TRANSPORT ACCIDENT INVESTIGATION COMMISSION

TE KOMIHANA TIROTIRO AITUA WAKA

No. 94-022

AEROSPATIALE AS350B ZK-HZP

NEEDLE ROCK 10 NM NORTH-EAST OF WHITIANGA

11 OCTOBER 1994

ABSTRACT

At approximately 1351 hours on Tuesday 11 October 1994 an AS350B helicopter, ZK-HZP, flew into the sea near Needle Rock, 10 nm north-east of Whitianga. Two of the five passengers lost their lives in the accident and the pilot received serious injuries. The safety issues discussed include the hazards associated with hydraulic jack stall, and the necessity for pilots to make sound command decisions appropriate to air transport operations.

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AIRCRAFT ACCIDENT REPORT NO. 94-022

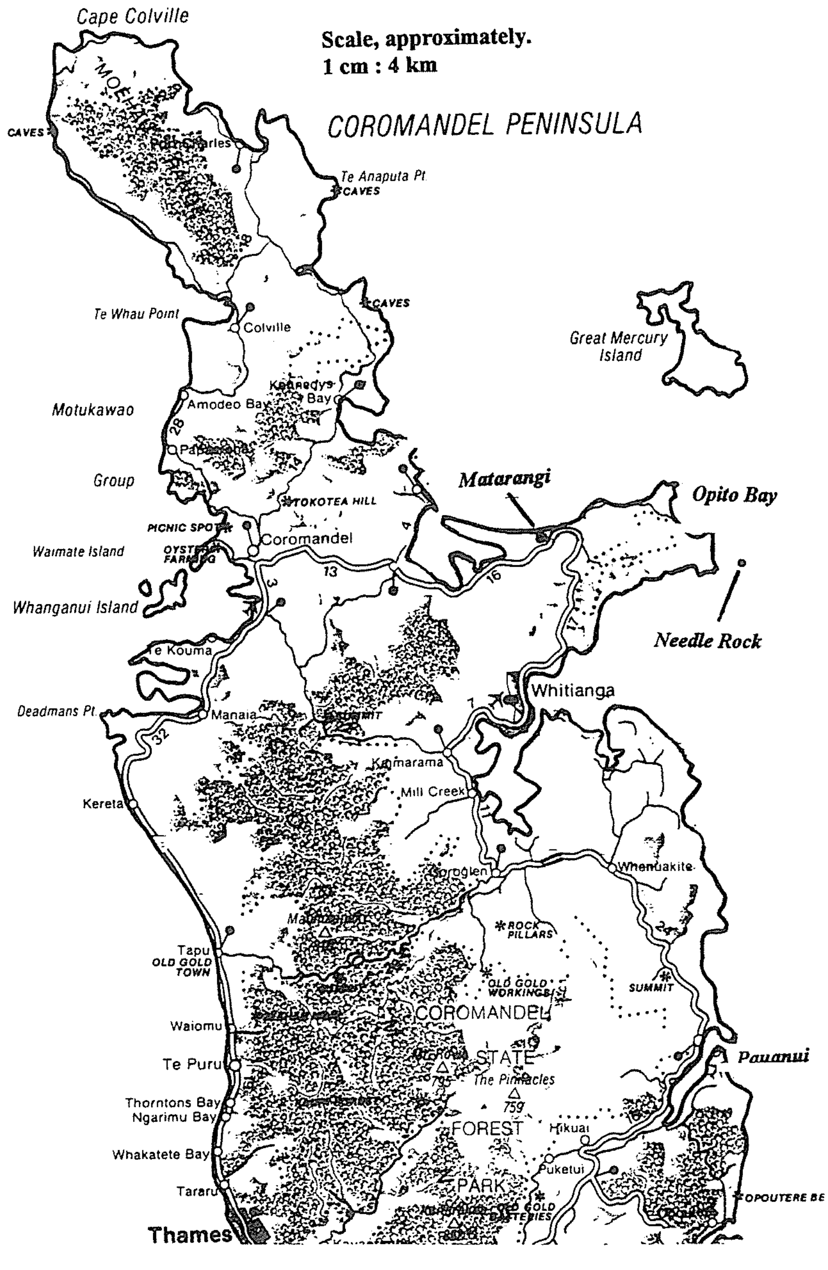
Aircraft Type, Serial Number and Registration:	Aerospatiale AS350B Squirrel, 1243, ZK-HZP
Number and Type of Engines:	One Turbomeca Arriel 1B
Year of Manufacture:	1979
Date and Time:	11 October 1994, 1351 hours*
Location:	Needle Rock. 10 nm north-east of Whitianga Latitude: 36° 45' S Longitude: 175° 51' E
Type of Flight:	Air Transport, Charter
Persons on Board:	Crew: 1 Passengers: 5
Injuries:	Crew: 1 Serious Passengers: 2 Fatal 3 Minor
Nature of Damage:	Aircraft destroyed
Pilot-in-Command's Licence:	Commercial Pilot Licence (Helicopter)
Pilot-in-Command's Age:	35
Pilot-in-Command's Total Flying Experience:	607 hours. Helicopter, 501 hours. 47 hours on type
Information Sources:	Transport Accident Investigation Commission field investigation
Investigator in Charge:	Mr K A Mathews

