TRANSPORT ACCIDENT INVESTIGATION COMMISSION

TE KOMIHANA TIROTIRO AITUA WAKA

NO. 93-013

MIL Mi-8T

YS-1005P

NEAR HOKITIKA

16 OCTOBER 1993

ABSTRACT

On 16 October 1993, Mil Mi-8T helicopter YS-1005P, went out of control and broke up while in cruise flight. An uncommanded yaw led to a pitch excursion severe enough for the main rotor to strike and sever the tail boom. The helicopter's three occupants were killed in the accident. The precise cause of the uncommanded yaw could not be determined.

AIRCRAFT:	Mil Mi-8T	OPERATOR:	South Pacific Heli-Logging Ltd
REGISTRATION:	YS-1005P	PILOT:	Mr C J Green
PLACE OF ACCIDENT:	9.5 nm south of Hokitika	OTHER CREW:	Mr D G Ashworth
DATE AND TIME:	16 October 1993, 0735 hours*	PASSENGERS:	One

SYPNOSIS:

The Transport Accident Investigation Commission was notified of the accident at 0905 hours on 16 October 1993. The aircraft had been on transit from Hokitika to its operating area when an in-flight attitude disturbance resulted in the striking and severing of the tail boom by the main rotor. All three occupants were killed in the accident. Mr A J Buckingham was appointed Investigator in Charge, and commenced the on-site investigation later the same day.

1.1 History of the Flight:
See page 3

1.2 Injuries to Persons:
Crew: 2 Fatal
Passengers: 1 Fatal

1.3 Damage to Aircraft
The aircraft was destroyed.

1.4 Other Damage
Nil

1.5 Personnel Information:
See page 3

	Mr Green		Mr Ashworth	
Flight Times:	**Last 90 days**	**Total**	**Last 90 days**	**Total**
All Types:	62.2	7730.5	114.8	10872.6
On Type:	53.6	53.6	86.8	86.8

1.6 Aircraft Information:
See page 5

1.7 Meteorological Information:
See page 5

1.8 Aids to Navigation:
Nil

1.9 Communications:
See page 7

1.10 Aerodrome:
Nil

1.11 Flight Recorders:
Nil

1.12 Wreckage and Impact Information:
See page 7

1.13 Medical and Pathological
See page 8

1.14 Fire:
Fire did not occur.

1.15 Survival Aspects:
See page 8

1.16 Tests and Research:
See page 9

1.17 Additional Information:
See page 9

1.18 Useful or Effective Investigation Techniques:
Nil

2. Analysis:
See page 11

3. Findings:
See page 13

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

1. FACTUAL INFORMATION

1.1 History of the flight

1.1.1 On 16 October 1993, Mil Mi-8T helicopter YS-1005P departed Hokitika Aerodrome on a ferry flight to its operating area 18 nautical miles to the south. The aircraft was owned by Helica SA de CV of El Salvador, and was being operated in New Zealand by South Pacific Heli-Logging Limited on a logging contract, involving long-line slinging of selectively-felled native timber.

1.1.2 The crew consisted of two pilots, accompanied by an engineer; the pilots were to fly as captain and co-pilot on a "leg-for-leg" basis, changing at hourly intervals coincident with refuelling stops. The engineer had planned to leave the aircraft on arrival at the logging site and wait on the ground while the actual slinging operations took place.

1.1.3 A training sortie had been flown prior to the aircraft's departure on the day's logging programme, and the aircraft had been crewed by a training captain, a pilot undergoing conversion instruction, and Helica's Director of Maintenance. The latter had gone on the training flight to verify that the helicopter was operating normally following some routine maintenance which had been carried out the previous evening. At the completion of the training sortie, a "running change" was performed, the training crew handing the helicopter over to the operational crew.

1.1.4 The helicopter departed Hokitika about 0725 hours; the normal flight time to the logging site was approximately 14 minutes. Several minutes later, a witness who lived on a farm about nine miles from Hokitika and about one mile to the east of the direct flight route between Hokitika and the logging site (see Diagram 1), heard the sound of the approaching helicopter and went to a window to see it fly past. She observed the helicopter flying in apparently normal cruise flight at a low altitude. After watching the helicopter for a short while, she left the window to walk to the other end of the house, but several seconds later, she heard a noise like a short burst of helicopter "blade slap" followed by a pause, then the sound of an impact.

1.1.5 The witness hurried back to the window, but was unable to see the helicopter. Instead, she saw a long thin object spiralling earthwards; this was one of the helicopter's main rotor blades. She called her husband, and together they saw a short-lived plume of smoke or steam rising from behind some intervening trees. Believing that the helicopter had crashed, they alerted the Hokitika emergency services, and also contacted a local helicopter pilot and expressed their concern. The pilot had also heard the noises from his home, and deciding to investigate further, flew his helicopter over to the witness's home. After picking up the witness's husband, he flew to the area where the Mi-8T was last seen.

1.1.6 They discovered the main wreckage of the Mi-8T lying inverted, minus its tail boom, in swampy ground on the western side of the Hokitika River. A wreckage trail consisting mainly of portions of the tail boom extended back along the flight path. The fuselage had compressed on impact to a height of about one metre, and the occupants had died as a result of the impact forces. Hokitika Police, Ambulance and Fire Service personnel arrived on the scene by helicopter, and were later assisted by a Royal New Zealand Air Force helicopter and crew.

