Report 10-009: Walter Fletcher FU24, ZK-EUF,
loss of control on take-off and impact with terrain,
Fox Glacier aerodrome, South Westland, 4 September 2010

Final Report

Aviation inquiry 10-009

Walter Fletcher FU24, ZK-EUF

loss of control on take-off and impact with terrain

Fox Glacier aerodrome,

South Westland

4 September 2010

Approved for publication: April 2012

Transport Accident Investigation Commission

About the Transport Accident Investigation Commission

The Transport Accident Investigation Commission (Commission) is an independent Crown entity responsible for inquiring into maritime, aviation and rail accidents and incidents for New Zealand, and co-ordinating and co-operating with other accident investigation organisations overseas. The principal purpose of its inquiries is to determine the circumstances and causes of occurrences with a view to avoiding similar occurrences in the future. Its purpose is not to ascribe blame to any person or agency or to pursue (or to assist an agency to pursue) criminal, civil or regulatory action against a person or agency. The Commission carries out its purpose by informing members of the transport sector, both domestically and internationally, of the lessons that can be learnt from transport accidents and incidents.

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Chief Commissioner	John Marshall, QC
Deputy Chief Commissioner	Helen Cull, QC
Commissioner	Captain Bryan Wyness
Assessor	Pat Scotter

Key Commission personnel

Chief Executive	Lois Hutchinson
Chief Investigator of Accidents	Captain Tim Burfoot
Investigator in Charge	Ian McClelland
General Counsel	Rama Rewi

Email	inquiries@taic.org.nz
Web	www.taic.org.nz
Telephone	+64 4 473 3112 (24 hrs) or 0800 188 926
Fax	+ 64 4 499 1510
Address	Level 16, AXA Centre, 80 The Terrace, PO Box 10 323, Wellington 6143, New Zealand

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Nature of the final report

This final report has not been prepared for the purpose of supporting any criminal, civil or regulatory action against any person or agency. The Transport Accident Investigation Commission Act 1990 makes this final report inadmissible as evidence in any proceedings with the exception of a Coroner's inquest.

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Citations and referencing

Information derived from interviews during the Commission's inquiry into the occurrence is not cited in this final report. Documents that would normally be accessible to industry participants only and not discoverable under the Official Information Act 1980 have been referenced as footnotes only. Other documents referred to during the Commission's inquiry that are publicly available are cited.

Photographs, diagrams, pictures

Unless otherwise specified, photographs, diagrams and pictures included in this final report are provided by, and owned by, the Commission.

Walter Fletcher FU24, ZK-EUF
(Courtesy of Super Air Limited)

Source: mapsof.net

Location of accident

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Figures

Abbreviations

ATSB	Australian Transport Safety Bureau
CAA	Civil Aviation Authority (of New Zealand)
Commission	Transport Accident Investigation Commission
FAA	Federal Aviation Administration
HSE Act	Health and Safety in Employment Act 1992
kg	kilograms
m	metres
NTSB	National Transportation Safety Board (of United States)
NZPIA	New Zealand Parachuting Industry Association
STC	supplemental type certificate
THC	Δ^9-tetrahydrocannabinol