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

1. NARRATIVE

1.1 At 1345 hours on Tuesday 11 October 1994 ZK-HZP, an AS350B Squirrel helicopter, departed Matarangi for Pauanui. On board were the pilot plus five passengers.

1.2 ZK-HZP had been positioned at Matarangi earlier that morning and had been carrying out local aerial photography work under charter. The pilot had departed from his base at Mechanics Bay in Auckland, flown to Auckland International Airport to pick up two camera men, and had then proceeded to Matarangi. The flight included an unanticipated en-route diversion via Pauanui at the request of the two camera men. After two flights totalling approximately 50 minutes the charterer informed the pilot that he required a further hour of flying, and additionally he would like the pilot to take five of his employees for a scenic flight at some time during the day. The pilot determined that in order to complete the work and have sufficient fuel with reserves to return to Mechanics Bay that evening, he needed to top up the helicopter's fuel tank which was approximately 50 % full. No fuel was available at Matarangi so he decided to fly ZK-HZP to Pauanui, the closest refueling point. As the helicopter was to be flown to Pauanui and back to Matarangi empty, the pilot elected to take the employees along on the round trip rather than complete a later separate flight. This classified the flight an



air transport operation.

1.3 The pilot departed Matarangi, having told the Charterer that the return flight would take approximately 30 minutes. The Charterer assumed the flight would be direct to Pauanui and return, as the pilot had not indicated otherwise. As no overwater flight was anticipated the pilot did not equip the passengers with life jackets, but wore one himself as a normal procedure. The passengers life jackets remained in the helicopter's rear luggage locker situated in the tail boom, and were not accessible to them. The life raft had been removed from the helicopter prior to the commencement of the photography work, and was not placed back in the helicopter prior to the flight. The helicopter was not fitted with emergency flotation equipment.

1.4 The pilot gave a departure call on the local frequency (119.1 MHz), climbed ZK-HZP to 800 feet and headed in an easterly direction towards Opito Bay. As he reached the coast to the south-east of Opito Bay he asked the passengers if they would like to have a closer look at Needle Rock, a prominent scenic attraction. The passengers agreed to this suggestion. Needle Rock is a rocky outcrop 252 feet high, protruding from the sea one nautical mile from the mainland. Through its centre is a large hole extending to about 150 feet above sea level, giving it a needle-like appearance.

1.5 The pilot descended his helicopter toward Needle Rock from the north-west at an airspeed of some 110 knots, and entered a right-hand turn. He intended to fly around the seaward side of the rock, from north to south, and then back to the mainland at 500 feet.

1.6 Passenger statements indicated that during this manoeuvre the helicopter descended to a height below or level with the top of the rock, and that the helicopter was approximately 50 metres laterally from the rock. One passenger recalled that he could see the mainland through the hole in the rock, and another estimated that the helicopter descended to within 40 or 50 metres of the sea. The pilot could not be specific regarding an altimeter reading at this stage of the flight, as his attention was primarily directed toward Needle Rock, but he believed that he terminated the descent at a height of about 500 feet.