1.1.7 The accident occurred in daylight about 0735 hours, on the western bank of the Hokitika River, latitude 42° 52.1' S, longitude 170° 56.4' E; grid reference 418134, NZMS 260 Sheet J33 "Kaniere".

1.5 Personnel information

1.5.1 Pilot in command Christopher John Green, 44, held a New Zealand Lifetime Commercial Pilot Licence (Helicopter), endorsed with Agricultural and Chemical ratings. Mr Green's Class 1 Medical Certificate was issued on 14 October 1993 and valid to 15 April 1994. On the basis of the New Zealand licence, a Salvadorean licence validation certificate had been issued to Mr Green by the Dirección General de Aeronáutica Civil, the Salvadorean civil aviation authority. A Type Rating Certificate for the Mi-8T had been endorsed in his pilot logbook by the Director of Flight Operations, Helica SA.

1.5.2 His total flying time was 7730.5 hours, which included 166 hours on aeroplanes. He had flown 53.6 hours on the Mi-8T, including dual conversion time of 13.2 hours. All of his helicopter experience prior to converting onto the Mi-8T had been on light single-engined helicopters.

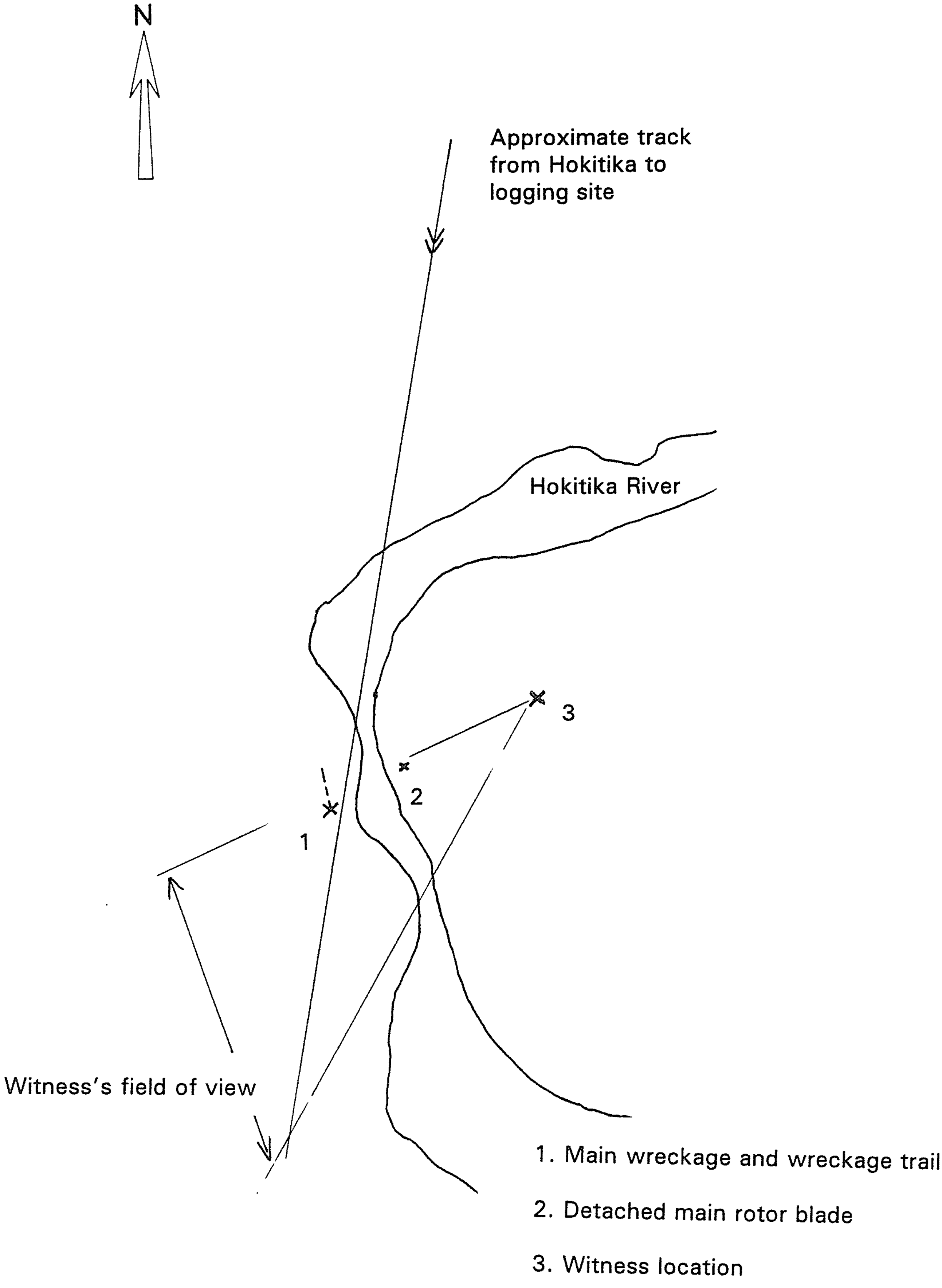

DIAGRAM 1: WRECKAGE LOCATION

1.5.3 Mr Green had flown 62.2 hours, including all of his Mi-8T time, in the previous 90 days, and 43.7 hours in the seven days preceding the accident date. His last day free from flying duty was 6 October 1993.