Glossary

acceptable data	that technical data considered acceptable by the New Zealand Civil Aviation Authority and listed in Civil Aviation Rules Part 21, Appendix D, paragraph (a), but subject to the conditions of paragraph (b). Examples of acceptable data included a type certificate data sheet, an advisory circular and an airworthiness directive that gives a specific instruction for a modification or repair
airmanship	the ability of a pilot to choose the safest and most effective course of action for a particular set of circumstances. Sometimes described as "effective threat and error" management skills
annual review of	an annual assessment of an aircraft and its associated documentation airworthiness to help ensure that the aircraft is airworthy and complies with the relevant Rules, and the documentation is correct and current
approved data	a subset of acceptable data that requires specific Civil Aviation Authority approval for use. An example of approved data is design change data that supports a design change through the approval of a modification
bulkhead	a dividing partition across the structure of the fuselage separating one compartment from another for reasons of safety or strength
datum	a predetermined reference point on the fore and aft axis of an aircraft, about which centre of gravity calculations can be performed. For the Fletcher FU24-950 series of aeroplanes, the datum point was the leading edge of the wings. This was 100.21 inches (2.54m) aft of the propeller spinner for the original piston-powered aeroplanes
empennage	the tail assembly of an aeroplane, including the vertical fin and horizontal stabiliser
restricted category	an aircraft that is otherwise eligible for the standard category may have its airworthiness certificate classified in the restricted category when: • the design approval for any modifications incorporated in the aircraft limits the aircraft to the restricted category, including: - special-purpose operations, such as agricultural operations - long-range ferry flights • the certificate information able to be provided by the applicant is inadequate to support the granting of a standard category certificate
special category	special category airworthiness certificates are for the likes of historic, ex-military, home-built and experimental aircraft
standard category	the issue of a standard category airworthiness certificate indicates the acceptability of the aircraft for all types of operation, subject to any operational rule requirement
tandem	2 parachutists, normally comprising a tandem master and a passenger or rider, attached by a harness to a single parachute
technical data	drawings, instructions or other data required to be used for product certification, approvals and authorisations under Civil Aviation Part 21 or for the maintenance, modification and repair of products, their components and appliances under Part 43
trim	an attachment to a flight control, primarily the elevator, that eases the control forces felt by a pilot

Data summary

Aircraft particulars

Aircraft registration:	ZK-EUF
Type and serial number:	Walter Fletcher FU24, 281
Number and type of engines:	one Walter M601D-11NZ turbo-propeller
Year of manufacture:	1980
Operator:	Skydive New Zealand Limited
Type of flight:	commercial – parachuting
Persons on board:	9
Pilot's licence:	commercial pilot licence (aeroplane)
Pilot's age:	33
Pilot's total flying experience:	4554 hours (41 on type)

Date and time	4 September 2010, 1325 NZST[1]
Location	Fox Glacier aerodrome, South Westland latitude: 43° 27´ 39" south longitude: 170° 00´ 53" east
Injuries	9 fatal
Damage	aeroplane destroyed

[1] Times in this report are New Zealand Standard Time (universal co-ordinated time+ 12 hours) and are expressed in the 24-hour mode.

1. Executive summary

1.1. General

1.1.1. On 4 September 2010 the pilot of a Walter Fletcher aeroplane with 8 parachutists on board lost control during take-off from Fox Glacier aerodrome. The aeroplane crashed in a paddock adjacent to the runway, killing all 9 occupants.

1.1.2. The Walter Fletcher had been modified from an agricultural aeroplane into a parachute-drop aeroplane some 3 months before the accident. The modification to the aircraft had been poorly managed, and discrepancies in the aeroplane's documentation had not been detected by the New Zealand Civil Aviation Authority (CAA), which had approved the change in category.

1.1.3. The new owner and operator of the aeroplane had not completed any weight and balance calculations on the aeroplane before it entered service, nor at any time before the accident. As a result the aeroplane was being flown outside its loading limits every time it carried a full load of 8 parachutists. On the accident flight the centre of gravity of the aeroplane was well rear of its aft limit and it became airborne at too low a speed to be controllable. The pilot was unable to regain control and the aeroplane continued to pitch up, then rolled left before striking the ground nearly vertically.

1.2. Recommendations

1.2.1. The Commission made 6 recommendations to the Director of Civil Aviation. Three related to the operation of parachute-drop aircraft, 2 related to the process for converting aircraft for another purpose and one related to seat restraints. A recommendation was made to the Secretary for Transport regarding the need for a drug and alcohol detection and deterrence regime for the various transport modes.

1.3. Key lessons

1.3.1. The investigation findings and recommendations provided reminders of the following practices that contribute to aviation safety:

- no 2 aircraft of the same model are exactly the same, even if they look that way; therefore pilots must do weight and balance calculations for every individual aircraft
- modifying aircraft is a safety-critical process that must be done in strict accordance with rules and guidelines and with appropriate regulatory oversight
- good rules, regulations and recommended practices are key to ensuring safe commercial aviation operations
- operators need to ensure that aircraft are being operated in accordance with prescribed rules and guidelines, and flown within their operating limitations
- aircraft operations need to be accompanied by relevant and robust procedures
- maintaining flight safety requires active participation and a co-ordinated approach by all sectors of the industry.

