NO 95-009

BELL 206B JET RANGER III

ZK-HDI

MT STEVENSON
18 km north east of Glentanner

6 JUNE 1995

ABSTRACT

On Tuesday, 6 June 1995 at 1415 hours the pilot was carrying out a snow landing in ZK-HDI in the course of a scenic flight. The right skid began to drop as the pilot settled the helicopter onto the snow so he lifted off and repositioned to a seemingly flatter area 10 to 15 m away. The helicopter tilted to the right again during the second landing, and as the pilot attempted to retrieve the situation the helicopter rolled rapidly onto its right side. The causal factors in this accident were the difficulty of assessing snow conditions accurately and "dynamic rollover". As a result of the accident the operator re-emphasised and developed further the use of an existing system of pilot/task grading, and reviewed the suitability of various helicopter types for snow landing operations when flown by pilots with relatively limited helicopter experience.

TRANSPORT ACCIDENT INVESTIGATION COMMISSION

AIRCRAFT ACCIDENT REPORT NO 95-009

Aircraft Type, Serial Number and Registration:	Bell 206B Jet Ranger III 4007, ZK-HDI
Number and Type of Engines:	One Allison 250-C20J
Year of Manufacture:	1988
Date and Time:	6 June 1995, 1415 hours*
Location:	Mt Stevenson 18 km north east of Glentanner Latitude: 43° 49.5' S Longitude: 170° 19.4' E
Type of Flight:	Air Transport, Scenic
Persons on Board:	Crew: 1 Passengers: 3
Injuries:	Crew: Nil Passengers: Nil
Nature of Damage:	Substantial
Pilot in Command's Licence:	Commercial Pilot Licences (Helicopter and Aeroplane)
Pilot in Command's Age:	37
Pilot in Command's Total Flying Experience:	1262 Hours 375 Hours on Helicopters 266 Hours on Type
Information Sources:	Transport Accident Investigation Commission field investigation
Investigator in Charge:	Mr D G Graham

* All times in this report are NZST (UTC + 12 hours)

1. NARRATIVE

1.1 On the afternoon of Tuesday, 6 June 1995 arrangements had been made for members of an overseas tour group to take scenic flights by helicopter from the operator's base at Glentanner Aerodrome.

1.2 The flights were to be of 30 minutes duration and include a snow landing. Two helicopters were to be used, Aerospatiale AS 350B Squirrel ZK-HZO carrying six passengers, and Bell Jet Ranger III, ZK-HDI, with three passengers.

1.3 ZK-HZO departed at 1350 hours. The pilot of this helicopter, who was senior in experience to the pilot of ZK-HDI, flew initially to a regularly used snow landing area near Gorilla Stream located to the north of Glentanner. Flying conditions en-route were smooth but a strong south-west wind was causing swirls at the site. The pilot therefore decided to divert some 15 km to the south-east and land on the north-east shoulder of Mt Stevenson, an area often used by him for snow landings in south-west wind conditions.

1.4 The pilot was in radio telephone (RTF) contact with both Glentanner base, and the pilot of ZK-HDI. He suggested that the latter should join him at Mt Stevenson as the wind there presented no problem for landing. After landing, disembarking his passengers and moving them clear of the helicopter, the pilot walked across the snowfield to a slightly higher snowbench in anticipation of the arrival of ZK-HDI. Snow had fallen two days earlier, resulting in fresh snowcover to a depth of some 400 mm.

1.5 ZK-HDI had departed from Glentanner at 1355 hours. The pilot followed a route similar to that of ZK-HZO and also encountered smooth flight conditions. He proceeded as far as The Nun's Veil and carried out an orbit in this area, enabling his passengers to obtain good views of Mt Cook and Mt Tasman before taking up a new heading for Mt Stevenson.

1.6 The pilot of ZK-HDI noted the position of the parked Squirrel helicopter as he flew over the ridge of Mt Stevenson in a southerly direction. He assessed local wind and surface conditions, and set up a left circling approach to the site. The pilot of ZK-HZO assisted in accurate determination of wind direction by throwing snow into the air as ZK-HDI approached to land.