1.5.4 Co-pilot David George Ashworth, 44, held a New Zealand Commercial Pilot Licence (Helicopter) and a Commercial Pilot Licence (Aeroplane), both licences endorsed with Instrument, Agricultural and Chemical Ratings. The accompanying Class 1 Medical Certificate was issued on 16 May 1993 and valid to 9 November 1993. Mr Ashworth also held a Salvadorean licence validation certificate, and had a Type Rating for the Mi-8T endorsed in his logbook.

1.5.5 He had a total flight time of 10872.6 hours, which comprised 5907.7 hours on helicopters and 4964.9 hours on aeroplanes. His total experience on the Mi-8T was 86.8 hours, including 7.2 hours conversion and 2.3 hours operational training. Mr Ashworth had approximately 1000 hours twin-engined helicopter experience on the Bell 212 type.

1.5.6 In the 90 days preceding the accident date, Mr Ashworth had flown 114.8 hours, which included all his Mi-8T experience. He had flown 44.2 hours in the previous seven days, and his last day free from flying duties was 6 October 1993.

1.5.7 Although both pilots were on their tenth consecutive day of flying duty, there was no evidence to suggest that they were affected by fatigue. It could be reasonably assumed that they had had a rest period of at least 12 hours prior to commencing duty on the day of the accident. Had they been feeling unduly fatigued, they had the option of requesting a break, as there were other pilots available who could have stood in for a day if required.

1.5.8 The engineer, Laurence John Dale, a Canadian citizen, was a Licensed Aircraft Maintenance Engineer employed by the Canadian part-owner of Helica. He was not normally part of the flight crew, and was occupying the cockpit "jump seat" only for the transit from Hokitika to the operating area, where he would have spent the day on the ground, supervising refuelling and providing any field maintenance which may have been required.

1.6 Aircraft information

1.6.1 Mil Mi-8T helicopter, serial number 8146, was manufactured in the former Soviet Union in 1980, and exported initially to Cuba. It was later operated in Nicaragua before being acquired by Helica SA, El Salvador in May 1993. The aircraft was transported to New Zealand in July 1993 to commence heli-logging operations. It remained on the Salvadorean register, and was to be maintained and operated in accordance with the requirements of the Dirección General de Aeronáutica Civil. At the time of the accident, the aircraft held a current Salvadorean Certificate of Airworthiness and Certificate of Registration.

1.6.2 Up to the commencement of operations on the day of the accident, the aircraft had accrued 1370.3 hours flight time. Of this total, 409 hours had been flown since the aircraft's arrival in New Zealand. Examination of the aircraft documents showed that since construction the aircraft's utilisation had been low, with the hours flown each year ranging from a high of 260 in 1982 down to one in 1991 and zero in 1992.

1.6.3 Number 1 engine, Isotov TV2-117A[1], serial number S94111083, had run 468.2 hours since new, and the number 2 engine, serial number S94111102, had run 468.2 hours since overhaul and 1528.5 hours since new.

1.6.4 The main transmission had run 802 hours since overhaul, and 1401.6 hours since new. Each of the five main rotor blades had accrued 1067 hours out of a service life of 2000 hours. The blades also had a calendar life of six years, which expired on 4 January 1993, but had been extended a further year (to 4 January 1994) after inspection by a manufacturer's authorised representative. The calendar lives of a number of other components were similarly extended following inspection.

1.6.5 On departure from Hokitika, the aircraft's fuel state was 550 litres (of Jet A-1), sufficient for about 0.7 hours flying. The aircraft was to be refuelled on arrival at the logging site.

1.6.6 The gross weight of the helicopter on departure was approximately 7600 kg; the maximum all-up weight in the internally-loaded configuration was 12000 kg. The centre of gravity was approximately in the centre of the permitted range.

1.7 Meteorological information

1.7.1 An aftercast of the conditions at the time of the accident was provided by the Meteorological Service

[1]Note: Cyrillic characters have been Anglicised throughout this report.