2. Conduct of the inquiry

2.1. The Transport Accident Investigation Commission (Commission) was notified of the accident at 1410 on Saturday 4 September 2010. An investigation team was assembled at Christchurch on the Sunday morning and arrived at Fox Glacier township at 1645, where they were briefed by Police before commencing the site examination. On 8 September, on completion of the site examination, the wreckage of ZK-EUF was removed to Commission facilities for further examination and security.

2.2. Approximately 15 witnesses, many of them local residents who had observed the accident sequence or portions of it, were interviewed by the Commission's investigation team. The owner of the aeroplane and a business partner in the parachuting operation provided background information to the investigation. The manufacturer of the aeroplane and the company involved in the original modification of the aeroplane and subsequent parachuting conversion also provided extensive background information on ZK-EUF.

2.3. The Walter Fletcher aeroplane was a New Zealand manufactured and certificated aeroplane primarily used in agricultural operations. Extensive modifications had therefore been required to convert the aeroplane for parachuting. Commercial parachuting activities formed part of the fast-growing adventure aviation industry in New Zealand and at the time of the accident regulations were being developed to better manage the industry. For these reasons the CAA provided information crucial to the investigation.

2.4. In September and October 2010 the investigators held meetings with various CAA staff, including the managers of General Aviation, Safety Information and Sports and Recreation, and several airworthiness engineers and other staff with knowledge of ZK-EUF or the Walter Fletcher. On 10 December 2010 the Chief Commissioner visited the manufacturer of the Fletcher FU24 aeroplane on a general familiarisation visit, and met with senior management. On 17 February 2011 a series of follow-up questions was forwarded to the CAA regarding the modification of ZK-EUF and parachuting operations. On 6 April 2011 the CAA provided written responses to the questions.

2.5. On 18 July 2011 the Commission met with the CAA's manager of Health and Safety with the objective of confirming the CAA's responsibilities under the Health and Safety in Employment Act 1992 (HSE Act), and its application to commercial parachuting generally and the operator of ZK-EUF specifically.

2.6. A consulting engineer, who was also a licensed aircraft maintenance engineer, was engaged to provide technical advice. The engineer was familiar with aircraft modification and certification processes.

2.7. On 11 November 2010 the Commission published an interim factual report on the accident. The interim factual report included 2 urgent recommendations to the Director of Civil Aviation regarding the operation of the Fletcher FU24-954 for parachuting.

2.8. On 14 October 2011 the Commission approved a draft final report, which was sent to interested persons for comment. Several submissions were received and these have been considered and the report amended where appropriate.

2.9. This final report includes more factual information than the interim report; an analysis of that information; findings; and further recommendations.

3. Factual information

3.1. Narrative

3.1.1. At about 1230 on Saturday 4 September 2010, 8 passengers from a tour group arrived at the Fox Glacier aerodrome facilities of Skydive New Zealand Limited (the operator)[2] in preparation for a tandem skydive jump. The passengers were divided into 2 groups of 4. Each passenger in the first group was allocated a tandem master and taken aside and briefed in preparation for their jump.

3.1.2. The aeroplane to be used for the flight was a Walter Fletcher FU24, registration ZK-EUF. The pilot for the flight had flown 9 flights that morning, totalling about 3.6 hours, before stopping for a lunch break of about 45 minutes. During this time the pilot shutdown the engine and refuelled the aircraft to a total fuel load of about 160 litres. This was described by the aeroplane owner as the standard fuel load for such a flight. To facilitate the refuel, the aeroplane was parked on the side of the runway near the refuel tanker, with the right main wheel about 3 metres (m) off the edge of the sealed portion of the runway. A further 6 flights were planned for the afternoon. The weather was fine, with no wind or significant cloud.

