CIVIL AVIATION AUTHORITY OF NEW ZEALAND

AIRCRAFT ACCIDENT REPORT

OCCURRENCE NUMBER 03/3733

FLETCHER FU24-950M

ZK-BXZ

10 NM SOUTH-WEST OF TE KUITI

19 DECEMBER 2003

Glossary of abbreviations used in this report:

C	Celsius
CAA	Civil Aviation Authority
CAR	Civil Aviation Rules
CPAP	continuous positive airway pressure
E	east
ft	foot or feet
G	A unit of force that is equal to the force exerted by gravity on a body at rest and is used to indicate the force to which a body is subjected when undergoing acceleration
km	kilometre(s)
lb	pound(s)
M	magnetic
MCTOW	maximum certificated take-off weight
nm	nautical mile(s)
NZDT	New Zealand Daylight Time
S	south
UTC	Coordinated Universal Time
WGS 84	World Geodetic System 1984

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Aircraft type, serial number and registration:	Fletcher FU24-950M, 65, ZK-BXZ
Number and type of engines:	1 Lycoming IO-720-A1B
Year of manufacture:	1956
Date and time:	19 December 2003, 1500 hours[1] (approx)
Location:	Mairoa, 10 nm south-west of Te Kuiti Latitude[2]: S 38° 22.9' Longitude: E 174° 57.0'
Type of flight:	Agricultural – topdressing
Persons on board:	Crew: 1
Injuries:	Crew: 1 fatal
Nature of damage:	Aircraft destroyed
Pilot's licence:	Commercial Pilot Licence (Aeroplane)
Pilot's age:	57 years
Pilot's total flying experience:	14335 hours, 5000 on type
Information sources:	Civil Aviation Authority field investigation
Investigator in Charge:	Mr A Buckingham (Transferred to Mr M Carrelli)

[1] Times are NZDT (UTC + 13 hours)

[2] WGS 84 co-ordinates

Synopsis

The Civil Aviation Authority was notified of the accident at 1520 hours on Friday 19 December 2003. The Transport Accident Investigation Commission was in turn notified shortly thereafter, but declined to investigate. A CAA site investigation was commenced the next morning.

The pilot was spreading lime on a farm property. The aircraft had completed a number of flights from the strip that day at the same take-off weight as at the time of the accident. The aircraft crashed approximately 170 metres from the end of the strip.

1. Factual information

1.1 History of the flight

1.1.1 On the morning of 19 December 2003, the pilot began work about 0630 hours, flying from Te Kuiti aerodrome to an agricultural airstrip about eight nautical miles to the west. At that strip he completed a 150 tonne lime contract that had been started by two other aircraft the day before.

1.1.2 Refuelling of the aircraft was completed approximately every hour, and the pilot stopped for a break with about four loads remaining. At 1400 hours, with the job completed, he flew to the strip from which he operated until the time of the accident.

1.1.3 On arrival at this strip, the pilot completed a reconnaissance flight with the pilot of ZK-EMW, discussed their sowing plan, and agreed on a 1.1 tonne load with the loader driver. Take-offs were made to the south-west, landings in the opposite direction.

1.1.4 The loader driver reported that the job was going smoothly, and that the pilot seemed in good spirits, at one stage miming wiping his brow, which the loader driver took to be a comment on the heat of the day. During this time, a third company aircraft, ZK-JAL, arrived at the strip and shut down, as the loader driver was able to handle only two aircraft at a time. The pilot of ZK-JAL flew a briefing sortie with the pilot of ZK-BXZ prior to the planned departure of ZK-BXZ.

1.1.5 After each take-off, ZK-BXZ would turn left on to a downwind leg and then cross over the top (loading) end of the strip on the way to the sowing area. ZK-BXZ was working inward from the eastern boundary of the property, and ZK-EMW from the western boundary. While topdressing was in progress, fresh lime was being trucked to the strip and placed in the large fertilizer bin from which the loader was replenishing the aircraft. The lime was received directly from the processing plant, and was dry and free-flowing. As each load arrived, the farmer would mix a cobalt supplement with it in the bin.

1.1.6 One of the truck drivers, who himself held a Commercial Pilot Licence (Aeroplane), took several photographs of the aircraft landing and taking off. One photograph showed ZK-BXZ leaving the end of the strip on probably its penultimate take-off, with ZK-EMW on final approach on the reciprocal heading.

On this occasion ZK-EMW passed over ZK-BXZ just after the latter became airborne.

1.1.7 The next photograph showed ZK-BXZ approximately two thirds of the way down the strip, with 20° of flap set on its final take-off, with dirt being thrown up by the wheels as it hit the soft spots in the strip. The driver did not watch the take-off beyond this point.

1.1.8 The pilot of ZK-EMW initially reported that on his landing approach, he flew over ZK-BXZ while it was still on its take-off run. He later disputed this and claimed that ZK-BXZ had just become airborne when it disappeared from view under his right wing. In any event, ZK-BXZ only flew approximately 170 metres, so the proximity of these two aircraft was very close if ZK-BXZ was already airborne at this point in time.

1.1.9 The close proximity of the two aircraft is significant as it is possible that ZK-BXZ, being the lower of the two aircraft, may have encountered wake turbulence from ZK-EMW. All aircraft produce wake turbulence as a by-product of generating lift from their wings, the intensity varying with the aircraft's speed, weight and configuration. The weather conditions, as discussed in the article appended to this report, were favourable for ZK-BXZ to encounter the wake vortices from the aircraft passing above.

1.1.10 The first indication of the accident was a loud bang heard by the farmer – he was in the bin mixing in the cobalt supplement, and initially thought he had heard a truck tailgate slamming. Looking towards the end of the strip, he saw a plume of smoke and immediately went by motorcycle to investigate. On arrival at the scene, he found the aeroplane well ablaze, and was unable to get close because of the heat.

1.1.11 As the accident occurred, a fourth company aircraft, ZK-EGV, arrived at the strip. The pilot did not see the actual impact, but flew over the burning wreckage on approach. As soon as he landed he went by foot to the accident site, as he had arrived too late to join those that had gone on board the loading vehicle. The loader driver used his fire extinguisher to quell the flames, but could do nothing to assist the pilot. After the extinguisher ran out, the fire flared up again, and all those present could do was to await the arrival of the Fire Service.

1.1.12 The accident occurred in daylight, at approximately 1500 hours NZDT, at Mairoa, 10 nm south-west of Te Kuiti aerodrome, at an elevation of 1150 ft.
Latitude: S 38° 22.9', longitude: E 174° 57.0'; grid reference: 260-R16-806117.

1.2 Injuries to persons

Injuries	*Crew*	*Passengers*	*Other*
Fatal	1	0	0
Serious	0	0	0
Minor/None	0	0	

1.3 Damage to aircraft

1.3.1 The aircraft was destroyed.

1.4 Other damage

1.4.1 Nil.

1.5 Personnel information

1.5.1 The male pilot, aged 57, held a Commercial Pilot Licence (Aeroplane), endorsed with Flight Radio Telephone Operator, Agricultural, and Chemical ratings. Additionally he also held a C category instructor rating. He was type rated on the FU24 series of aircraft.