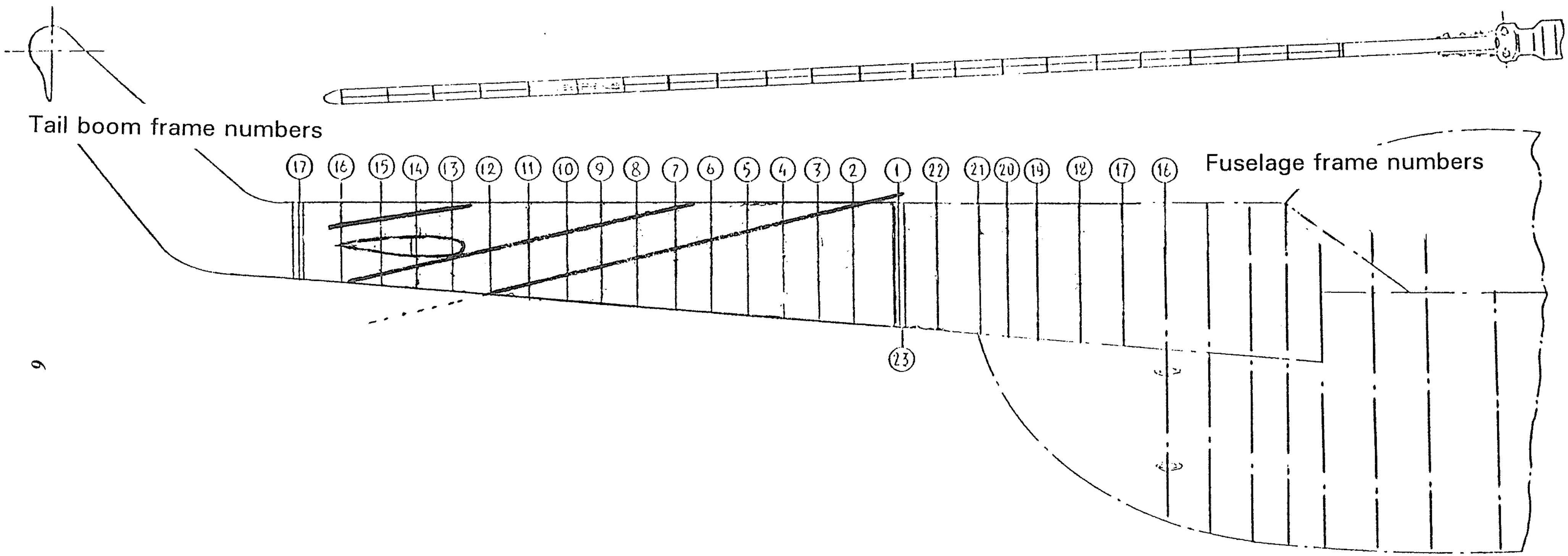

DIAGRAM 2: LOCATION OF MAIN ROTOR BLADE STRIKES

of New Zealand Limited. It indicated that a broad south-westerly airstream covered the entire country; the direction of the flow was more or less parallel to the Southern Alps. The wind at 1000 feet in the accident area was estimated as 240° true, 10 to 15 knots.

1.7.2 The 0800 METAR (routine aerodrome report) for Hokitika Aerodrome was: surface wind calm, visibility 10 km in haze, cloud 1/8 stratocumulus, base 4000 feet, temperature 8° C, QNH 1018 hPa.

1.7.3 Witness reports of the weather in the accident area were consistent with the Hokitika Aerodrome report; the helicopter pilot who was first on the scene reported "flat calm" flying conditions.

1.9 Communications

1.9.1 The aircraft was equipped with one aeronautical VHF transceiver, and an additional commercial VHF-FM set had been fitted to facilitate communication with the logging crews. No report of any communication relevant to the accident was received.

1.12 Wreckage and impact information

1.12.1 The main wreckage, essentially the fuselage minus the tail boom and four main rotor blades, had impacted in an inverted attitude in soft swampy ground amid light scrub. The fuselage had come to rest on a heading of 030° magnetic, but the direction of travel before impact was approximately 145° magnetic. A wreckage trail, consisting mostly of portions of the tail boom, lay generally to the north-north-west of the main wreckage for a distance of approximately 360 m. See Diagram 1.

1.12.2 The main rotor blade seen by the witness landed on the eastern side of the Hokitika river, 750 m from the main wreckage. One blade was with the main wreckage, still partially attached to the rotor hub; the remaining three were scattered to the east, within a 150 m radius. It appeared that these three blades had broken off and been flung to the east of the main wreckage during the impact sequence. The complete tail assembly, comprising the tail rotor, its associated gearboxes and the complete tail pylon, lay in a creek 175 m to the north-east of the main wreckage.

1.12.3 The first, or northernmost, item on the wreckage trail was a light-gauge alloy fairing from the belly of the helicopter; it normally covered the gap between the fuselage and the right-hand external fuel tank. It was fixed to the fuselage by a line of screws along its inner edge, but was not attached to the tank itself; this arrangement accommodated the normal small flexing movements of the tank relative to the fuselage. The fairing had torn free of its retaining screws in a manner consistent with a sudden left yaw of the helicopter at normal cruise speed, allowing the airflow to penetrate under the free edge and to tear the fairing from its fasteners. The fasteners themselves remained in place on the fuselage.

1.12.4 Examination of the rotor blades and the pieces of tail boom showed that the tail boom had been struck and severed by the main rotor. Blade number 4 had detached in flight, and this blade exhibited the most severe damage. This blade was probably the second to strike the boom, severing it. The reactive loads on the blade were sufficient to cause it to fail near the root and be flung a considerable distance. The first strike had occurred above the horizontal stabiliser, but was probably not severe enough to result in the loss of the tail pylon; The second blade strike involved almost the full cross-section of the boom, including the tail rotor driveshaft (see Diagram 2, which shows the position of the first three strikes). The section of the driveshaft from this area was not found.

1.12.5 The tail rotor showed evidence of strike damage on the tips of all three blades; the damage was consistent with the tail rotor having struck fragments of the tail boom while still turning at reasonably high rpm, and the distance it travelled after separation suggested that it could have been developing significant thrust. Additionally, one of the tail rotor pitch-change control cables, after being severed as a result of the main rotor strike on the boom, had become tightly wound around the tail rotor hub. Examination of the magnetic plugs from both tail rotor gearboxes disclosed no abnormality.

1.12.6 Severe fragmentation of the tail boom aft of fuselage frame 21 (see Diagram 2) had occurred, but the various portions had fallen in a reasonably straight line and were concentrated within an area of approximately 150 m by 50 m. The largest piece of the boom was from the upper rear, and to which the horizontal stabiliser was still attached. This section showed clear evidence of the angle of strike by the main rotor, as did another distinct "slice" of the boom which had fallen close to the section which included the stabiliser.