1.7 The pilot recollected that, during the turning manoeuvre around Needle Rock, he believed the helicopter had effectively ceased to descend. However as the turn to the right continued around the south-eastern face of the rock, the lee side, the pilot felt the controls suddenly "lock up". The helicopter rolled to the right, and impacted the water on its right side in a nose-down attitude.

1.8 The pilot and passengers survived the impact but two of the passengers drowned. One had sustained serious back injuries and the other minor injuries. The pilot was seriously injured and the three surviving passengers received minor injuries. They found themselves floating close to the wreckage along with the body of one of the passengers, but the fifth passenger was still in the inverted helicopter. Realising that one of the passengers was unaccounted for, the pilot dived back into the wreckage to search for him. He briefly located the passenger but was unable to free him before the helicopter sank. Despite their injuries the survivors were able to swim to a nearby rocky ledge that jutted out from Needle Rock and scramble up onto it, recovering the body from the sea in the process. Shortly afterwards one of them noted the time as 1415 hours.

1.9 The accident occurred at approximately 1351 hours, as indicated by the helicopter's analogue clock which stopped as a result of the impact. At about 1500 hours the Charterer of the helicopter became concerned that it had not returned to Matarangi and began to make inquiries. A lone fisherman in a passing boat discovered the survivors at around 1535 hours but was unable to manoeuvre in close enough to the rock to rescue them. Using a cellular telephone he contacted the Coastguard advising them that there had been a helicopter accident and the location of the survivors. A boat with medical staff on board was subsequently dispatched to the area from Whitianga to assist the fisherman and a rescue helicopter from Mechanics Bay responded to the emergency.

1.10 The rescue helicopter arrived at the scene around 1625 hours and winched two paramedics onto the rock to attend to the survivors. ZK-HZP's pilot was winched on board the rescue helicopter and flown directly to Auckland Hospital. The three remaining survivors were taken off the rock by boat and subsequently transported to Thames Hospital. Later that evening the body of the fifth passenger was recovered from the sea bed near the wreckage by divers.

1.11 The wreckage was submerged in 100 feet of water about 50m from the south-eastern side of Needle Rock. The Royal New Zealand Navy recovered ZK-HZP from the ocean floor and Naval divers took video footage of the wreckage prior to its removal. The helicopter was recovered to Devonport Naval Base at 1830 hours on 13 October 1994 and transported from there to maintenance facilities at Ardmore Aerodrome.

1.12 Examination of the wreckage showed that the helicopter had been destroyed during the impact with the water. The damage to the rotor blades, rotor head and transmission was consistent with a sudden rotor stoppage, and the tail boom had separated on impact. The extensive damage to the nose area and right side of the helicopter showed that it had struck the water nose low in about a 90° banked attitude with a high rate of descent and at a high forward speed.

1.13 Extensive examination of the helicopter's control system including the hydraulic system showed no evidence of any pre-impact failure. Each of the hydraulic components was individually tested, and the three hydraulic accumulators were found to be charged to normal operating pressure. The main hydraulic system filter had been in service for approximately 300 hours out of a 400 hour servicing cycle and was thought, by the pilot, to contain a higher than normal level of contamination thereby having the potential to cause the fluid flow to be restricted abnormally. Examination and differential pressure testing of the filter by the RNZAF at Woodbourne showed no evidence of any blockage or restriction, and the contamination was found to be usual debris from the hydraulic system itself. An electrical hydraulic pressure "dump switch", situated on the end of the collective control lever, was found to be in the normal open position and functioned correctly when tested. All switches and controls were in the normal position for flight, and further examination of the helicopter showed no evidence of any malfunction that might have contributed to the accident.

1.14 During normal operation a failure in the hydraulic system causing a hydraulic pressure loss will be indicated to the pilot by illumination of a warning light and activation of an audible alarm (horn). The available evidence indicated that these warning systems had been functioning normally up to the time of the accident, and the pilot recalled that he was not alerted by either the horn or the light at any stage throughout the flight.