1.5.2 He held a current Class 1 medical certificate, valid to 16 June 2004, and endorsed with a requirement to have half spectacles readily available.

1.5.3 He had flown a total of 14335 hours, of which 5000 hours were in the FU24 type, including 150 hours on the Walter turbine engine version.

1.6 Aircraft information

1.6.1 ZK-BXZ a Fletcher FU24-950M, serial number 65 was manufactured in 1956 and first registered in New Zealand on 4 October 1960. It was issued with an initial airworthiness certificate on 23 March 1961.

1.6.2 The current certificate of registration had been issued on 28 October 1988. The current airworthiness certificate issued on 20 May 1996 was non-terminating in the restricted category with the conditions of use being private and aerial work operations only.

1.6.3 The aircraft had flown a total time in service of 23036.4 hours and 5131.2 hours since the last overhaul.

1.6.4 The engine, a Lycoming IO-720-A1B, serial number L-852-54A had run a total time in service of 9126.6 hours and 1227.4 hours since overhaul.

1.6.5 An annual review of airworthiness had been carried out on 11 March 2003 and the last 100 hour inspection on 7 December 2003 at 23014 hours total time in service.

1.7 Meteorological information

1.7.1 The weather was reported by witnesses as being fine and clear. The wind was a light north-westerly breeze at an estimated three to five knots with an occasional gust up to possibly eight knots with the imminent arrival of the sea breeze. The temperature at the airstrip was estimated to be 24°C.

1.7.2 Actual conditions at the two nearest weather recording stations showed the following:

- Hamilton 80 km to the north; wind variable at 3 knots, few clouds at 3000 ft, visibility 30 km, temperature 24°C.

- Taupo 76 km to the east; wind 210°M at 8 knots, few clouds at 3000 ft, visibility 80 km, temperature 22°C.

1.8 Aids to navigation

1.8.1 Not applicable.

1.9 Communications

1.9.1 Not applicable.

1.10 Aerodrome information

1.10.1 The airstrip was located on the crest of a ridge, orientated 045°/225° M, with an available take-off run (from the loading point) of 420 metres. The grass surface was not in particularly good condition, and had a number of soft patches along the take off run.

1.10.2 The strip sloped towards the south-west being virtually level for the first 381 metres, followed by a slightly increasing downward gradient, with the usable surface terminating at the top of an increasingly downward slope which continued down to the boundary fence, 30 metres further on. An access track for the fertilizer trucks ran at right angles across the end of the strip, at the top of this slope. Take-offs were made to the south-west, with landings in the opposite uphill direction.

1.10.3 Beyond the boundary fence below the end of the strip, the ground sloped down and then rose again progressively to a small knoll. A small gully originated close to the strip extended centreline, and fanned downward to the left of the knoll, with a farm track following the knoll side of the gully.

1.10.4 The pilot was making left turns after take-off, climbing on the ‘downwind’ leg parallel to the strip, and crossing over the fertiliser bin and loading area to the north of the strip.

1.10.5 The fertiliser bin was a concrete and steel roofing structure built against a bank, to facilitate delivery via a hinged roof panel. Access for the loading vehicle was via double doors at strip level. Lime was being delivered to the bin during the topdressing operation, and when the lime was examined in the course of the investigation, was found to be clean, dry and free flowing.

1.11 Flight recorders

1.11.1 Not applicable.

1.12 Wreckage and impact information

1.12.1 The first ground contact was 170 metres from the departure end of the strip, and was a distinctive 4.5 metre scar made by the left aileron fence. This was on the grass surface of the track mentioned in 1.10.3. The left outer wing section separated on striking the low embankment on the knoll side of the track, and the remainder of the aircraft collided with the knoll slope above the track.

1.12.2 Placing the separated wing section in the ground scar enabled the bank angle to be precisely determined at 55° to the left, taking into consideration the 8° dihedral of the outer wing section. The pitch angle could not be determined accurately, but was approximately 5° nose down.

1.12.3 From the departure end of the strip, the aeroplane had descended some 20 ft to the impact point. It had first climbed slightly once airborne, and cleared a single electric fence conductor which ran across the end of the strip boundary. The crew of the fire appliance attending the accident confirmed that this conductor was still standing and that they had brought it down on their way to the fire.

1.12.4 The aircraft heading at impact was 191° M, but it had only deviated 7° to the left of the strip heading. The main impact was taken by the left wing, followed by the nose and right wing. During the impact sequence, the fuselage ‘cart-wheeled’ some 80° anticlockwise (viewed from above), the left wing partially separating at the root, and the rear fuselage fracturing aft of the hopper.

1.12.5 The engine and propeller made a substantial impact scar on the slope, before the entire aircraft rebounded about 1.5 metres down the slope. Asymmetric damage to the exhaust system was consistent with the angle of bank noted in 1.12.2. Both wing leading edges sustained crush damage, which extended into the fuel tank area on the left wing. The cockpit suffered longitudinal deformation, reducing the occupiable space.

1.12.6 Weighing the lime at the scene was not practicable, however it was noted that no release had taken place before impact. The pre-impact position of the hopper doors could not be determined, owing to the total destruction of the operating mechanism.

1.12.7 All extremities and control surfaces were accounted for at the site, and pre-impact integrity of the primary flight controls was established. The flap position and trim setting could not be determined; however, it was known that the pilot had been using 20° of flap on take-off. The cockpit area was destroyed by fire. The throttle, mixture, and propeller pitch levers were all in the fully aft position, which is consistent with the disruption of the control runs as the engine became dislodged at impact.

1.12.8 The wreckage was recovered from the scene by the owner, and the engine and propeller were delivered to an overhaul facility for strip examination.

1.13 Medical and pathological information

1.13.1 Post-mortem examination showed that the pilot died of injuries consistent with a high energy impact, and not from the effects of the fire.

1.13.2 There was no indication of any pre-existing physical condition that could have resulted in incapacitation or affected the pilot's ability to fly the aircraft.

1.13.3 The post-mortem report stated that there were no significant abnormalities with the toxicological tests.

1.13.4 The investigation was advised that the pilot was undergoing treatment for a sleep disorder. This was confirmed by the pilot's wife who stated that he had been using a CPAP machine every night for at least a year prior to the accident and was always enjoying a good night's sleep.

1.14 Fire

1.14.1 An intense fire consumed much of the centre section of the aircraft. Dislocation of the engine, fracture of the main fuel supply line and splitting of the leading-edge fuel tanks on impact provided means for the fire to break out.

1.15 Survival aspects

1.15.1 Although the pilot was restrained by a combination lap and shoulder harness, the severity of his injuries was beyond human tolerance, and instantly fatal.

1.15.2 ZK-BXZ was fitted with a Pointer 3000 ELT. The burnt remains of the ELT were found in the wreckage. Had it operated on impact as designed, the signal would have lasted only a short time before the unit was destroyed by fire. No ELT signal that could have related to ZK-BXZ was reported, or detected by the search and rescue satellites.