3.1.3. At about 1320, in preparation for the first post-lunch flight, the pilot re-boarded the aeroplane and started the engine. Each tandem master then led their passenger (referred to as a tandem rider in Civil Aviation Rules Part 105)[3] to the aeroplane and boarded. Once they were seated on the floor in the rear of the aeroplane, the tandem masters attached themselves to their passengers via 4-point harnesses. It was normal practice for the first 2 tandem pairs to sit as far forward as possible, facing rearwards with the tandem masters' backs against the bulkhead behind the pilot. The third pair would sit at the back of the rear compartment area against the rear bulkhead and right side of the aeroplane facing forward. The last tandem pair would sit opposite the door and would be the first to exit (see Figure 1).

3.1.4. After the last pair had been loaded and the door closed, the pilot taxied forward a few metres onto the runway before increasing power to commence the take-off roll. The take-off was witnessed in part or fully by about 10 people, including several local pilots, most of whom were located about the operator's facilities at the end of the runway. Several witnesses were positioned to one side of, and about halfway down, the runway and saw the latter stages of the take-off. The take-off was not recorded on video or photographed by any of the witnesses or persons on board.

3.1.5. Witness accounts varied in detail, but they generally described the aeroplane accelerating normally down the airstrip and getting airborne at about, but certainly not later than, the usual position. Two local witnesses standing near the operator's facilities at the end of the runway, and who were familiar with ZK-EUF taking off from the Fox Glacier runway, thought the aeroplane got airborne earlier than it normally did. The aeroplane was then seen to continue pitching upward until it appeared to be almost vertical. At about 100m the aeroplane entered what was described as a wing-over to the left to point almost vertically downwards.

3.1.6. Some witnesses recounted that the aeroplane started to manoeuvre out of the dive before the left wing lowered further and the aeroplane struck the ground in about a near-vertical attitude. Several witnesses reported that a fine mist or vapour shrouded the aeroplane on impact and this immediately erupted into flames. Numerous witnesses ran to the aeroplane to render assistance, but were unable to do so owing to the intensity of the fire. All occupants died in the accident. Emergency services were notified of the accident at 1327 and the local fire brigade vehicle arrived at the scene several minutes later.

[2] Skydive New Zealand consisted of 2 elements – the parachuting operator supported by the aeroplane owner. The aeroplane owner provided the operator, who was a tandem master, with the aircraft and pilots. The accident aircraft was flown by one of 2 pilots: either the owner himself or the pilot who was flying ZK-EUF at the time of the accident. The terms operator, aeroplane owner and pilot are used in this report to identify the 3 parties.
[3] Civil Aviation Rules are identified by a Part number and topic, for example Civil Aviation Rule Part 105 Parachuting – Operating Rules, and thereafter termed "Rule Part (number)".