1.15 ZK-HZP had been maintained correctly, and its last maintenance inspection had been completed on 21 September 1994. The pilot had carried out the routine daily and pre-flight inspections of the helicopter, as well as the normal after start checks. No defects were evident in the helicopter, and the pilot reported that ZK-HZP had been performing normally up to the time of the accident. He recalled later however that on some occasions he believed the hydraulic low pressure warning light had remained on for about 10 to 15 seconds beyond normal, when he had started ZK-HZP's engine.

1.16 Throughout the morning and at the time of the accident a strong westerly flow covered the region with the wind strength being reported as 25 to 35 knots. Significant turbulence and downdraughting was reported to exist in the lee of the hills and the eastern side of the Coromandel Ranges, and a local pilot operating from Whitianga Aerodrome reported severe turbulence and downdraughting in the area from Mercury Bay to Opito Bay at about 1430 hours. The pilot of the rescue helicopter experienced severe buffeting of his helicopter in the lee of Needle Rock during the rescue.

1.17 It was calculated that at the time of the accident ZK-HZP's weight would have been around 1874 kgs, 76 kgs below its maximum allowable weight of 1950 kgs. It was also calculated that if the helicopter had descended from 800 feet off the coast of the mainland to below the height of Needle Rock, a rate of descent in excess of 1000 feet per minute would have been necessary in the time available. In addition, in the existing wind conditions an increase in the angle of bank would have been required for the helicopter to achieve a relatively constant radius of turn about the rock. The pilot however believed his angle of bank to be no greater than 20° as he initiated the turn, with no significant increase in the angle of bank at the time the controls locked up. He believed the rate of descent to Needle Rock to have been no more than 800 feet per minute.

1.18 During the turning manoeuvre the pilot recalled having focused his attention principally on Needle Rock and the surrounding expanse of water, not the horizon. Consequently he may not have immediately perceived a higher rate of descent developing and/or an increase in the angle of bank. Such factors, combined with the helicopter's heavy weight and high forward airspeed, would have contributed to a high rotor disc loading in the helicopter. This high disc loading would have been accentuated if the helicopter flew into turbulence on the lee side of the rock.

1.19 The AS350 type helicopter's flight controls are hydraulically boosted by a single hydraulic servo system. This servo system supplies hydraulic power to reduce the operational loads of the cyclic, collective and directional control systems. Under normal flight conditions the servo system provides adequate power to overcome the aerodynamic forces encountered, and the controls "feel light". When manoeuvring this helicopter type it is possible to load the rotor disc to a point where the servo system is not able to overcome the aerodynamic forces encountered and "feedback" may be felt in the cyclic control system. This will be accompanied by an increasing heaviness of the controls, which if not corrected by reducing the severity of the manoeuvre will result in a hydraulic jack stall, referred to as servo transparency by the manufacturer. At this point the controls will become very heavy and difficult to move.

1.20 In this helicopter type, jack stall, or servo transparency, is an aerodynamic phenomenon that can occur when the helicopter is flown outside its normal flight envelope and subject to positive manoeuvring (g-loading). It results in uncommanded aft and right-cyclic and down-collective motion accompanied by pitch-up and right roll of the helicopter. The manoeuvre, often abrupt and a surprise to the pilot, tends to be self correcting since the rapid loss of airspeed due to the pitch-up and down collective causes an equally quick reduction in feedback forces. The manoeuvre, though uncomfortable, is therefore always short-lived. However height loss during the recovery phase may be critical if jack stall occurs when the helicopter is at a relatively low height above the ground or water.

1.21 As the result of an investigation into an accident in 1986 involving an AS350B where hydraulic jack stall was considered to be a likely cause, flight manual "Supplement O" for the AS350B type helicopter operating in New Zealand was issued in 1988, and includes the following information:

"HYDRAULIC JACK STALL

The hydraulic system pressure is relatively low (40 bar; 570 psi) and is capable of providing hydraulic boosting to the flight controls under most conditions of flight. When the aircraft is manoeuvred at high positive normal acceleration, the main rotor aerodynamic loads will increase to a point where the hydraulic servo commands will become incapable of rendering assistance. This "jack stall" manifests itself as an increase in the cyclic and collective control forces. If the severity of the flight manoeuvre is reduced, the control forces will reduce. If the severity of the flight manoeuvre is continued, an uncommanded right roll will result. The roll can be overcome by the pilot; however the control force required will depend on the severity of the manoeuvre."