1.16 Tests and research

1.16.1 Strip examination of the engine was carried out under the observation of a CAA investigator. The examination was largely confined to the core engine, namely cylinder assemblies and crankcase, owing to the extensive impact and fire destruction of most accessories. Those that could be tested were the propeller governor and the fuel flow divider, both of which gave normal results.

1.16.2 The strip of the engine and propeller confirmed that the engine was delivering high power at the point of impact.

1.17 Organisational and management information

1.17.1 Not Applicable.

1.18 Additional information

1.18.1 One of the other pilots present at the strip commented that the 1.1 tonne load was probably too much for the conditions and that 950 kg would probably have been more appropriate. The fact that ZK-BXZ was using the entire strip before becoming airborne could well support this statement. However, it must be borne in mind that ZK-BXZ had already completed a number of take offs with this load and was getting lighter due to fuel usage.

1.18.2 The Airplane Flight Manual prescribes a maximum take-off weight for normal flight of 4860 lb. with a flight load factor limitation of +3.8 g to -1.5g with flaps up and +2.0 g with flaps down.
For agricultural flight the maximum take-off weight is 5430 lb. and the flight load factor limitation is +3.0 g with no lower limit stated.
The agricultural flight load factor for flaps down is not stated. However this aircraft was taking off using flaps 20.

CAR 137 Appendix B "*Overload Weight Determination*" allows for the original weight and limit load factor to be used in the graph supplied to determine the percentage overload that may be applied. The term "original" is not defined as to whether it is the normal or agricultural flight limits. However it is the CAA's view that the limit load factor for the normal category is the correct limit to be applied. Appendix B is inserted below

Appendix B — Overload Weight Determination

(a) The pilot procedures required by 137.103(a) consist of—

(1) finding the MCTOW in the aeroplane flight manual and the original aeroplane limit load factor; and

(2) locate the 'original aeroplane limit load factor' on the horizontal axis of figure 2, going vertically up to the reference line and then horizontally to the vertical axis to read the 'maximum recommended percentage weight increase'; and

(3) increasing the original category MCTOW by this percentage to find the new maximum take-off weight.

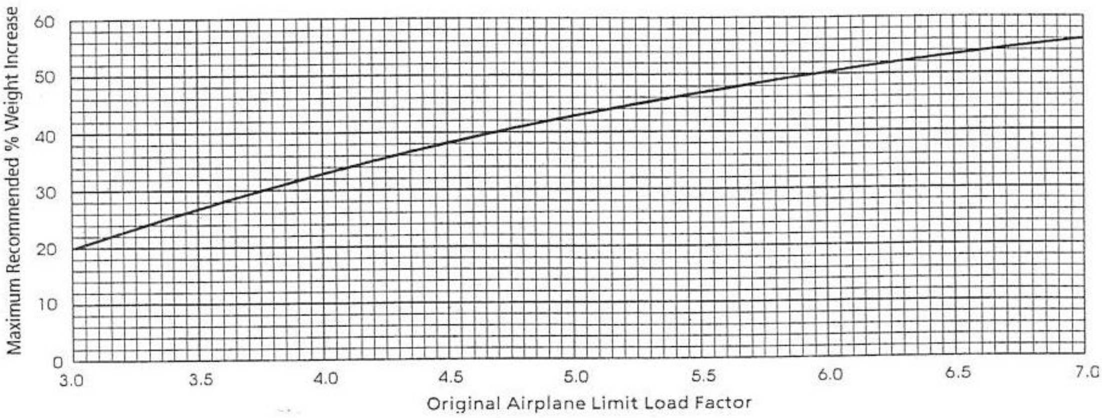

Figure 2

(b) When considering whether to operate up to this new maximum takeoff weight, the pilot must take the following factors into account:

(1) the pressure altitude of the aerodrome;
(2) the ambient temperature at the aerodrome;
(3) the runway surface type and condition;
(4) the runway slope in the direction of take-off;
(5) the headwind or tailwind component in the direction of the takeoff;
(6) any other factors that may affect the performance of the operation.

137.103 Maximum take-off weight

(a) Notwithstanding Part 91 and subject to paragraph (b), a pilot performing, or being trained to perform, an agricultural aircraft operation in an aeroplane must not take-off at a weight greater than the MCTOW prescribed in the aeroplane's flight manual unless—

(1) the pilot complies with the procedures listed in Appendix B; and
(2) the aeroplane is equipped with a jettison system that, in accordance with D.5, is capable of discharging not less than 80 percent of the aeroplane's maximum hopper load within five seconds of the pilot initiating the jettison action.
(b) Where there is a third party risk as defined in Appendix A, the pilot must determine the maximum take-off weight in accordance with 137.107 and 137.109.

Weight and balance calculations showed that the aircraft was taking off at approximately 5713 lb which is within the overload limit permitted by CAR 137 Appendix B, which when using the normal flight category flight load limitation of +3.8 g, would have allowed a maximum take off weight of 6366 lb.

1.18.3 The Airplane Flight Manual shows a loading envelope for the C of G limits which includes the weight limits for normal flight (4860 lb) and the absolute maximum for agricultural flight (5430 lb). There is no information for loading above these weights as is allowed in CAR 137.

1.18.4 For this flight the C of G envelope was simply extended by continuing the limit lines further up the graph to the higher weight of 5713 lb. By using this method it was found that the C of G was on the extreme aft limit. However as this area of the flight envelope has not been tested or published, it cannot be proved that this is in fact a safe area of the aircraft's flight regime in which to be operating.

1.18.5 The above paragraphs deal purely with the structural load limit and C of G issues. The next factor that needs to be considered is the performance envelope of the aircraft at these higher than certified weights. As there was no third party risk involved in this operation the pilot had to comply with CAR 137.105 which is inserted below.

137.105 Take-off distance and flight path — no third party risk
A pilot performing, or being trained to perform, an agricultural aircraft operation in an aeroplane where there is no third party risk as defined in Appendix A is not required to comply with the following:
(1) the take-off distance specified in the aeroplane flight manual;
(2) the take-off flight path gradient specified in the aeroplane flight manual.

Whilst the pilot needs to take into consideration the items listed in Appendix B (b) there is no requirement to comply with the performance stipulated in the Airplane Flight Manual, or any specified lower level of performance. This means the pilot can on successive take-offs continue to increase the maximum take-off weight until the aircraft only just gets airborne.

1.18.6 As the aircraft weight is increased above the certified maximum all-up weight, the stall speed will increase by an unknown amount above the figures published in the Airplane Flight Manual.

1.18.7 In summary this means the aircraft is overloaded in terms of the manufacturers weight and C of G criteria, and is on the limits of becoming airborne and/or climbing away. The slightest change in runway or flight conditions, such as turbulence or wind shift, may leave the aircraft uncontrollable due to an aft C of G and airspeed going beyond the limits within which the aircraft can be controlled by the pilot.