1.12.7 Other items on the wreckage trail included fragments of perspex from the cockpit transparencies, an engine inlet cowl, a transmission compartment access door and fragments of electrical/avionic equipment from within the tail boom.

1.12.8 After initial examination in situ, the main wreckage was partially rolled over using an excavator to facilitate inspection of the engines, transmission and other components located on the engine/transmission deck. At this stage, it was possible to enter the cabin and inspect the flight control runs between the cockpit controls and the point at which they connected with the hydraulic boosters. No abnormality apart from impact damage was found. The transmission, which was still attached to the fuselage despite impact damage to the mounts, was lifted clear along with the hydraulic panel.

1.12.9 The engines appeared to have been operating up to the time of impact. Malleable deformation was evident on the hot section casings and exhaust ducts of both engines, there was evidence of sudden stoppage on the left transmission input drive quill, and residual rpm indications were present on both dual tachometers. The right input drive quill showed rotational damage consistent with partial separation of the transmission and the right engine while the latter was still operating. This was possibly an effect of the gross imbalance of the main rotor following the loss of one blade, causing the transmission to move in relation to the engine.

1.12.10 The main transmission itself was remarkably undamaged, probably because of the soft ground into which it was driven at impact. The main rotor hub was still in place, together with the root ends of all five main rotor blades. There was no evidence of any pre-existing defect in any of the rotor hub components, all damage being attributed to impact. This was confirmed by metallurgical examination where required. The hydraulic flight control boosters attached to the rear of the transmission suffered varying degrees of damage, but were recovered for later inspection, along with a number of other hydraulic system components. The magnetic plugs from the main transmission did not show any abnormal indications.

1.12.11 The cockpit area suffered severe impact damage to the overhead panels, which revealed little useful information, but the pilot and co-pilot instrument panels had, on the other hand, sustained relatively little damage; most instrument faces were undamaged, hence there were no "trapped" readings. The tachometers were the only engine instruments to retain a reading of any significance. On the exterior roof surface of the cockpit, scuff marks were found, indicating that the roof had been struck at a shallow angle by the underside of one or more main rotor blades.

1.12.12 Both attitude indicators (AI's) were of a type that retain the attitude indication at the time the power supply to the instrument is interrupted. The right (or co-pilot's) indicator displayed the attitude in which the aircraft had come to rest, but the left-hand indicator, which was also the primary attitude information source for the autopilot system, showed an attitude of 75° nose-down pitch, combined with 100° of right bank.

1.12.13 One explanation for the difference in the "frozen" attitude indications on the AI's could be that the instruments' power supply was interrupted at different times. The right-hand or copilot's AI showed the attitude in which the aircraft came to rest, thus the instrument appears to have been powered until the final impact. Both instruments shared a common power supply, but had the wiring to the pilot's AI been disrupted during the period when the aircraft was out of control, it would have retained the attitude indicated at that instant, 75° nose-down pitch and 100° right bank.

1.12.14 The 445-litre internal fuel tank (known as the service tank) located on the engine/transmission deck aft of the main transmission, had ruptured on impact and a considerable amount of spilled fuel was present beneath the aircraft. The main transmission had formed a "crater", in which much of the fuel and a mixture of engine, transmission and hydraulic oils had pooled. Both the external fuel tanks had suffered only minor damage, and did not appear to have contained significant quantities of fuel at impact.

1.13 Medical and pathological information

1.13.1. Post-mortem examination and toxicological tests disclosed nothing which would have impaired either pilot's ability to control the helicopter in flight.

1.15 Survival aspects

1.15.1 Although both pilots were restrained by a combined lap belt and shoulder harness, impact forces rendered this accident unsurvivable. The engineer had only a lap belt restraint available to him in the jump seat.

1.16 Tests and research

1.16.1 The witness observation of the helicopter's flight path immediately prior to the accident was examined in some detail. The field of view from the window through which the helicopter was observed was precisely delimited by trees to the right and left, and ridgelines in the background facilitated determining the aircraft's altitude, estimated to be about 300 feet above the terrain. The observed flight path and point at which the witness ceased watching the helicopter were analysed, and related to the time it took for the witness to walk to the other end of the house. A minimum time interval of 20 seconds was recorded for the latter event, but the actual time taken on the day of the accident could not be determined precisely. To fit the reconstruction of events, this time would have to have been at least one minute.

1.16.2 It transpired that the point at which the witness last saw the helicopter was virtually over the final impact point, but while it was under her observation, the helicopter appeared to be intact and flying normally. At this point it had already overflown the area of the wreckage trail. For the wreckage to land where it did, and to fit with the witness observations, the helicopter had to have turned at least 180°, backtracked in the general direction of Hokitika for several hundred metres, then resumed its original flight path. The disintegration was assumed to have been initiated once the helicopter was again heading towards the logging area.

1.16.3 Because of the lack of familiarity with the aircraft type, the Transport Accident Investigation Commission sought the assistance of the Russian investigative authority, the Flight Safety Commission, Interstate Aviation Committee. Their Deputy Chairman spent ten days in New Zealand assisting with the investigation.

