, showed that at 1734:00, 48 seconds before the collision, the aircraft were closing as ZK-ENX had started turning some 10 to 15 seconds earlier. At that time they were about 3000 m apart and would have each presented a visual target of some 2.4 minutes of arc in size.

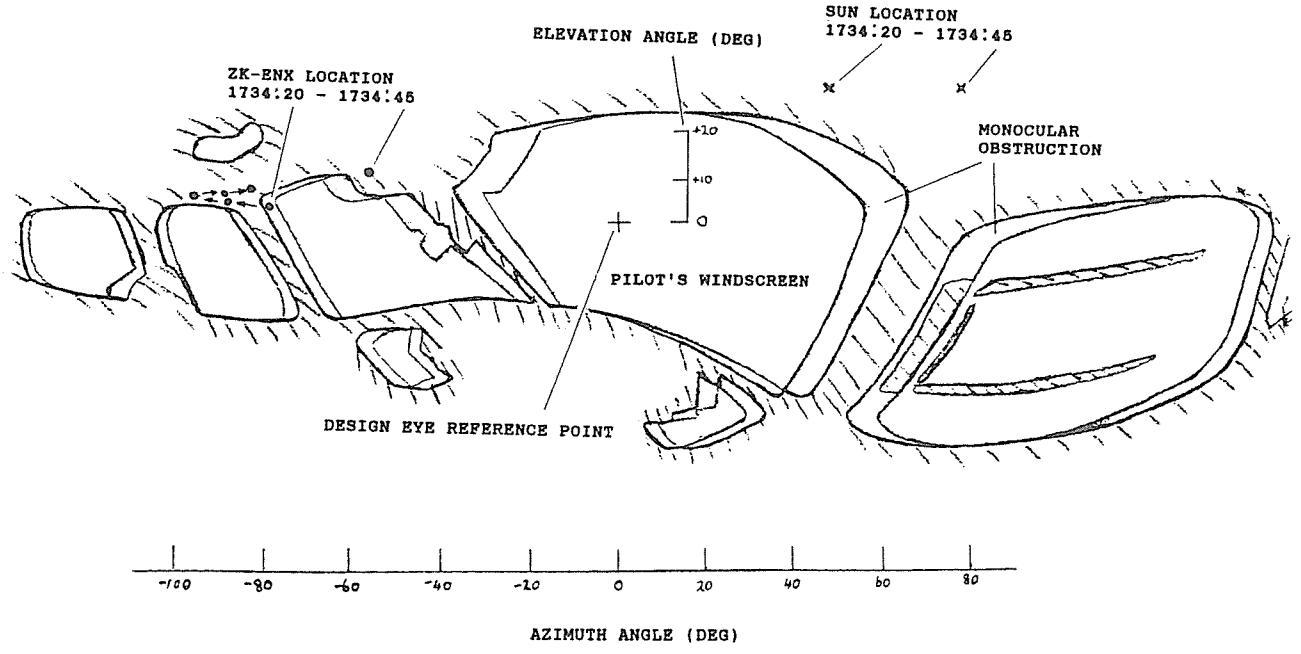
2.10. Research has established that a pilot with normal vision may be able to detect a target of 1 minute of arc in favourable conditions and should be able to identify a target of 5 minutes of arc or larger in size. These aircraft would have presented such a target to each other as they closed through about 1400 m, at about 1734:22, some 26 seconds before the collision. (Table 1)

2.11. At that time ZK-ENX was turning steadily to the left with about 20° of bank, having commenced the turn around the road accident 40 seconds earlier. ZK-HIT was flying fairly straight, climbing, and about 250 feet lower than the PA 28.

2.12. From the pilot's viewpoint in ZK-ENX, the helicopter was just left of straight ahead, in his 12 o'clock position, low in his windscreen and just above the nose of his aircraft. It was some 3° below his horizon, and would have had a background of the predominantly built-up area of North Shore, across Waitemata Harbour. His view would have been of the left side of the helicopter. The study showed that the lowering afternoon sun appeared in his field of view at about the same time, in the top left of his windscreen. If his sun visor had been raised, the resulting dazzle would have impaired his ability to discern the helicopter. If the visor was lowered, the effects of dazzle would have been mitigated, but the helicopter would not have been easily distinguished from such a background



PIPER PA 28-181
ATTITUDE: 20° L. BANK



AEROSPATIALE AS 355
ATTITUDE: LEVEL

Figure 6

against the light.

2.13. From the pilot's viewpoint in ZK-HIT, the aeroplane was a few degrees ahead of abeam his left side, in his 9 o'clock position, and 3° above his horizon. The aeroplane would have been head-on to the helicopter. It would have been partly visible to him, to his right eye, if he turned his head to the left, for only 2 or 3 seconds before it moved from sight behind the top left corner of the left windscreen. The aeroplane would have been well illuminated as it was down-sun. Its background would have been clear blue sky.