1.7 The elevation of the landing site was approximately 6600 feet. The pilot had not landed at this particular site before. His proposed touchdown area lay in a shallow, slightly dished region of the snowslope to the south, and well clear of the parked helicopter.

1.8 The pilot estimated the wind as 5 to 8 knots from the west. There were no significant gusts. His final approach and landing was on a north-westerly heading resulting in a light crosswind component from the left.

1.9 As the pilot allowed ZK-HDI to settle onto the snow he felt the right skid sink more deeply than the left and at the same time was aware that he was applying considerable left cyclic control. Not being happy with the situation, he lifted off and traversed some 10 m or 15 m to the right, to an area which appeared to be flatter.

1.10 Touching down again, the helicopter felt stable. The pilot lowered the collective lever, but as ZK-HDI's skids settled into the snow the right skid dropped. The pilot recalled having the cyclic control hard against his left leg. The right skid continued to go down, and within seconds the helicopter rolled onto its right side. Events occurred so quickly that the pilot was unable to recollect with certainty his actions at the time, but believed it was likely he had pulled on some power in an endeavour to lift off, as he had done previously.

1.11 The mast and transmission assembly fractured and the main rotor blades were destroyed as they struck the snow. The main rotor blades quickly ceased rotating. A section of main rotor blade two metres in length, which broke away was recovered some 15 m to the south of the helicopter. Minimal damage occurred to the helicopter's cockpit, cabin, and tail rotor assembly, but the engine sustained overtemperature indications and other damage typically associated with a power-on rollover mishap.

1.12 None of the occupants of ZK-HDI sustained injury. When the helicopter had come to rest, the pilot ensured the throttle was closed and turned off the fuel and master switches. The pilot and front seat passenger were wearing the full shoulder harness installed in the forward seating positions and the two other passengers were wearing the combined lap-belt and diagonal upper torso restraints provided for the rear seat occupants. The restraint systems functioned effectively in the rollover. No difficulty was experienced in releasing the individual seat belts.

1.13 The pilot of ZK-HZO assisted the four occupants to vacate the helicopter and disconnected the battery. Together with three of his own group he then flew the three passengers from ZK-HDI to Glentanner Aerodrome where they received a medical check-up and other attention to ensure their welfare. ZK-HZO returned to the site and the pilot of ZK-HDI and remaining three passengers were flown out without delay. All personnel had been returned to Glentanner within 30 minutes of the occurrence.