1.18.8 The aircraft was fitted with an enlarged fibreglass hopper, approved modification number AP 41. The hopper was fitted with a high volume solids application system, approved modification number SL/M/098. This design has louvre doors for dispersing and dumping of the load. The requirement for dumping as per CAR 137.103 (a) (2) is to be able to dump 80% of the load in 5 seconds so as to quickly return the aircraft to within the manufactures limits of weight and performance. It is sometimes difficult to initially activate the doors as they have to lift the load, on one half of each louvre door, which may have packed down on them during the take off run. As a result it is sometimes necessary for the pilot to apply negative G so as to be able to apply enough force to activate the dump mechanism. If dumping is required during or immediately after take-off the option of applying negative G is not available. Once the louvre doors have been opened they have the tendency to remain open.

1.18.9 It is possible, however remote in this case due to the product being dry and free flowing, that some of the lime could have hung up in the hopper. If the lime had hung up in the hopper and a new measured load was added then the aircraft would have been heavier than expected for the subsequent take off.

1.18.10 It is also possible that a small amount of lime had spilled unnoticed on the wing upper surface during the loading process. Lime tends to stick to a wing and does not blow off easily in the slow moving boundary layer airflow close to the aerofoil surface. This would have the same aerofoil deforming characteristics as a layer of frost which normally increases the stall speed of the wing. Whilst it may have eventually been removed by the air stream it is very possible that it would have remained during the take-off run and initial climb. The Transport Accident Investigation Commission has published a report reference 05-008 *Cessna U206G, ZK-WWH, loss of control on take-off, Queenstown Aerodrome,* which investigates the effects of frost on the wings of a Cessna 206 which encountered wake turbulence from another Cessna 206 aircraft approximately 600 meters ahead, both of which are light aircraft.

1.19 Useful or effective investigation techniques

1.19.1 Nil.

2. Analysis

2.1 The aircraft was observed using the full length of the strip, thereby suggesting it was carrying the maximum load it could for the strip length, temperature and wind conditions.

2.2 The aircraft was being operated at approximately 5713 lb which is 17.5% above the manufacturer's normal category maximum allowable take off weight, as it is entitled to be by CAR 137 Appendix B. This resulted in the operation of the aircraft in a region outside the published C of G flight envelope.

2.3 As per CAR 137.105 *Take-off distance and flight path – no third party risk* the pilot had no requirement to comply with the take-off distance or the take-off flight path gradient specified in the aeroplane flight manual.

2.4 The aircraft had completed a number of take-offs from the strip with the same payload prior to the accident. As the aircraft had not been refuelled during this time the final take-off would have been the lightest due to the decreasing fuel load.

2.5 The soft patches in the strip would have been a significant factor in retarding the aircraft's acceleration, and its ability to reach adequate lift-off speed during the take-off run.

2.6 It has been established that the aircraft did initially become airborne after leaving the end of the strip as the fire crew attending the scene found the single conductor electric fence still intact.

2.7 Another aircraft landed on the strip, passing just above, or close to just above, ZK-BXZ whilst it was still in the take-off run or just airborne.

2.8 Due to the light winds it is possible that the aircraft encountered the wake vortices of the landing aircraft which, in terms of wake separation, was extremely close.

2.9 As ZK-BXZ was at the limits of its performance envelope it is possible that an encounter, even a mild one, with wake turbulence was sufficient to roll the aircraft, or change the airflow in such a way as to alter the angle of attack so that the aircraft entered an incipient spin to the left. This would account for the impact being at a high bank angle with a nose down attitude.

2.10 Whilst the engine strip revealed no particular cause for the engine not to be producing full power, it is not impossible that the engine suffered a partial reduction in power for some reason.

2.11 The investigation could not establish any conclusive reason for the accident; however, the following factors may have contributed either individually or in combination:

- The aircraft operating outside the published C of G envelope, thereby possibly decreasing in-flight controllability.
- The aircraft operating to the limits of its performance for the given conditions.
- The aircraft encountering some of the soft patches in the runway during the take-off run and therefore not achieving adequate flying speed at lift-off.
- The wings having a less than optimum aerodynamic profile due to a small amount of lime that had stuck to them, thereby increasing the stall speed.
- Encountering a change in wind direction and/or speed at lift off.
- Encountering, even if only light, wake turbulence just after lift-off.
- A reduction of power for reasons unknown.
- Medical incapacitation for reasons unknown, which may be why the load was not dumped.
- Misjudgement of the developing scenario by the pilot and therefore no dumping of the load. Had the load been dumped the aircraft may have gained the required performance to escape contacting the ground.
- The pilot may not have been able to apply enough force to initially activate the dump mechanism.

3. Conclusions

3.1 The pilot was properly licensed, rated, and fit for the flight undertaken.

3.2 The aircraft had been subjected to regular maintenance and appeared to be airworthy prior to the accident.

3.3 The engine strip found no reason why the engine would not be producing full power.

3.4 The aircraft was operating to the limits of its performance for the given conditions.

3.5 The accident was not survivable.

3.6 It has not been possible to determine a conclusive cause for the accident.

4. Safety Actions

4.1 The CAA has published an extensive article on wake turbulence in the May/June 2006 edition of the *Vector* magazine which is sent to all licence holders. The article quotes the number of accidents that have been recorded by light aircraft following another light aircraft. It further states that the conditions seen on the day of this accident were the ideal conditions in which wake turbulence is likely to be encountered.
The article is attached to this report.

4.2 The CAA is in the process of considering both:

- The current status of Appendix B in CAR 137, and
- The Rule's effect on the safety of the New Zealand agricultural aviation industry.

To this end the Director of Civil Aviation has:

- Appointed an internal CAA working group to urgently address the Appendix B provision of CAR 137.
- Undertaken to progress this project in consultation with representatives of the agricultural aviation industry. Therefore, the internal CAA Working Group will work with the industry to form a larger joint CAA/Industry Working Group.

On 11 April 2006 the CAA wrote to all agricultural operators outlining the short, medium, and long term action, and made known who the members of the CAA/Industry Working Group will be.
Appended to this letter to all agricultural operators is material to be treated as urgent safety advice, which is to be made available to each and every pilot in every agricultural organisation.

4.3 The CAA has raised an Aviation Related Concern and appointed a person to investigate the difficulty of opening the hopper discharge doors.
The requirement for opening the discharge doors needs to be as stated in CAR 137 Appendix D (a) which states that the jettison system must be:

- Simple to operate, and
- Designed so that once the control is selected by the pilot the load will fully discharge without requiring the pilot to continue holding the control.