1.22 When ZK-HZP's flight manual was recovered from the wreckage, "Supplement O" was not included. It was however listed in the index.

1.23 Research has shown that when operating the AS350B type helicopter normally in moderate to severe turbulence it is possible to randomly "load up" the rotor disc and encounter the incipient stages of jack stall. A high forward airspeed will compound the problem, and a jack stall may result without warning. A helicopter operating at a heavy gross weight is more susceptible than one operating at a lighter weight.

1.24 Inadvertent operation of the hydraulic pressure "dump switch"[1] at an airspeed of 100 knots or greater would cause a similar effect to that of encountering hydraulic jack stall. Two overseas incidents involving the AS350B type helicopter described inadvertent activation of the dump switch at speeds in excess of 100 knots, which resulted in the controls becoming very heavy, accompanied by an unexpected roll to the right. In both cases the pilots had to exert considerable effort to overcome the increased control forces to return the helicopter to level flight. The helicopters were however flying at a height which permitted recovery from the temporary control upset. The switch installation in both these instances differed from the push-type "on-off" switch installed in the end of the collective lever of ZK-HZP, which was protected against inadvertent operation by a shrouded guard.

1.25 The pilot of ZK-HZP was certain that he had not operated the "dump switch", and the available evidence (see 1.13) indicated that the switch had been functioning correctly and had not been activated prior to the accident.

1.26 During its descent to Needle Rock the helicopter was operating at a high gross weight, and its forward speed was likely to have been high. If a high rate of descent had developed in conjunction with a steepening of the angle of bank, requiring application of aft cyclic control, a higher than normal rotor disc loading may have been induced. The possibility of additional disc loading due to turbulence in the lee of Needle Rock held increased potential for the unexpected onset of jack stall causing the controls to suddenly become heavy and for the helicopter to roll unexpectedly to the right.

1.27 The pilot stated that the control "lock up" had caught him by surprise, and that his attention was fixed on the rock and surrounding expanse of water, not the horizon. The

[1]Used to relieve all hydraulic pressure to the servos simultaneously in the event of a hydraulic system malfunction/failure.

accident circumstances suggest that there was insufficient time available for him to recognize, analyze and correct the problem before impact with the water. It is possible that a fully developed jack stall did not occur, but the incipient stages of one. The sudden increase in the control effort required by the pilot, from the normal "light" feel, may have misled the pilot into thinking he had a control system failure in which case if he shifted his eyes from their focus on the rock and expanse of water, to the horizon, it is possible that a moment of disorientation may have occurred during which time the helicopter descended into the water.

1.28 Prior to departure from Matarangi on the accident flight the pilot had not lodged a flight plan with Air Traffic Services due to radio communication difficulties normally experienced in the area, but had informed the Charterer that he would return in approximately 30 minutes. The Charterer assumed the flight would proceed direct to Pauanui and return. As this was an air transport flight however a flight plan was required and could have been filed by the use of a telephone.

1.29 With reference to the filing of the flight plans the Company Operations Specifications included the following instructions.

> "The operator shall ..... file a flight plan for all air transport operations except in the case of local flights within a radius of twenty five nautical miles which commence and terminate at the same aerodrome."

As Pauanui was within a radius of 25 nm from Matarangi and the primary purpose of the flight was to obtain additional fuel, the necessity to file a flight plan may therefore have been obscure to the pilot. The pilot had provided the Charterer with an estimate of the return trip duration but had not informed him of the specific route. The lack of suitable "flight-following" arrangement providing the opportunity to give notification of diversions, delays, or other en-route occurrences, and the absence of a formally submitted "flight-plan" potentially compromised the effectiveness of search and rescue activity following the accident.

1.30 The in-flight impromptu decision to fly out to Needle Rock meant that ZK-HZP would be flown beyond its autorotational distance from land. This deviation meant that the flight became an "offshore" flight and although only involving an over-water distance of 1 nm each way, necessitated the fulfilment of additional CAA and company requirements, i.e. that the passengers be fitted with life jackets, a liferaft be carried, the helicopter be equipped with emergency flotation equipment, and two-way radio communications with an approved flight following organization be established and maintained.