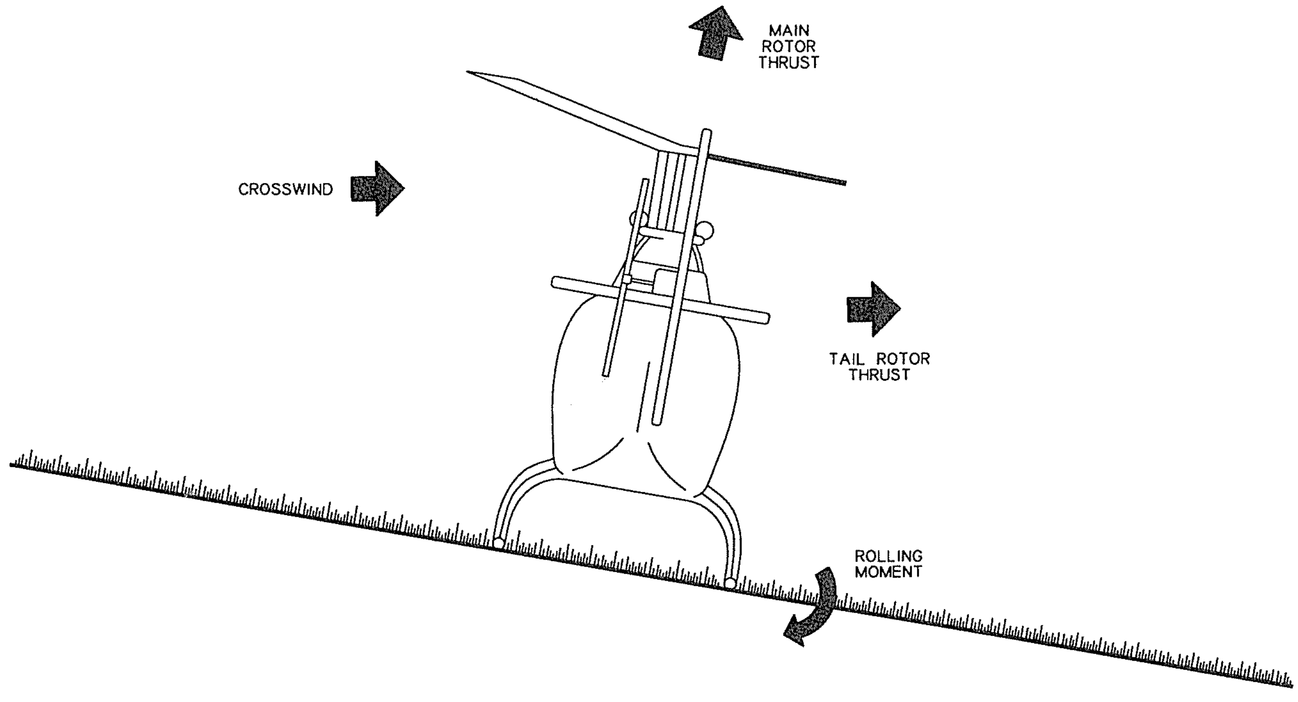
1.14 One of the passengers on board ZK-HDI was using a video camera to record the flight. The video record included the landing sequence and the rollover. It confirmed the short time-frame of about two seconds within which the final roll developed and took place.

1.15 A high overcast resulted in diffuse lighting rather than bright sunlight. The pilot had no difficulty in establishing adequate surface references during the landing. The snow was wind rippled, and dry, but despite its freshness was well compacted and somewhat heavy in texture. The rotor downwash did not produce any blowing snow.

1.16 There was a slight slope from left to right where the pilot first touched down. The area to the right to which he then moved had appeared to be flatter but the pilot noted after the accident that it also sloped from left to right at an estimated angle of about 5°. The pilot did not recall any residual sideways or forwards movement as he allowed ZK-HDI to settle during the second landing, which might have induced or accentuated a tendency to roll. The skid marks observed by the recovery team confirmed that the helicopter initially had settled squarely into the snow.

1.17 The pilot's report, and the circumstances surrounding the accident to ZK-HDI, were consistent with the occurrence of dynamic rollover.

1.18 'Dynamic rollover' is the tendency of a helicopter to pivot around one of its skids. This usually occurs during slope operations but can happen on level ground.



FACTORS CONTRIBUTING TO DYNAMIC ROLLOVER

1.19 Several factors can contribute to dynamic rollover. The main factor is the thrust of the main rotor when it is tilted from the vertical. If the rotor system is not tilted or if there is no thrust, then dynamic rollover will not occur.

1.20 Other factors which contribute to dynamic rollover are the tail rotor thrust, especially when it is located high up on the helicopter, and a downslope crosswind. Also, in order for a rollover to occur, the skids must be in contact with a high friction surface. If the surface is slippery, the helicopter will tend to slide and not pivot if a sideways force is applied. In addition, a helicopter with a high centre of gravity (CG) and/or on narrow skid tracks is more susceptible to dynamic rollover than one with a low CG and/or wide skids.

1.21 A feature of dynamic rollover is that the helicopter's CG pivots around the skid; therefore, once a roll is started it may be difficult, if not impossible, to stop. Since a pilot may not be able to stop the roll, the only way to be sure a dynamic rollover does not occur is to be aware of the problem and try to eliminate as many of the contributing factors as possible.