Authorised by:

Richard White
Manager Safety Investigation

Date

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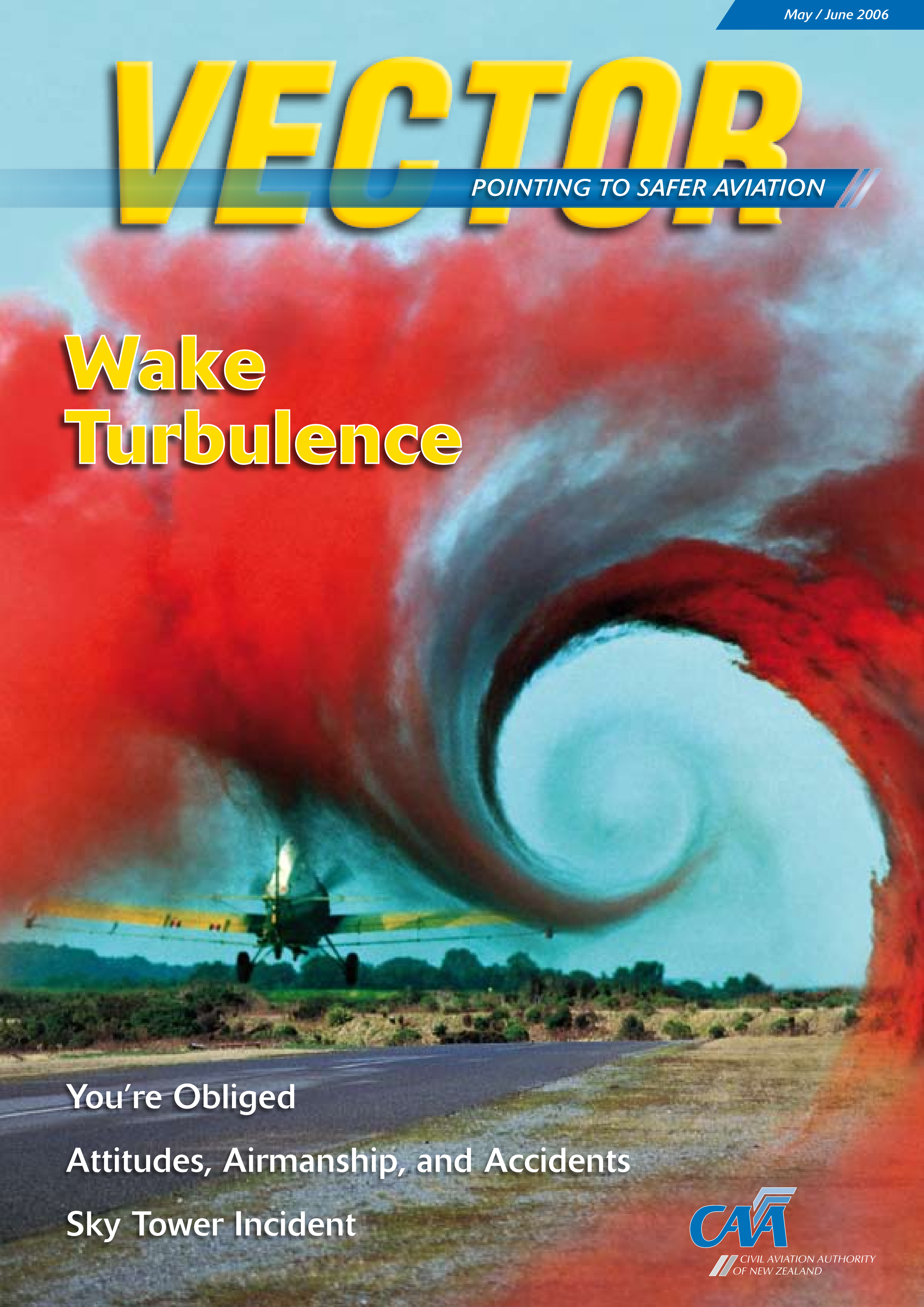
May / June 2006

VECTOR

POINTING TO SAFER AVIATION



Wake Turbulence

You're Obliged

Attitudes, Airmanship, and Accidents

Sky Tower Incident

CAA
CIVIL AVIATION AUTHORITY
OF NEW ZEALAND

WAKE TURBULENCE

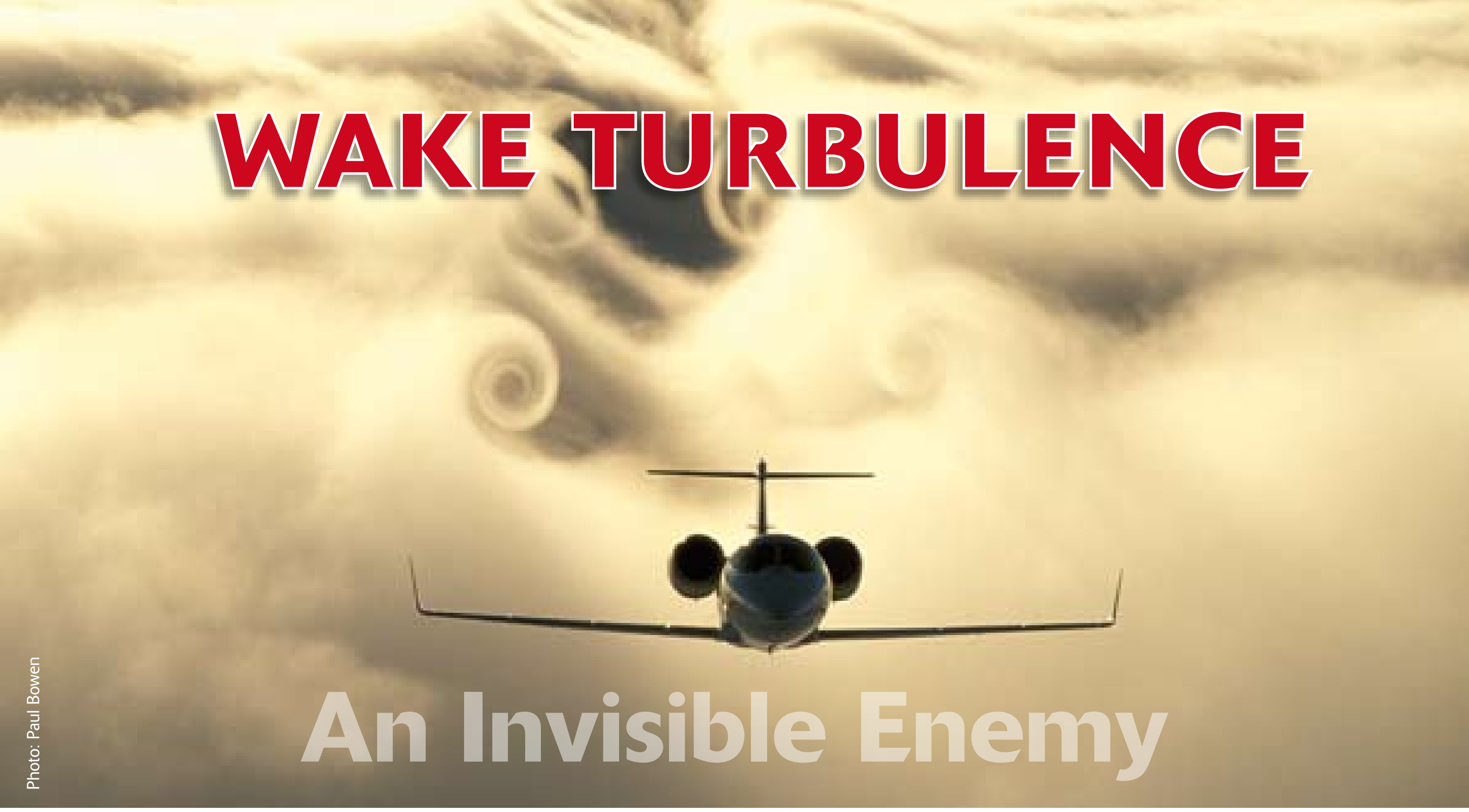


Photo: Paul Bowen

An Invisible Enemy

All pilots need to be aware of wake turbulence. Depending on the type of aircraft, the phase of flight, and the weather conditions, the potential effect of an aircraft's wake turbulence on other aircraft can vary. Encountering wake turbulence can be especially hazardous during the landing and takeoff phases of flight, where the aircraft's close proximity to the ground makes a recovery from the turbulence-induced problems more difficult.