2.14. As the aircraft closed further, with the aeroplane continuing to turn, the helicopter would have moved slowly right from the aeroplane pilot's viewpoint, from straight ahead at 1734:30, to 22° right at 34:40, to probably 70° right just before the collision. It moved progressively lower as it moved right, to 5.7° below his horizon at 34:40. The cockpit visibility study showed that shortly after 1734:30 the helicopter became hidden from his sight beneath the aeroplane's nose, not to reappear. The exact time when it went out of sight was sensitive to the pilot's eye position, such as from his seat adjustment positions, but it probably allowed a maximum viewing opportunity of ten seconds.

2.15. From the helicopter pilot's viewpoint, the aeroplane moved slowly back, to 7° behind his 9 o'clock at 1734:30. His 30° left turn then brought it forwards, to 6° ahead of his 9 o'clock at 34:40. It then continued to move forwards to about his 10 o'clock position just before the collision. It progressively rose to 5.7° above the horizon at 34:40. After the aeroplane moved from sight to the left of his windscreen it remained hidden from the pilot's view. His total viewing opportunity was 2 or 3 seconds from about 1734:20.

2.16. The local measurements of the fields of view of the observers in the left front and rear seats did show that they both had available unobstructed views of the aeroplane from 1734:20 to 1734:45.

2.17. The "see and avoid" concept is a simple and easily understood means of collision avoidance. It does, however, contain some significant limitations, as well as several opportunities for its effectiveness to be further compromised.

2.18. The first obvious limitation is the short time interval which may be available in some situations. This depends both on the closing speed between the aircraft and their size, which determines how far away they may be seen. In this collision the aircraft were close enough to be identified some 26 seconds before the collision. The time for a pilot to spot another aircraft, identify it, realise it as a threat, react and have the aircraft respond to his control input has been demonstrated to be a minimum of 10 seconds. The previous 16 seconds therefore represented the critical opportunity for the pilots to see the other approaching aircraft.

2.19. The next limitation relates to the performance of the human eye. Only the narrow field of central vision produces sufficient visual acuity to enable a pilot to achieve the performance described in 2.10. As a result a pilot must perform a methodical visual scan so that his central vision may take in all of the area of potential conflict ahead and to each side of him. A typical time to complete such a scan is about 15 seconds. It follows that when a collision hazard does come within sight a diligent pilot may take up to 15 seconds of looking before he actually sees it. Any time spent on other tasks may only increase this time further.

2.20. Any obstructions to a pilot's field of view from the cockpit may obviously compromise the effectiveness of his scan, by introducing blind spots. Some of these may be overcome by the pilot moving his head to see round the obstruction, but this action does require an educated awareness of the problem. Some other areas of obstruction, such as below windows or under the aircraft's nose may be relieved to some extent by banking or turning the aircraft, but such manoeuvring may not always be appropriate.

2.21. The conventional wisdom concerning methodical scanning, as published in some flight safety material, teaches a scan from 60° left to 60° right, or from a pilot's 10 o'clock to 2 o'clock positions. While this might cover the most common directions of confliction with other aircraft, it could not suffice in this accident because the aeroplane was in the helicopter pilot's 9 o'clock position from 1734:20, only moving to the 10 o'clock position some 3 or 4 seconds before the collision.

2.22. Any distraction, perhaps by other tasks, is likely to cause a pilot to reduce his lookout, either by his looking inside at instruments, controls or maps, or by looking outside at some particular feature and thus not scanning his field of view. The pilot of ZK-ENX might well have been looking out at the road accident as he turned

his aircraft around it, to the detriment of his scan. The cockpit vision analysis, however, showed that the helicopter became shielded from his view by the nose of his aircraft from about 1734:32, 16 seconds before the collision.

2.23. Another item of conventional wisdom concerning collisions is that converging aircraft maintain a constant bearing from each other, i.e. each remains stationary in the other pilot's field of view. This only applies if they are both in straight flight, and obviously did not apply in this accident. The relative movements in this case resulted from the turning path of the aeroplane, and could have led to the helicopter crew spending time being unsure if it was on a collision course at all, assuming they saw it. On the other hand, the relative movement would have made either target easier to detect visually.

2.24. These shortcomings in the practical application of the "see and avoid" concept mean that a pilot must supplement it with compensating strategies to ensure an acceptable level of safety. These strategies include: using other crew members to actively support his lookout for traffic; avoiding where possible areas of high traffic density; complying with (or avoiding) known or established patterns of traffic; using a system of separate operational heights where regular traffic patterns may conflict; and using radio communications to report and receive traffic information.