1.17 Additional information

Maintenance and regulatory aspects

1.17.1 Although the crew were operating a foreign-registered helicopter, they were subject to the flight and duty limitations as laid down in Civil Aviation Safety Order 20. The (New Zealand) Civil Aviation Act 1990 (as amended by the Civil Aviation Amendment Act 1992) stated at Section 4:

> "(1) This Act and all regulations and rules made under this Act shall apply to the following:
>
> ... (d) Every foreign registered aircraft operating in New Zealand."

1.17.2 The relevant (CASO 20) flight time limit in this case was a maximum of 35 hours in the preceding week, and the duty time limitation required a day free of all duties, including standby, at least once in every seven days. Both pilots were on their tenth consecutive day of flying, the last day off flying being due to bad weather, and both had flown about 44 hours in the week preceding the accident date.

1.17.3 Investigation of the airworthiness and maintenance of the helicopter concluded that, despite several irregularities which were revealed, the maintenance and record keeping had been in accordance with normal aviation practices. The maintenance had been performed by experienced Licensed Aircraft Maintenance Engineers under the direct observation of the Mil Design Bureau representative.

1.17.4 One anomaly found concerned the Mil Design Bureau's issuing of a service bulletin applicable to Mi-8 helicopters used specifically on heavy-lift logging operations. The bulletin required each hour flown on this type of operation to be recorded in the engine and main transmission logbooks as 7.5 hours. The operator had not been recording the flight time in this manner, because of some dispute as to the applicability of the bulletin to this particular helicopter. It was found after the accident that the bulletin was in fact applicable, although the failure to record the flight times as required by the bulletin did not appear to have contributed to the cause of the accident. The engines and main transmission were not suspected as causal factors.

The flight control, hydraulic and autopilot systems

1.17.5 The flight controls of the Mi-8 series are conventional, with dual cyclic pitch controls, collective pitch levers, and directional (tail rotor pitch) control pedals. Incorporated in the cyclic and directional control runs are "spring feel" units and electromagnetic brakes, directly analogous to the force trim system found on some Western helicopter types, notably the Bell 205 and its derivatives.

1.17.6 The forces necessary for the control of the main and tail rotors are provided by hydraulic servos (boosters), which effectively amplify the control forces applied by the pilot. Three boosters are connected in series with the main rotor controls, i.e. lateral cyclic, longitudinal cyclic and collective. A fourth, slightly different, booster is similarly incorporated to the directional control system. The actuating rods of the main rotor control boosters are linked directly to the swashplate, and the directional control booster drives a sector and pulley arrangement, connected to the tail rotor pitch change mechanism by duplicated wire cables.

1.17.7 Two independent hydraulic systems are provided, the "main" system and the "duplicating" system. The main system normally provides the required operating pressure, and in the event of a main system failure, the duplicating system takes over, supplying the boosters via completely independent plumbing. The boosters have inlet ports for main system pressure, duplicating system pressure, and "combined control" pressure.

1.17.8 The routine maintenance referred to in paragraph 1.1.3 included the replacement of the rubber diaphragms in both of the main hydraulic system accumulators. This operation had been performed without the required special tooling, but had been done under the supervision of the manufacturer's representative. The diaphragms were examined after the accident and found to be intact, as was the diaphragm in the duplicating system accumulator. The manufacturer advised that failure of one or both of the diaphragms would not normally lead to control problems.

1.17.9 The Mi-8 autopilot is a three-axis system which utilises the pilot AI as its primary attitude reference. The autopilot can be operated in a true "hands-off" mode; it provides attitude retention, and height or airspeed hold if required. It can also be left engaged while the helicopter is flown manually, in which case it acts as a stability and control augmentation system (SCAS). It was normal practice to fly with the autopilot on, but it was not determined whether the autopilot was on or off at the time of the accident.

1.17.10 When the autopilot is engaged, solenoid valves (one for each of the four boosters) admit main system hydraulic pressure to the "combined control" port in the booster assembly. This "combined control" pressure is modulated by an internal solenoid valve which in turn is operated by electrical signals from the autopilot system. The combined control pressure operates a piston and cylinder arrangement within the booster body (the piston is actually the inner end of the actuating rod which provides the output force from the booster) to give the rod a stroke length of 20% of full travel. Full travel of the rods of the cyclic boosters is provided by the main cylinder/piston assembly, which is external to the booster body. These normally operate when the helicopter is under manual control.

1.17.11 The directional control booster differs from the cyclic and collective boosters, in that, under combined control, the actuator rod is not limited to 20% of its stroke, as the others are. Under combined control, the rod can move through its full range of travel. In the "hands-off" flight mode, the pilots' cyclic controls are restrained by the force gradient springs and magnetic brakes, and do not move unless reset by the pilot. The directional control booster rod is equipped with a microswitch system which senses movement of the rod in excess of 20% of full stroke, and disengages the magnetic brake, permitting the directional control pedals to move correspondingly. This pedal movement is rate limited.

1.17.12 The longitudinal cyclic and directional control hydraulic booster assemblies were stripped at a Royal New Zealand Air Force facility, and examined for any abnormality which may have led to the accident.

1.17.13 Nothing of significance was found in the longitudinal cyclic booster, but in the directional control booster, the solenoid valve controlled by the autopilot was found to have suffered a dislocation of the pushrod between the solenoid armature and the related shuttle valve.