Wake turbulence accidents are not just limited to light-weight aircraft flying into the wake turbulence of heavier aircraft. Worldwide, there have been a number of wake turbulence incidents between light-weight aircraft. For example, a Flight Safety Foundation study of 130 wake turbulence accidents in the United States over the period from 1983 to 2000, revealed that 22 percent of the accidents involved small aircraft that were flown into the wake turbulence of other small aircraft. The aircraft in the study weighed 2300 kilograms (5000 pounds) or less. If these statistics are hard to believe, the cover photo illustrates very clearly the wake turbulence generated by a light-weight aircraft.

Wake Turbulence Categories of Aircraft
(ICAO-DOC 4444 PANS ATM)

Heavy (H) – all aircraft types of 136,000 kilograms or more*.

Medium (M) – all aircraft types less than 136,000 kilograms but more than 7000 kilograms.

Light (L) – all aircraft types of 7,000 kilograms or less.

* The B757 is categorised as heavy when applying following distances.

What is Wake Turbulence?

All aircraft produce wake turbulence[1] (more correctly called wingtip or wake vortices) which consists of wake vortices formed any time an aerofoil is producing lift. Lift is generated by the creation of a pressure differential over the wing surfaces. The lowest pressure occurs over the upper surface and the highest pressure under the wing. Air will always want to move towards the area of lower pressure. This causes it to move outwards under the wing towards the wingtip and curl up and over the upper surface of the wing. This starts the wake vortex.

The same pressure differential also causes air to move inwards over the wing. Small trailing edge vortices, formed by outward and inward moving streams of air meeting at the trailing edge, move outwards to the wingtip and join the large wingtip vortex. Swirling air masses trail downstream of the wingtips. Viewed from behind, the left vortex rotates clockwise and the right vortex rotates counter-clockwise (see Figure 1).

Typically, a vortex develops a circular motion around a core region. The core size can vary in size from only a few centimetres in diameter to a metre or more, depending on the type of aircraft. The speed of the air inside this core from larger aircraft, can be up to 100 metres per second.

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[1] The definition of wake turbulence also includes jet blast, propeller wash, and rotor wash.

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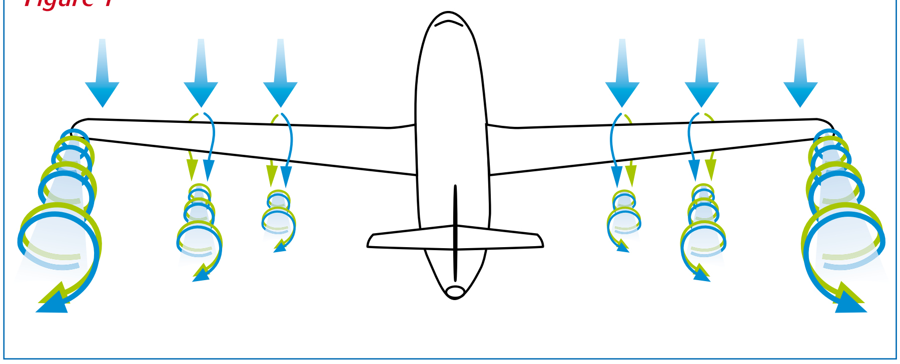
The core is surrounded by an outer region of the vortex, as large as 30 metres in diameter, with air moving at speeds that decrease as the distance from the core increases (see Figure 2). Wake vortices can persist for three minutes, or longer in certain conditions.

Figure 1



Viewed from behind the generating aircraft, the left vortex rotates clockwise and the right vortex rotates counter-clockwise.

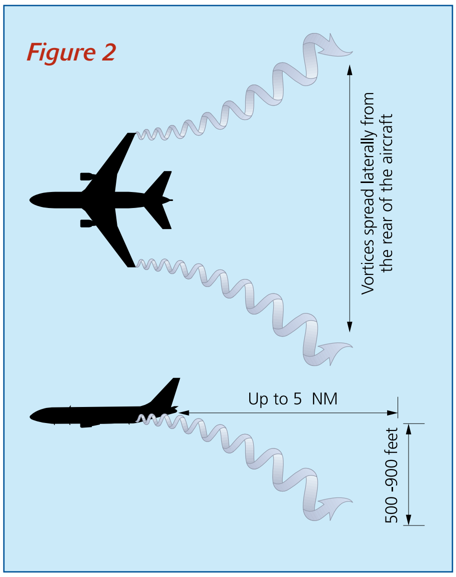
Intensity and Persistence

The initial intensity of the wake vortices is determined by the weight, speed, configuration, wingspan, and angle of attack of the aircraft. The most important variables in determining the intensity of the vortex beyond a distance of 10 to 15 wingspans from the aircraft, are atmospheric stability, wind strength and direction, ground effect, and mechanical turbulence.

The strongest vortices are produced by heavy aircraft flying slowly in a clean configuration at high angles of attack. Considerable wake vortices can also be generated by manoeuvring aircraft, for example, during aerobatics. Aircraft with smaller wingspans generate more intense wake vortices than aircraft of similar weights and longer wingspans.

Wake vortices near the ground are most persistent in light wind conditions (3 to 10 knots) in stable atmospheric conditions. Light crosswinds may cause the vortices to drift. A 3 to 5 knot crosswind will tend to keep the upwind vortex in the runway area, and may cause the downwind vortex to drift toward another runway. Atmospheric turbulence generally causes them to break up more rapidly.

Figure 2



Wake vortices spread laterally away from the aircraft and descend approximately 500 to 900 feet at distances of up to five miles behind it. These vortices tend to descend at approximately 300 to 500 feet per minute during the first 30 seconds.

Helicopters

Depending on the size of the helicopter, significant wake turbulence can be generated. Helicopter wakes may be of significantly greater strength than those from fixed-wing aircraft of similar weight. The strongest wake turbulence can occur when the helicopter is operating at lower speeds (20 to 50 knots). Some mid-size or executive-class helicopters produce wake turbulence as strong as that of heavier helicopters.