2.25. ZK-ENX had no other crew members to supplement the pilot's lookout, but ZK-HIT had the two Police observers on board. While their primary tasks related to Police duties, they had specific training and were reportedly practised in looking for and reporting other aircraft traffic. They were seated in the left front and left rear seats, where they should have had unrestricted views of the approaching PA 28 abeam the left side of the helicopter. There was no evidence to suggest whether or not they saw the aeroplane, or what they might have been doing to prevent their seeing it. The absence of any witnessed avoidance manoeuvre suggested that the aircraft was not seen at all, or was not seen in time to alert the pilot.

2.26. Both aircraft were equipped with strobe lights. While it was not determined that they were switched on at the time, it was normal practice for each pilot to do so. In the bright sunny conditions prevailing, the strobe lights would not have been prominent on either aircraft.

2.27. The traffic density in the uncontrolled airspace area was light—the only other aircraft detected was probably a microlight some 6 NM away—so this clearly played no part in the collision. Reports suggested, however, that significant levels of light aircraft activity did sometimes prevail in this area.

2.28. The two aircraft involved were flown frequently over the area; their pilots and crew were the most familiar with each other's operations. The routine aeroplane patrol pattern in particular was well known for the helicopter pilots to avoid, or to approach with foreknowledge of the aeroplane's position.

2.29. The normal and agreed patrol altitudes of 1500 feet for the aeroplane and 1000 feet for the helicopter were common sense, and represented good airmanship in their adoption and inclusion in the "Police Traffic Patrol" part of the Operations Manual. The lack of a specific reference to this in the "Police Helicopter" part of the Manual was probably an oversight but should not have affected the issue as the procedure and the reason for it was well known and complied with by the helicopter pilots and crews. The altitudes specified could not be mandatory because of other occasionally conflicting operational imperatives, but it was evident that they were normally used.

2.30 These altitudes specified in the Operations Manual, however, were expressed in an inconsistent manner which was open to misinterpretation. The altitudes for the Police Traffic Patrol and the Police Eagle Helicopter (1.17.3) were described as "heights" without specifying the datum. In addition, the altitude specified for the Police Helicopter for noise abatement, however, (1.17.4) was described as an "altitude ... above the terrain", which was a misnomer.

2.31 While it was established that the normal patrol altitudes used were 1500 and 1000 feet (ie. above mean sea level), the altitude of 1000 feet meant that the Police Helicopter was probably flown routinely at less than 1000 feet above some terrain or obstructions over Auckland City.

2.32 The imprecise specifications of altitudes in the Operations Manual could have led to an interpretation that the helicopter should have followed the contours of the terrain to maintain a height of 1000 feet above ground level in order to comply with Minimum Safe Height Regulations, and doing so compromised the 500 foot separation between the patrol altitudes. The Operations Manual needed amendment to unequivocally specify altitudes which satis-

fied regulatory and operational requirements while achieving the 500 foot separation.

2.33. The radar evidence was that ZK-ENX was maintaining his 1500 foot altitude reasonably well, but that ZK-HIT continued to climb on this occasion through his normal 1000 feet, thereby obviating the 500 foot vertical separation which applied normally, and which would have prevented this collision. No reason for this continued climb was evident, but it might have resulted from the pilot being distracted during the climb, perhaps by the request for information from the Mechanics Bay office, and thus overshooting his normal altitude.

2.34. There was no information available to indicate any specific Police task for ZK-HIT as it departed from Mechanics Bay. Most tasks were accomplished at normal patrol altitude, so it was unlikely to have been climbed above 1000 feet deliberately. It was possible that the crew had heard Police ground patrol radio traffic concerning the road accident, and had decided to fly past it as they set out over the city. If a decision was made by the Police crew to proceed to the accident or on any other task which was known to be likely to bring the aircraft into proximity, making RTF contact first would have been both normal practice and good airmanship.

2.35. The absence of RTF contact between the aircraft may have been because either or both pilots were transmitting during the relevant period of opportunity. The Police Control VHF frequency was being used by the pilot of ZK-ENX just before the collision to report on the road accident, so he could not have received a call from ZK-HIT. Similarly, the pilot of ZK-HIT was engaged in the request for information from the Mechanics Bay office during most of his flight, using 129.9 and 118.5 MHz. If the helicopter was flown to the road accident area intentionally, without making RTF contact, and in addition allowed to climb to the known altitude of the traffic patrol aeroplane, the hazard of doing so should have been clearly apparent to the experienced pilot. However, his intention was not known, and the crew's survey of the road accident could only be a hypothesis.