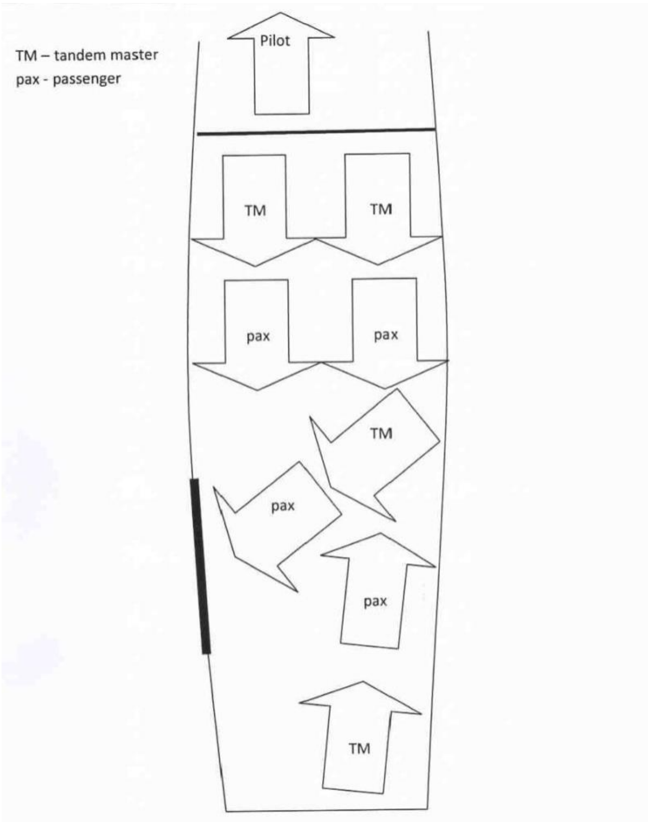

Figure 1
Loading diagram

3.2. Site and impact information

Accident site

3.2.1. The accident site was in a grassed paddock adjacent to the Fox Glacier aerodrome (see Figure 2). The aerodrome consisted of a single runway aligned about 265° magnetic. The runway sloped up to the east, which restricted take-offs to a westerly direction and landings to an easterly direction. The first approximately 400m of the runway, starting from the operator's buildings at the eastern end, were of bitumen construction. A further approximately 360m of grass were available if required. The wreckage of ZK-EUF was found 100m south of the runway and about 200m past the end of the bitumen section of runway (see Figure 3).

Wreckage information

3.2.2. Ground marks and aeroplane deformation were consistent with the aeroplane striking the ground in a near-vertical attitude, on a heading of about 325° magnetic. Clear ground indentations made by the left wing and the separation of the left wing tip indicated that the left wing tip had impacted before the right wing.

3.2.3. The fuselage forward of the wing had separated and was lying upright where it had hit the ground. The propeller had separated from the engine and was buried about 0.5m into the ground below the engine. A probable slight left rotation of the fuselage on impact had thrown the fuselage and empennage (tail assembly) some 10m to the east of the forward section.

3.2.4. An intense fire had severely damaged most of the aeroplane and destroyed much of the fuselage and the inner sections of the wings. However, all the aeroplane components, including flight controls, cables and linkages, and other flight-critical items, with the exception of the control lock, were able to be accounted for at the site. The 4 fuel tanks, normally located along the leading edge of the wings, had been ejected from the aeroplane and were grossly deformed by compression. The smell of fuel was still evident at the site for several days afterwards and the surrounding grass had started to brown-off due to fuel spillage. The cockpit area, engine, propeller and empennage were recovered and transported to a secure facility for detailed examination.

3.2.5. The elevator control and elevator trim components displayed no evidence of binding or fraying. The elevator trim was manually controlled by the pilot rotating a handle on the left wall of the cockpit. A direct mechanical linkage from the handle to a screw jack in the empennage moved the trim. The positions of the handle and screw jack were consistent with the trim having been set to the nearly full full-forward or nose-down trim position at the time of impact. The trim assembly in the empennage displayed no evidence of binding and the trim was able to be moved in both directions. Refer paragraph 3.5.4 for further information on the trim system.

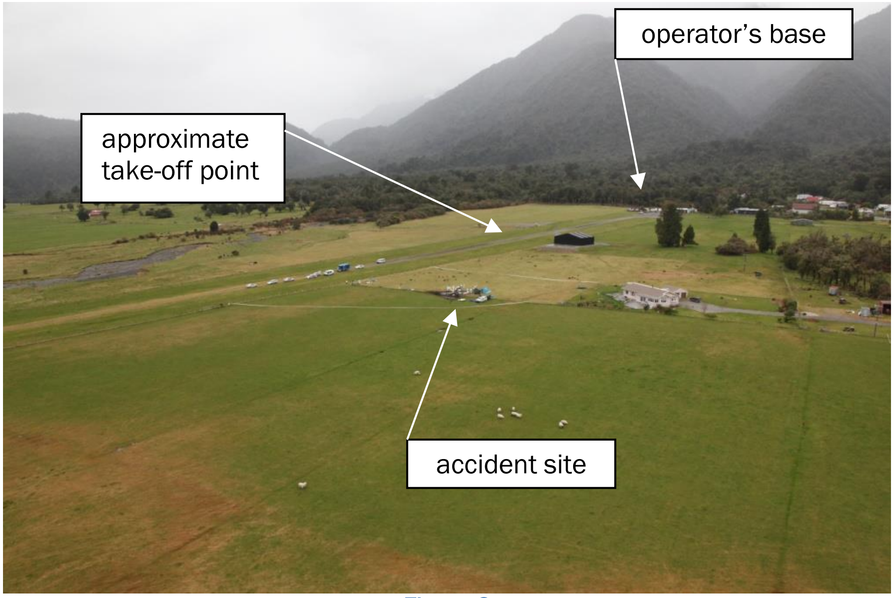

Figure 2
Fox Glacier aerodrome - general
(Courtesy of New Zealand Police)