1.31 In the event these specific requirements were not complied with, and the available evidence suggests that the helicopter descended to below the minimum altitude of 500 feet normally permitted for air transport operations carrying passengers.

1.32 The pilot stated that he usually set the "bug" on the radio altimeter fitted in ZK-HZP to 250 feet, and if he descended to this altitude an audio signal would alert him. Prior to the accident flight however he had set the "bug" to zero due to an unserviceability in the radio altimeter.

1.33 The pilot of ZK-HZP was appropriately licensed and rated on the AS350B type helicopter. His type conversion and most recent competence and emergency procedures check was completed during June 1994, and a check of his knowledge of company operating procedures and requirements was carried out in July 1994. He had attended a "Heliprops"[2] seminar while in the service of the company, and an earlier one at his own

[2]Helicopter Professional Pilot Safety. An accident prevention programme designed for helicopter pilots, concentrating on the human factors associated with accidents.

expense prior to joining the company.

1.34 The instructor's records showed that during his AS350B type conversion training of ZK-HZP's pilot, hydraulic jack stall, referred to as "servo transparency" by the instructor, had been taught and demonstrated to him. This included the opportunity to enter and recover from its incipient stages. The pilot however believed that he had not received any instruction in hydraulic jack stall.

1.35 ZK-HZP's pilot had taken training in judgement and decision making, but the evidence suggests he did not apply the principles of this to the accident flight, by electing to fly to a point out to sea and not attempting to comply with CAA and company operating requirements. As a result the passengers were exposed to unnecessary risk.

2. FINDINGS

2.1 ZK-HZP had a valid Certificate of Airworthiness and Maintenance Release.

2.2 ZK-HZP had been maintained correctly.

2.3 ZK-HZP was airworthy and had been functioning correctly at the time of the accident. No defect or malfunction had occurred during the flight to suggest to the pilot that the helicopter was not operating satisfactorily.

2.4 ZK-HZP's weight and centre of gravity were within limits.

2.5 The pilot was appropriately qualified to conduct the flight.

2.6 The pilot's in-flight decision to fly out to Needle Rock involved an "off-shore" flight.

2.7 The helicopter and passengers were not suitably equipped in accordance with CAA and company requirements, for an "off-shore" flight.

2.8 The pilot did not establish an adequate system of flight following to provide continuous monitoring of the progress of the flight, and/or enable him to give notification of any in-flight diversions or other unexpected occurrence.

2.9 The diversion from the anticipated direct route to Pauanui held potential for delay in locating the overdue helicopter.

2.10 The survivors of the accident were discovered by chance by a passing lone fisherman approximately 1 hour and 44 minutes after the accident, and were rescued some 2 hours and 40 minutes after the accident.

2.11 The pilot made inappropriate command decisions which compromised the safety of his helicopter and passengers.

2.12 The available evidence indicated that during a turn to the right around Needle Rock, the pilot of ZK-HZP encountered hydraulic jack stall, also known as servo transparency, or its incipient stages.

2.13 The height of the helicopter above the water at the time of the occurrence provided little opportunity for the pilot to recognise the problem and recover control of the helicopter before impact with the sea.

3. SAFETY ACTIONS

3.1 Following the accident the company advised that it has reviewed its quality assurance management programme and as a result are introducing additional safety measures which include: working toward ISO 9000[3] certification, appointment of a safety officer, and promulgation of a quality assurance management manual for their flight operations.

4. SAFETY RECOMMENDATIONS

4.1 As a result of this investigation it was recommended to the Director of Civil Aviation that he:

(1) remind all operators of AS350 series helicopters of the hazards associated with hydraulic jack stall and the precautions necessary to avoid its onset, particularly in conditions of moderate to severe turbulence; (075/94)

(2) stress to all operators carrying out air transport operations, the importance of their pilots making sound command decisions appropriate to these operations, and the need to have a management system for ongoing supervision and monitoring of their staff; (076/94)

(3) research what additional training for pilots should be carried out, with regard to the physical and psychological conditions that lead to errors of judgment and violation of rules and procedures, to better equip them to make sound command decisions, prior to being permitted to engage in air transport operations. (077/94)

4.2 The Civil Aviation Authority advised that action has been initiated to implement the above Safety Recommendations.

19 April 1995

M F Dunphy
Chief Commissioner

[3] International Standards Organisation. A quality management and quality assurance standards system.