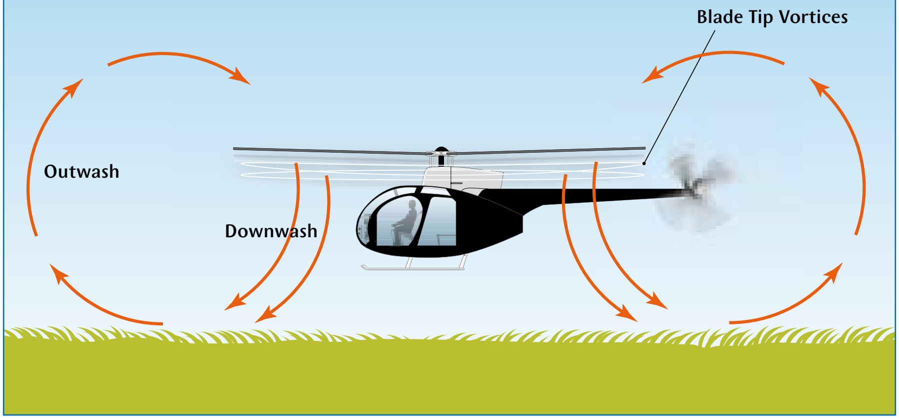
The majority of wake turbulence accidents that involve helicopters and small aircraft occur when small aircraft are taking off or landing while helicopters are hovering near the runway or flying in the circuit traffic pattern.

Helicopter wake turbulence takes different forms, depending on how a helicopter is flown:

- During a stationary hover, or a slow hover-taxi, a helicopter generates considerable downwash – high velocity outwash vortices that extend to a distance three times the diameter of the rotor (Figure 3). The outwash vortices circulate outward, upward, around, and away from the main rotor (or main rotors) in all directions. It is recommended that pilots should not operate small aircraft within three rotor diameters of a helicopter in a stationary hover or a slow hover-taxi.
- During forward flight, a helicopter generates a pair of spiralling wake vortices from the rotor blades (Figure 4). Wake turbulence also occurs in the rotating air beneath the helicopter. In this situation the wake vortices are similar to those of larger fixed-wing aircraft. It is, therefore, recommended that small aircraft exercise caution when in the vicinity of a helicopter in forward flight.

Flight tests conducted by the FAA found that wake vortices are generated differently, depending on whether the helicopter was climbing or descending.

Figure 3



Simplified flow pattern around a helicopter during a stationary hover close to the ground.

Figure 4

Simplified wake vortices generated from a helicopter in forward flight.

The vortex cores were observed to be closer together during ascents and further apart during descent. The wake vortices also did not sink in a predictable manner and in some cases remained at a similar altitude to where they were generated.

The area affected by the wake turbulence of a helicopter is larger than the area affected by the wake turbulence of an aeroplane of comparable size and weight, especially at speeds below 70 knots.

A flight test by the FAA using a Bell UH-1H (weighing 9500 pounds) flying at slow speeds and a Beechcraft T-34C (4300 pounds, a military trainer), resulted in the Beechcraft being rolled between 30 degrees and 75 degrees while flying between 3 and 5 NM behind and below the helicopter. At several test points, the effects were much more pronounced and led to a loss of control of the Beechcraft.

Light Aircraft Occurrences

A Fletcher pilot, some years ago, made a low-level pass along the airstrip to clear the strip of stock and turned back onto a reciprocal heading for the approach to the airstrip. On the approach, low to the ground the pilot lost control of the aircraft and crashed beside the airstrip. The investigation found that one of the contributing factors of the accident, was that the pilot lost control of the aircraft when it flew through the wake turbulence generated from its previous low pass along the strip.

There are several other accidents and incidents involving light-weight aircraft where wake turbulence may have been a contributing factor. Ask other pilots about their wake turbulence experiences, and you could be surprised to find that some have had some unexpected encounters of wake turbulence behind light-weight aircraft.

Separation

ATC will apply wake turbulence separation standards as shown by Table 1 and Table 2, **except** for:

- Arriving VFR aircraft following a medium or heavy-weight aircraft.
- IFR aircraft on a visual approach, where the pilot has reported sighting the preceding aircraft, and has been instructed to follow or maintain visual separation from that aircraft.

Note that controllers will give a wake turbulence caution in both situations.

Table 1 shows the wake turbulence radar separation applied to aircraft in all phases of flight when an aircraft is operating directly behind (1/2 NM laterally) another aircraft, or is crossing behind another aircraft, at the same level or less than 1000 feet below. Note that whenever the distance between a lead aircraft of a heavier wake turbulence category, and a following aircraft at the same level or less than 1000 feet below, is less than the equivalent of two minutes flying time, radar controllers should issue a caution of possible wake turbulence.

Table 1

Leading Aircraft	Aircraft Following or Crossing Behind	Minimum Separation Distance
Heavy	Heavy	4 NM
	Medium	5 NM
	Light	6 NM
Medium	Light	5 NM

Table 2 shows the non-radar separation standards for **arriving** aircraft using the same runway (or parallel runway separated by less than 760 metres) or if the projected flight paths are expected to cross at the same altitude or less than 1000 feet below.

Table 2: Arriving Aircraft

Leading Aircraft	Following Aircraft	Minimum Time
Heavy	Heavy	2 Minutes
	Medium	2 Minutes
	Light	3 Minutes
Medium	Light	3 Minutes

Table 3 shows the non-radar separation standards for **departing** aircraft using the same runway (or parallel runway separated by less than 760 metres), or if the projected flight paths are expected to cross at the same altitude, or less than 1000 feet below.

Table 3: Departing Aircraft

Leading Aircraft	Following Aircraft	Minimum Spacing at Time Aircraft are Airborne	
		Departing from same takeoff position	Departing from intermediate takeoff position
Heavy	Heavy Medium Light	2 Minutes	3 Minutes
Medium	Light	2 Minutes	3 Minutes

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These separation standards are the **minimum,** and the effects of wake turbulence may still occur even beyond these distances. For example, recently there was a wake turbulence incident between a Boeing 757 (200 series) and an Airbus 340 (500 series), en route at separation standards greater than the minimum required. The 757 experienced a violent and uncontrollable roll of 45 degrees accompanied by a 400-feet loss of altitude, caused by the preceding Airbus climbing through its level. At the time of the incident the separation was 1000 feet vertically and 9 NM.

If you consider wake turbulence separation standards are inadequate in controlled airspace, you can request increased separation. This may be achieved by vectoring, a change of flight path, or a change in the requested altitude to be above the suspected wake turbulence. There is also the option that you can take responsibility for your own wake turbulence separation and request a waiver from the wake turbulence separations. This option should be treated with caution – you will be reminded by the controller of the category of the other aircraft.

In New Zealand, there are no wake turbulence separation standards between two medium-weight category aircraft or between two light-weight aircraft. In these situations it is **entirely** up to the pilot to ensure adequate wake turbulence separation.

In light wind conditions, it is prudent to ensure greater wake turbulence separation if you are flying a light-weight aircraft and the leading aircraft is a heavier aircraft in the light-weight category. For example, if you are in a light single-engine aircraft and are following a Metro 3, Jetstream 32, Islander, or a Nomad. In these situations it would be wise to maintain the medium to light-weight separation standards as indicated in Table 1, 2 and 3. Additionally, it is recommended that two medium-weight aircraft apply separation standards similar to that between medium and light-weight aircraft.