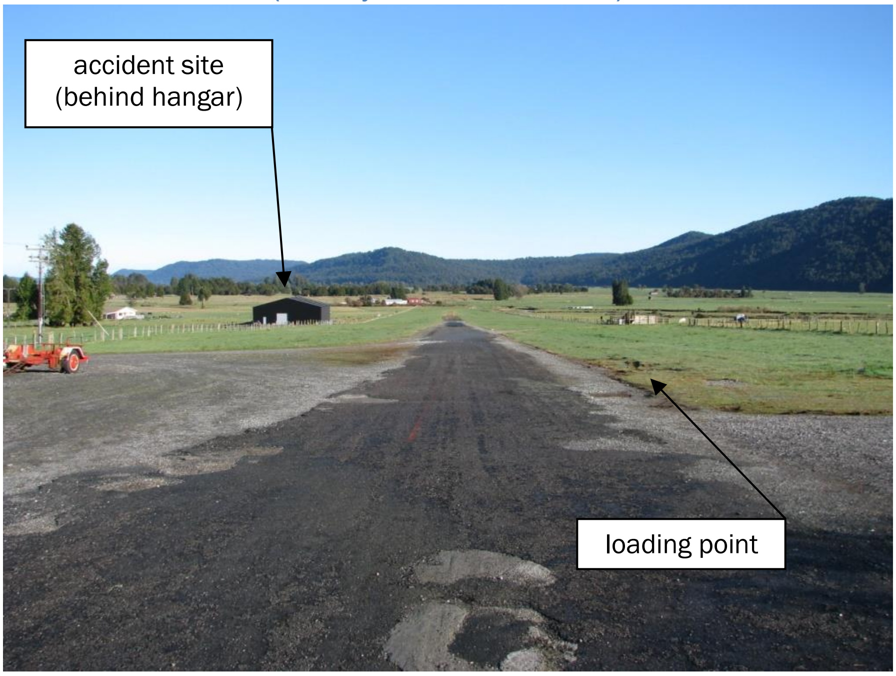

Figure 3
Fox Glacier aerodrome –take-off

3.2.6. The instrument panel had been severely damaged and deformed during the impact sequence. The control lock support bracket, located at the bottom of the instrument panel forward of the pilot, was damaged and the control lock was missing. The 2 locating holes through which the control lock would normally be held were torn open. The direction of the tear was down and forward.

3.2.7. The 3-bladed propeller had broken from its attachment to the engine on impact and displayed a progressive bending of each of the blades. The fracturing of the propeller attachment and the nature of the bending were consistent with the engine driving the propeller at about its normal operating speed at the time of impact. There was no evidence of any mechanical failure other than a gross overload failure of components at the time of impact. Witnesses did not report any unusual noises or lack of noise that could indicate that an engine malfunction had occurred during the take-off sequence.

3.2.8. The pilot was found in the cockpit. The 4 tandem masters and 4 passengers were found about the fuselage area and were still harnessed in pairs as expected.

3.3. Operator information

3.3.1. The parachuting operation at Fox Glacier consisted of 2 elements. Skydive New Zealand was owned by a tandem master who had an agreement with the owner of ZK-EUF to provide an aeroplane and pilot. The operator and aeroplane owner had first started carrying parachutists in mid-1997, flying out of Hokitika.

3.3.2. In October 1997 the operator relocated to Fox Glacier to better cater for tour groups of generally younger people who travelled along the West Coast and South Westland, and stayed overnight at either Franz Josef Glacier or Fox Glacier. The aeroplane owner initially flew a Cessna 180 before purchasing a more powerful Cessna 185 aeroplane.

3.3.3. In late 2009, as a result of increased patronage and local noise abatement considerations, the operator and aeroplane owner started looking for a turbine-powered aeroplane as a replacement for the Cessna 185. The aeroplane operator purchased ZK-EUF in February 2010.