1.17.14 It was concluded, however, that the dislocation could only have occurred at impact. The booster body bore evidence of a severe blow, and the actuating rod had broken off flush with the booster body. It was found that there was sufficient freedom of movement of the armature relative to the shuttle valve pushrod (which itself was rigidly restrained in the lateral sense) for the pushrod to have slipped out of the recess in the armature in which it was held by spring tension.

FLIGHT CHARACTERISTICS

1.17.15 During the investigation, other pilots employed by the operator mentioned a characteristic of the Mi-8 series which they thought was the subject of a warning in the aircraft flight manual. The warning was to the effect that rapid reduction of collective pitch, combined with the application of aft cyclic (as in a rapid entry into autorotation), can result in the striking of the tail boom by the main rotor.

1.17.16 Although the other pilots were well aware of the warning, no one was able to locate it in the flight manual. It was later discovered that the warning existed only in the original Russian-language manual, and had not been carried over into the English-language version.

1.17.17 The basis for the warning is that the rapid reduction of collective pitch causes the main rotor disc to flap forward, in turn causing the helicopter to pitch nose-down. At the same time, the resulting reduction of rotor thrust causes the coning angle of the blades to reduce, thus decreasing the clearance between the main rotor and the tail boom. If the pilot overreacts with aft cyclic in response to the nose-down pitch, particularly if the aircraft is still pitching (which means that the tail boom is rising) the combination of reduced coning and rearward tilting of the rotor disc may result in a tail boom strike. In this accident, assuming that these strikes were made by three blades in succession, the relative pitch rate between the main rotor disc and the tail boom was calculated as 55° per second. This is a severe manoeuvring rate for a helicopter of this size.

1.17.18 The ability of the main rotor to come into contact with the tail boom in flight is not confined to the Mi-8 series of helicopters, but abnormal flight conditions generally precede this type of occurrence.

2. ANALYSIS

2.1 Both pilots had only recently converted onto the Mi-8T helicopter, and were relatively inexperienced on the type. They had been flying intensively in the ten days leading up to the accident date however, and would have been developing a reasonable "feel" for the aircraft, which was a much larger type than those to which they were accustomed.

2.2 The helicopter appeared to have been operating normally prior to the accident flight, and the crew who had performed the first flight of the day reported no abnormalities or defects.

2.3 The helicopter had been maintained in accordance with good aviation practice, and there was no evidence to suggest that the record keeping had been improper. A misunderstanding had existed regarding the recording of engine and transmission hours while the aircraft was used on heavy-lift (logging) operations, but there was nothing to indicate that this had any bearing on the accident.

2.4 A number of components on the helicopter had been "calendar-lifed" as well as having "time in service" lives. These components, including the main rotor blades, had been inspected by a factory representative, who granted extensions to the calendar lives.

2.5 When the helicopter was sighted by the witness just before the accident, it appeared to be in straight and level cruise flight at a low altitude, and showing no overt signs of any difficulty. The point at which the witness last saw the helicopter was over, or close to, the point where it finally came to rest, having already overflown the area where the fragmented tail boom and other parts had fallen.

2.6 The time from when she left the window to when she heard the sounds of the accident was estimated by the witness to be at least 20 seconds, but was probably of the order of one minute. Given the witness sighting, and the location of the wreckage, it follows that the helicopter must have carried out some manoeuvre(s) between the last sighting and the accident. This could have taken the form of a circuit or orbit over the area where the wreckage trail subsequently lay. No reason for any deviation from the intended flight path could be determined, although possibilities include:

a. some sort of problem developing, causing the crew to seek an area suitable for a forced landing;

b. the sighting by the crew of something on the ground warranting a closer look;

c. an experimental manoeuvre by the crew.

2.7 The possibility of some warning of a developing problem is a real one, although the terrain on which the wreckage finally landed was unsuitable for a forced landing. It may have given the appearance of being suitable from a distance, but below an altitude of about 500 feet, its true nature (scrub-covered, swampy) would have been readily apparent. Nevertheless, suitable grass fields and open river shingle flats were available only a few hundred metres to the east of the flight path. Had there in fact been a problem with the helicopter, it could be reasonably assumed that the crew would have made some attempt to advise the waiting logging crews of the situation, although any communication would have to be prioritised according to the cockpit workload and the urgency of the need to land. There is also the possibility that a problem may have occurred so suddenly as to preclude any communication. In any event, no communication was heard.

2.8 The first item on the wreckage trail was a fairing from the right-hand underside of the helicopter. The damage to the fairing indicated that it had become detached as a result of a severe yaw to the left. Comparison with the equivalent fairing on the other side showed that a considerable force would have been necessary to tear the fairing loose, thus it was concluded that an airflow of the order of 80 to 100 knots would have been required.

2.9 The next items on the trail were major portions of the tail boom, showing obvious evidence of having been struck and severed by the main rotor. These lay some 180 m nearer the main wreckage, and included some relatively heavy items which would not have drifted significantly had there been any wind in the area.

2.10 Because of the relative positions of the tail boom pieces and the belly fairing, it was apparent that the initiating factor in the accident sequence was probably a severe yaw to the left, at approximately cruise speed, permitting the airflow to peel the fairing from the belly. Because of its large surface area in relation to its weight, the fairing would have "fluttered" downward. As "flat calm" conditions were reported in the area at the time, it is likely that the fairing would have fallen reasonably close to the point beneath which it came off the aircraft. The fairing showed no sign of having been struck by any other object.