1.22 In relation to the accident, the moderate transverse slope combined with the depth and varying texture of the snow which had resulted in the right skid 'sinking in' unexpectedly, were all factors pre-disposing ZK-HDI to a rollover. The light downslope crosswind and the physical characteristics of the Jet Ranger, particularly in the high skid version, also increased the potential for such an occurrence.

1.23 On the first touchdown the pilot was alerted to the inherent danger for a rollover to occur and lifted off successfully. Having traversed to a seemingly flatter area on which the helicopter initially settled evenly, the pilot was taken by surprise when the right skid again sank into the snow unexpectedly, tilting the helicopter towards an unsafe attitude. Under such circumstances it would have been a natural reaction to apply power and attempt a further lift off.

1.24 An application of power, however, under such conditions where the helicopter may have already approached or exceeded its maximum slope capability, and the downslope skid was effectively anchored by the depth to which it had sunk in the snow, would have resulted inevitably and rapidly in the helicopter rolling onto its side. Events suggested this to have been the case.

1.25 It was not practicable to establish the depth to which the right skid sank at first into the snow and whether or not ZK-HDI would have remained upright had the pilot immediately reduced collective and not attempted to lift off. His impression after the event was that the angle of tilt which developed was such that the helicopter's static stability may already have been compromised.

1.26 The pilot had an extensive mountaineering background and was familiar with the snow conditions encountered at different times of the year and in varying locations in the area in which he was flying. Before taking up his position as a helicopter pilot he had been employed as a ski-plane pilot and had recorded numerous landings on snowfields in the Mt Cook National Park. He was, however, in the early stages of developing his helicopter experience.

1.27 He had worked for the operating company on ground duties between 1990 and 1992. He had commenced helicopter training in September 1993 and had obtained his Commercial Pilot Licence (Helicopter) in December 1994. He had joined the operating company as a helicopter pilot in the same month and had successfully completed an in-house company flying training programme, and his most recent CAA Regulation 76 check flight, shortly after joining.

1.28 ZK-HDI was a five seat helicopter powered by a single turbine engine mounted above the cabin. It was designed to be flown from the front right position and was so flown by the operator. Dual controls were not installed and the centre rear seat was not occupied at the time of the accident. The design of the helicopter included a two-bladed semi-rigid main rotor system, and a tail rotor mounted on the left side of the tailboom to provide directional control.

1.29 ZK-HDI was fitted with "high skid" landing gear, an approved installation used widely by New Zealand operators. This modification from the original design increased the helicopter's ground clearance by some 330 mm, permitting a greater safety margin for the tail rotor, main rotor, and fuselage underside when landing on rough terrain. The tubular skids had a track of some 1870 mm, and were fitted with square pattern "snowshoes" at their aft ends to reduce heel penetration in soft snow. Whether the edge of the down slope snow shoe caught in some way after the skid had dropped and thus contributed to the roll-over, was not established.

1.30 The helicopter's all-up weight at the time of the accident was approximately 1230 kg. Maximum approved gross weight was 1451.5 kg.

1.31 The longitudinal CG position was estimated as Station 2746 mm. At the estimated weight the forward CG limit was 2692 mm and the aft limit 2880 mm.

1.32 The lateral CG position was estimated as 30 mm Right of the helicopter's centre line. The lateral CG limits associated with the estimated longitudinal CG were Left 76.2 mm and Right 101.6 mm respectively.

1.33 Bell 206B Jetranger series helicopters have been used successfully in many roles since the inception of the type in 1965. However, the higher CG associated with the high skid version, in conjunction with the elevated engine, transmission, and main rotor system characteristic of the overall design, together with the particular skid arrangement probably rendered ZK-HDI less tolerant of slope and surface instability, and consequently more prone to dynamic rollover in the existing snow conditions, than the pilot expected. The pilot had accumulated some two thirds of his total helicopter time while flying ZK-HDI and had experienced no previous operating problem.

1.34 The accident to ZK-HDI drew attention to the conditions likely to induce dynamic rollover, and the desirability of eliminating, or minimising, such conditions as far as practicable in helicopter operations.