At uncontrolled aerodromes it can be easy to forget about wake turbulence. There are, however, a number of uncontrolled aerodromes around New Zealand where relatively heavy-weight aircraft mix with light-weight aircraft. In situations where wake turbulence is a danger, for example, during light wind conditions, the prudent pilot will apply increased separations on takeoff and during the approach. As a guide refer to Tables 1, 2 and 3.

Some Important Facts

- Overseas studies indicate that more wake turbulence accidents occur during the approach and landing than during the takeoff phase.
- Most wake turbulence accidents occur below 200 feet agl.
- The majority of wake turbulence accidents occur in light wind conditions.
- The most persistent wake turbulence occurs in light crosswind conditions (3 to 10 knots).
- Wake turbulence will persist for longer periods of time during stable atmospheric conditions.
- Wake vortices are further apart behind an aircraft flying in a clean configuration (gear and flaps retracted) than during the landing configuration. For example, the vortex spacing behind a B767 is 123 feet in the clean configuration compared with 80 feet in the landing configuration.

How to Avoid Wake Turbulence

The following are guidelines to avoid wake turbulence. For more information refer to the *Wake Turbulence* GAP booklet.

- **Takeoff**. Strong wake turbulence will occur at the rotation point and during the climb, as the leading aircraft will be flying slowly and at a high angle of attack. Therefore, observe the separation standards as identified in Table 1, 2, and 3. For light-weight category aircraft, depending on the size of the leading light aircraft, it is advisable to observe the medium to light separation in light-wind conditions. Don't be afraid to request a longer period of separation from the Tower if you feel it is necessary.
- **Climb**. After takeoff, if you cannot out-climb the leading aircraft's flight path, turn off the extended centreline as soon as possible. If you cannot deviate significantly from the leading aircraft's flight path, climb slightly upwind and parallel to the preceding aircraft's course.
- **Crossing.** If you must cross behind the leading aircraft, try to cross above its flight path (preferred) or, terrain permitting, at least 1000 feet below.
- **Approach.** Most wake turbulence accidents occur in visual meteorological conditions. Therefore, think twice before accepting a visual approach behind a large aircraft, as you then become responsible for maintaining your own wake turbulence separation. When flying a visual approach, do not assume that the aircraft you are following is on the same or lower flight path. If possible, during a visual approach stay away from the localiser centreline, as the larger aircraft are more likely to be there. Offset your flight path slightly to the upwind side of the localiser path. VFR pilots of slower light aircraft need to be especially wary of wake turbulence when flying at busy aerodromes with heavier aircraft on the approach.
- **Landing**. Land well before the departing aircraft's rotation point. When landing behind another aircraft stay above its flight path and land beyond its landing point if possible. Research has identified that wake vortices in ground effect do not necessarily move laterally away from the runway, but can rebound after reaching the ground, to the height of twice the wingspan of the aircraft. Be wary of this possibility when passing over the previous aircraft's landing point.
- **Crosswinds**. Crosswinds may affect the position of wake vortices and can be very dangerous during parallel runway operations. Adjust takeoff and landing points accordingly.

For light aircraft, be aware of the effects of wake turbulence from other light aircraft when operating in the following situations:

- **Takeoff and Landing**. Be aware of wake turbulence during stream takeoffs in light wind conditions, or landing in close proximity to other aircraft.
- **Gliding**. Wake turbulence can be experienced by glider pilots in certain tow positions behind the tow plane.

- **Formation Flying**. It is advisable to have training in formation flying to avoid unexpected encounters with wake turbulence – especially in a formation takeoff.
- **Confined Area**. Several aircraft operating in a confined area during calm conditions.

Effects of Wake Turbulence

The greatest hazard from wake turbulence is induced roll and yaw. This is especially dangerous during takeoff and landing when there is little altitude for recovery. Aircraft with short wingspans are most affected by wake turbulence.

The effect of wake turbulence on an aircraft depends on many factors, including the weight and the wingspan of the following aircraft and relative positions of the following aircraft and wake vortices. In the mildest form there may be only rocking of the wings, similar to that of flying through mechanical turbulence. In the most severe form a complete loss of control of the aircraft may occur. The potential to recover from severe forms of wake turbulence will depend on altitude, manoeuvrability and power of your aircraft.

In general you can expect induced roll and yaw. Small aircraft following larger aircraft most often have degrees of roll in excess of 30 degrees. Depending on the location of the trailing aircraft relative to the wake vortices, it is most common to be rolled in both directions.

The most dangerous situation is for a small aircraft to fly directly into the wake of a larger aircraft. This usually occurs flying beneath the flight path of the larger aircraft. In this situation, flight tests conducted have shown that it is not uncommon for severe rolling motions to occur with loss of control. In other instances, if the aircraft is flown between the vortices, high roll rates can coincide with very high sink rates in excess of 1000 feet per minute. Depending on the altitude the outcome could be tragic.

Flight tests conducted by pilots attempting to fly into the vortex at a slightly skewed angle resulted in a combination of pitching and rolling, which typically deflects the aircraft away from the wake. Research shows the greatest potential for a wake turbulence incident occurs when a light aircraft is turning from base to final behind a heavy aircraft flying a straight-in approach. The light aircraft crosses the wake vortices at right angles, resulting in short-lived pitching motions that can result in structural damage to the aircraft from a sudden increase in load factors.

A CX 747-200 on approach to Kai Tak airport, Hong Kong.

Taken from the chequerboard at a time when there was a fire in Kowloon City, thus making the vortices very visible.

Photographs, Cathay Pacific 'Crews News'.

Recovery Techniques

If you unfortunately find yourself in wake turbulence, your recovery will depend on a number of factors but the following technique is suggested by Fighter Combat International (US).

POWER – Increase the power especially at low altitudes or slow speeds.

PUSH – Unload the wings or "push" on the control column until you are slightly "light in the seat." This reduces the angle of attack of the wings, which gives you better roll control with the ailerons. It also reduces the drag on the aircraft for better acceleration and, if you are rolling over, slows your descent towards the ground.

ROLL – If possible, roll in the direction that will reduce the loading on the wings (this will depend on the direction of the roll of the vortex) or roll to the nearest horizon. If there isn't a nearest horizon, or if you have rolling momentum, continue to roll (unloaded) in that direction to the horizon. If there is induced yaw, prompt rudder inputs will also be required.

Note that this technique is primarily designed for wake turbulence encounters for aerobatic aircraft manoeuvring in tailchase or dogfight conditions. It may work when flying at altitude, but the ability of a pilot to 'unload' or 'push' may not be that great when operating close to the ground, during takeoff or landing.

If you encounter wake turbulence, it should be reported in accordance with Civil Aviation Rules, Part 12 *Accidents, Incidents and Statistics*. This is important to ensure that there is an ongoing improvement in the knowledge and awareness of wake turbulence incidents in New Zealand.

Summary

Wake turbulence affects aircraft of all sizes and therefore all pilots need to be aware of it. Wake turbulence incidents are not just confined to operations involving heavier aircraft. There are incidents involving all aircraft types.

In general, the risk of unexpected wake turbulence is greatest during the approach in visual conditions where all aircraft are maintaining their own wake turbulence separation.

Be aware of the situations where wake turbulence may be encountered, and take measures to avoid it. ■