ABBREVIATIONS COMMONLY USED IN TAIC REPORTS

AD	Airworthiness Directive
ADF	Automatic direction-finding equipment
agl	Above ground level
AI	Attitude indicator
AIC	Aeronautical Information Circular
AIP	Aeronatical Information Publication
amsl	Above mean sea level
AOD	Aft of datum
ASI	Airspeed indicator
ATA	Actual time of arrival
ATC	Air Traffic Control
ATD	Actual time of departure
ATPL (A *or* H)	Airline Transport Pilot Licence (Aeroplane or Helicopter)
AUW	ll-up weight
C	Celsius (normally preceded by °)
CAA	Civil Aviation Authority
CASO	Civil Aviation Safety Order
CFI	Chief Flying Instructor
C of G	Centre of Gravity
CPL (A *or* H)	Commercial Pilot Licence (Aeroplane or Helicopter)
DME	Distance measuring equipment
E	East
ELT	Emergency location transmitter
ERC	En route chart
ETA	Estimated time of arrival
ETD	Estimated time of departure
F	Fahrenheit (normally preceded by °)
FAA	Federal Aviation Administration (United States)
FL	Flight level
g	Acceleration due to gravity
GPS	Global Positioning System
HF	High frequency
hPa	Hectopascals
IAS	Indicated airspeed
IFR	Instrument Flight Rules
IGE	In ground effect
ILS	Instrument landing system
IMC	Instrument meteorological conditions
ins Hg	Inches of mercury
kgs	Kilograms
kHz	Kilohertz

KIAS	Knots indicated airspeed
kt	Knot(s)
LF	Low frequency
LLZ	Localiser
M	Mach number (e.g. M1.2)
M	Magnetic (normally preceded by °)
MAANZ	Microlight Aircraft Association of New Zealand
MAP	Manifold absolute pressure (measured in inches of mercury)
MAUW	Maximum all-up weight
METAR	Aviation routine weather report (in aeronautical meteorological
code)	
MF	Medium frequency
MHz/Mhz	Megahertz
mph	Miles per hour
N	North
NDB	Non-directional radio beacon
nm	Nautical mile
NOTAM	Notice to Airmen
NTSB	National Transportation Safety Board (United States)
NZAACA	New Zealand Amateur Aircraft Constructors Association
NZDT	New Zealand daylight time (UTC + 13 hours)
NZGA	New Zealand Gliding Association
NZHGPA	New Zealand Hang Gliding and Paragliding Association
NZMS	New Zealand Mapping Service map series number
NZST	New Zealand standard time (UTC + 12 hours)
octa	Eighth's of sky cloud cover, (e.g. 4 octas = 4/8 of cloud cover)
OGE	Out of ground effect
PAR	Precision approach radar
PIC	Pilot in command
PPL (A or H)	Private Pilot Licence (Aeroplane or Helicopter)
psi	Pounds per square inch
QFE	An altimeter subscale setting to obtain height above aerodrome
QNH	An altimeter subscale setting to obtain elevation above mean sea level
RNZAC	Royal New Zealand Aero Club
RNZAF	Royal New Zealand Air Force
rpm	revolutions per minute
RTF	Radio telephone or radio telephony
S	South
SAR	Search and Rescue
SSR	Secondary surveillance radar
T	True (normally preceded by °)

TACAN	Tactical Air Navigation aid
TAF	Terminal aerodrome forecast
TAS	True airspeed
UHF	Ultra high frequency
UTC	Coordinated Universal Time
VASIS	Visual approach slope indicator system
VFG	Visual Flight Guide
VFR	Visual flight rules
VHF	Very high frequency
VMC	Visual meteorological conditions
VOR	VHF omnidirectional radio range
VORTAC	VOR and TACAN combined
VTC	Visual terminal chart
W	West