1.35 The circumstances demonstrated the inherent difficulty, on occasion, of assessing snow slope accurately, and snow's load-bearing capability prior to touchdown, particularly if landing at an unfamiliar site.

1.36 In addition the accident prompted recognition of the slope limitations of differing helicopter types, and their consequent vulnerability in landings on potentially unstable surfaces.

2. FINDINGS

2.1 The pilot was appropriately licensed for the flight.

2.2 The aircraft had a valid Certificate of Airworthiness and Maintenance Release.

2.3 The aircraft was below the maximum Approved Gross Weight and the estimated CG positions were within the specified limits.

2.4 The pilot's difficulty in making a reliable assessment of the snow conditions led to his setting the aircraft down on an area which resulted in an unmanageable rollover situation.

2.5 Factors relevant to the accident included the slope, the depth and variation in texture of the snow, and surprise associated with the 'sinking-in' of the right skid while landing on an apparently suitable surface.

2.6 The probable cause of the accident was a dynamic rollover, induced as the pilot applied power to lift off with the helicopter already tilted significantly to the right.

3. SAFETY ACTIONS

3.1 About eight months prior to the accident the operator introduced a graded system of pilot categorisation and landing area classification intended to assist in matching pilot skill and experience levels to the differing challenges of the snow landing areas in regular use. The system was designed to enable pilots, initially building up helicopter skills and experience, to progress in controlled stages from operations at the less demanding snow landing sites eventually to those where maximum skill and experience might be required.

3.2 Following the accident further refinements to this system were developed. These included the marking of snow landing sites at the commencement of each day's flying to define clearly areas suitable for landings by pilots with limited experience.

3.3 The operator also undertook a review of the suitability of differing helicopter types for snow landing operations with reference also to the appropriate level of pilot skill and experience required in each case. This was to ensure, as far as practicable, that pilots, especially while building experience, would operate the helicopter types most suited to the operations for which they were tasked.

17 October 1995

M F Dunphy
Chief Commissioner

GLOSSARY OF AVIATION ABBREVIATIONS

AD	Airworthiness Directive
ADF	Automatic direction-finding equipment
agl	Above ground level
AI	Attitude indicator
AIC	Aeronautical Information Circular
AIP	Aeronautical 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	All-up weight
°C	Celsius
CAA	Civil Aviation Authority
CASO	Civil Aviation Safety Order
CFI	Chief Flying Instructor
C of G (*or* CG)	Centre of gravity
CPL (A *or* H)	Commercial Pilot Licence (Aeroplane *or* Helicopter)
DME	Distance measuring equipment
E	East
ELT	Emergency location transmitter
ERC	Enroute chart
ETA	Estimated time of arrival
ETD	Estimated time of departure
°F	Fahrenheit
FAA	Federal Aviation Administration (United States)
FL	Flight level
ft	Foot/feet
g	Acceleration due to gravity
GPS	Global Positioning System
h	Hour
HF	High frequency
hPa	Hectopascals
hrs	Hours

IAS	Indicated airspeed
IFR	Instrument Flight Rules
IGE	In ground effect
ILS	Instrument landing system
IMC	Instrument meteorological conditions
in	Inch(es)
ins Hg	Inches of mercury
kg	Kilogram(s)
kHz	Kilohertz
KIAS	Knots indicated airspeed
km	Kilometre(s)
kt	Knot(s)
lb	Pounds
LF	Low frequency
LLZ	Localiser
Ltd	Limited
m	Metre(s)
M	Mach number (e.g. M1.2)
°M	Magnetic
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	Megahertz
mm	Millimetre(s)
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)
OGE	Out of ground effect
okta	Eighths of sky cloud cover (e.g. 4 oktas = 4/8 of cloud cover)
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	Second(s)
S	South
SAR	Search and Rescue
SSR	Secondary surveillance radar
°T	True
TACAN	Tactical Air Navigation aid
TAF	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