2.11 A likely sequence of events is:

a. the initial severe yaw to the left, with accompanying roll and sideslip;

b. the tearing off of the fairing by the resultant relative airflow from the right;

c. **either**: the continuing of the yaw past 90° to the original heading (i.e. that at the time of the onset of the yaw) and the new relative airflow acting upon the horizontal stabiliser, causing a violent nose-down pitch of the helicopter;

or: the rapid lowering of the collective pitch lever by the pilot(s) in an attempt to enter autorotation (one method of dealing with a suspected tail rotor failure), with an accompanying nose-down pitch by the helicopter;

d. the instinctive reaction of the pilot(s) to the nose down pitch, applying full aft cyclic in an attempt to counteract it;

e. the striking of the tail boom by the main rotor, resulting in the departure of the tail rotor and pylon assembly, with overload failure of one rotor blade as it struck the tail boom;

f. resultant irretrievable loss of control, with the helicopter gyrating randomly about all three axes before striking the ground in an inverted attitude, further rotor strikes (including those on the cockpit roof) occurring during this period;

the entire sequence from the onset of the yaw occupying seven or eight seconds. Additionally, the loss of the weight of most of the tail boom, the tail pylon, tail rotor and gearboxes would have resulted in an abrupt forward movement of the centre of gravity and exacerbated the pitching tendency referred to in c. above. The relative pitch rate between main rotor and tail boom was calculated as 55° per second for the first three main rotor blade strikes, a severe manoeuvring rate for this type of helicopter.

2.12 A sudden uncommanded nose-down excursion in pitch could have resulted equally in a situation where instinctive pilot application of rearward cyclic, particularly if collective pitch were to be rapidly reduced at the same time, would cause the main rotor to strike the tail boom, but this would not account for the order in which the wreckage was found. The helicopter had to have been subjected to the yaw before the tail boom strike for the fairing to land where it did. Had the strike resulted purely from a pitch interaction between the main rotor and the tail boom, the yaw would not have occurred until after the loss of the tail rotor, hence the fairing would have landed between the severed portions of the tail boom and the main wreckage. As there was no wind at the time, it is reasonable to assume that the fairing did not blow back to where it landed.

2.13 The reason for the uncommanded yaw could not be isolated, however possibilities include:

a. a failure of the tail rotor drive train;

b. a failure of the tail rotor pitch-change mechanism;

c. a fault in the directional control hydraulic booster which caused the actuator to adopt the "full left pedal" position;

d. a spurious signal from the autopilot to the "combined control" portion of the booster, permitting the actuator to adopt the "full left pedal" position.

2.14 No conclusive evidence was found to indicate a failure in either the tail rotor drive train or the pitch-change mechanism. The tail rotor showed evidence of significant rpm at the time of the tail boom strike. Strip examination of the directional control booster revealed a condition which was probably a result of the final impact. Damage to the autopilot components precluded any useful examination or testing of these.

2.15 In view of the apparent magnitude of the yaw, it is considered that the "full left pedal" scenario is more probable than that of the failure of the tail rotor drive or pitch change mechanism. In the speed range of 80 to 100 knots, there should be sufficient weathercocking effect available from the tail boom and fin to prevent a violent yaw in the event of a simple tail rotor drive or pitch-change failure.

2.16 The handling characteristics of the helicopter, in particular the possibility of striking of the tail boom by the main rotor during mishandling in flight was not documented in the English version of the flight manual. However, it was sufficiently well known amongst the operator's other pilots, including the instructor who type-rated Messrs Green and Ashworth, to assume that the latter two were also aware of it.

3. FINDINGS

3.1 The pilots were appropriately licensed and rated for the type of operations in which they were involved.

3.2 The helicopter held a current Certificate of Registration and Certificate of Airworthiness, issued by the State of Registry, El Salvador.

3.3 The helicopter had been maintained in accordance with normal aviation practice, and while in New Zealand, under the supervision of a manufacturer's representative.

3.4 The helicopter appeared to be operating normally until shortly before the accident.

3.5 Immediately prior to the accident, the helicopter carried out some form of manoeuvre, probably involving a 360° turn.

3.6 The true nature of the manoeuvre and the reason for it could not be determined.

3.7 The helicopter was subject to a sudden attitude disturbance which resulted in the severing of the tail boom by the main rotor.

3.8 The probable nature of the initial disturbance was an uncommanded left yaw.

3.9 The left yaw probably led to an abrupt nose-down pitch, resulting from either reversed airflow over the horizontal stabiliser, or a rapid attempt by the crew to enter autorotation.

3.10 In an attempt to recover from the nose-down pitch, instinctive pilot control input probably caused the main rotor to strike and sever the tail boom.

3.11 After the loss of the tail boom and the tail rotor, its two gearboxes and the tail pylon, the helicopter was uncontrollable.

3.12 The helicopter then probably underwent random gyrations before final impact, further strikes by the main rotor blades occurring during this interval.

3.13 The cause of the left yaw was not isolated, but was probably due to either a fault in the directional control hydraulic booster, or a spurious signal from the autopilot to the "combined control" portion of the directional control booster, permitting the actuator to adopt the "full left pedal" position.

3.14 The accident was unsurvivable because of the impact forces involved.

24 August 1994

M F Dunphy
Chief Commissioner