2.36. While the absence of RTF communications between these aircraft may have stemmed from either pilot transmitting at the time, it became apparent during this investigation that the general mix of traffic at any other time might well include aircraft whose radios were on a variety of differing frequencies and thus not able to communicate their position reports mutually. In addition, the Mechanics Bay ATZ effectively prescribed a dedicated frequency for helicopters within it. Although it may not have affected the chain of events in this accident, it was concluded that flight safety would be enhanced if a single advisory frequency was promulgated for this uncontrolled area, including Mechanics Bay ATZ. A recommendation to the Director of Civil Aviation to this effect was made.

3. FINDINGS

3.1. Both pilots were appropriately licensed and experienced for the flights.

3.2. Both aircraft were maintained properly and had valid Certificates of Airworthiness.

3.3. Both aircraft were properly loaded.

3.4. The weather and visibility did not detract from either pilot's ability to see the other aircraft.

3.5. The sun's position may have reduced the aeroplane pilot's ability to see the helicopter, against the background at the time.

3.6. Traffic density was not a factor in the collision.

3.7. The aircraft were in uncontrolled airspace and Air Traffic Services were not involved.

3.8. The pilots were each responsible to "see and avoid" the other traffic.

3.9. The aircraft collided while the aeroplane was turning and the helicopter was climbing, at about 1400 feet.

3.10. Neither pilot saw the other aircraft in time to avoid the collision.

3.11. The aircraft were close enough for visual recognition for 26 seconds before the collision.

3.12. The helicopter was in the aeroplane pilot's

field of view for some 10 seconds, until about 16 seconds before the collision, thereafter blocked by aircraft structure.

3.13. The aeroplane was partly in the helicopter pilot's view for 2 or 3 seconds until about 23 seconds before the collision, but was outside a normal scan.

3.14. The aeroplane was in the helicopter crewmen's available fields of view throughout this 26 second period.

3.15. The helicopter crewmen did not see the aeroplane in time to alert their pilot to enable him to take effective action.

3.16. The aeroplane pilot may have been distracted from his lookout by his road traffic patrol task.

3.17. The anti-collision lights and colour schemes of both aircraft probably had little effect on their visibility in the circumstances of this accident.

3.18. The Operations Manual and mutually agreed procedures established normal operating altitudes of 1500 feet for the aeroplane and 1000 feet for the helicopter.

3.19. The aeroplane was being flown at the agreed altitude.

3.20. The helicopter was climbed through its agreed altitude to the altitude of the aeroplane.

3.21. The helicopter may have been climbed inadvertently because the pilot was distracted by an unrelated radio task.

3.22. The helicopter was flown into the well-known aeroplane patrol area without establishing mutual positions by radio.

3.23. Radio contact between pilots may have been temporarily prevented by both transmitting at the time.

3.24. This mid-air collision occurred because neither pilot saw the other aircraft in time to take effective avoiding action. Contributing factors were that the helicopter pilot did not level his aircraft at the agreed altitude; the helicopter pilot did not establish mutual positions by radio; the helicopter crewmen did not see the traffic in time to alert their pilot.

3.25. A causal factor was the inherent limitation of the "see and avoid" concept.

4. SAFETY RECOMMENDATIONS

4.1 It was recommended to the Director of Civil Aviation that:

> He promulgate a single advisory radio frequency for aircraft in the uncontrolled airspace are between Auckland and Whenuapai Control Zones, including Mechanics Bay ATZ. (073/94)

4.2 The Director responded:

> *"... a dedicated communication frequency has been promulgated for the uncontrolled airspace area concerned, including Mechanics Bay, thus recognising the recommendation ... An Auckland City Airspace User's Group has also been formed and further measures to help segregate traffic will be taken by the CAA in consultation with this group."*

24 August 1994

M F Dunphy
Chief Commissioner

GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT

AM	amplitude modulation
ATC	Air Traffic Control
ATIS	Automatic Terminal Information Service
ATS	Air Traffic Services
ATZ	Aerodrome Traffic Zone
CPL(H)	Commercial Pilot Licence (Helicopter)
CTR	Control Zone
DERP	design eye reference point
FM	frequency modulation
hPa	hectoPascal
IFR	Instrument Flight Rules
MAG BRG	magnetic bearing
MHz	megaHertz
mode C	secondary radar altitude data
NM	nautical mile
NZDT	New Zealand Daylight Time
QNH	pressure setting to indicate elevation above mean sea level
REL BRG	relative bearing
RTF	radiotelephone
TMA	Terminal Control Area
UHF	ultra high frequency
US FAA	United States Federal Aviation Administration
UTC	Coordinated Universal Time
VFR	Visual Flight Rules
VHF	very high frequency
VMC	Visual Meteorological Conditions
°C	degree Celsius
°M	degree magnetic