3.3.4. The operator specialised in tandem parachute descents and advertised being able to carry up to 4 passengers at a time. Typical parachute-drop altitudes ranged from 9000 feet (about 2700m) up to 12 000 feet (about 3700m), to a maximum of 16 000 feet (about 4800 m). There were normally 7 tandem masters available, so nearly continuous operations were possible, with refuels being done between each flight.

3.3.5. At the time of the accident, the pilot and aeroplane owner were writing standard operating procedures for ZK-EUF. The draft document was titled “Pilot General Handling and Operational Notes for operating ZK-EUF”, and contained information on ground handling, refuelling and climb, drop and descent profiles. They also had in their possession a copy of the “general procedures and policies” from another operator that also flew a Walter Fletcher on parachute flights.

3.4. Personnel information

3.4.1. The pilot, aged 33, had obtained his private pilot licence (aeroplane) in July 2001 and commercial pilot licence (aeroplane) in September 2002. He held a current class 1 medical certificate with no recorded medical restrictions or conditions. His last medical examination was completed on 16 October 2009.

3.4.2. The pilot had gained his parachute-drop qualification on 20 March 2003.[4] In June 2004, after initially flying piston-powered parachuting aeroplanes, he obtained his basic gas turbine knowledge qualification and started flying the turboprop-powered Pilatus PC-6 Turbo-Porter aeroplane as well. In May 2007 he moved to Glenorchy, near Queenstown, flying both piston- and turboprop-powered parachuting aeroplanes.

3.4.3. On 1 June 2009 the pilot joined the operator at Fox Glacier. The pilot shared the parachute-drop pilot duties with the aeroplane owner, flying a Cessna C185 aeroplane. The pilot was domiciled in Queenstown but would travel to Fox Glacier when the weather was considered suitable for parachuting operations.

[4] Civil Aviation Rule Part 61 Subpart N – Parachute Drop Rating, effective 8 May 2008, detailed eligibility requirements, limitations and currency requirements for pilots.

3.4.4. On 11 May 2010 the pilot, together with the aeroplane owner, completed a type rating for the Walter Fletcher aeroplane. The rating was completed in ZK-DJE, another Walter Fletcher that was fitted with dual flight controls to facilitate instruction.

3.4.5. The type rating included a technical review of the aircraft, the completion of a questionnaire covering aeroplane operating limitations and general knowledge, and 5 flights with an instructor. The pilot's rating took 1.6 flying hours and included 4 parachute-drop flights and 30 minutes of circuit work. Several weight and balance checks were completed in conjunction with the flights. The instructor who conducted his training commented that the pilot's extensive experience on another turboprop aeroplane enabled him to learn quickly to handle the Walter Fletcher.

3.4.6. At the time of the accident on 4 September 2010, the pilot had accrued 4554 flying hours, including 41 hours on the Walter Fletcher. His previous biennial flight review had been completed on 2 August 2010.

3.4.7. Adverse weather conditions prevented any parachuting activities in the 2 days before the accident. Witnesses reported that during the evening preceding the accident the pilot, who was anticipating a full day's flying, did not drink any alcohol and retired early to his accommodation. Witnesses who knew him said that on Saturday 4 September the pilot was his normal self and appeared to be in good health.

3.4.8. The aeroplane owner, aged 58, had obtained his commercial pilot licence (aeroplane) in November 1992 and his basic turbine knowledge rating on 25 March 2010. He held a current class 1 medical certificate. He had accrued some 5900 flying hours, including about 45 hours on the Walter Fletcher.

3.4.9. The 4 tandem masters were all experienced parachutists who had completed between 4600 and more than 13 000 jumps each. One of the tandem masters was the owner of the parachuting operation, while 2 others had worked for the parachuting operator for between 3 and 4 years. The fourth tandem master had worked for the parachuting operator for about 3 months. All tandem masters held current medical certificates and tandem master ratings issued by the New Zealand Parachuting Industry Association (NZPIA). Like the pilot, most of the tandem masters resided away from Fox Glacier, and would return when the weather was considered suitable for parachuting operations.

3.4.10. The 4 passengers were from Australia, England, the Republic of Germany and the Republic of Ireland, and members of a larger group that was touring the South Island.

Medical and pathological information

3.4.11. Post-mortem examinations of the pilot and 8 tandem masters and passengers showed that they all had sustained "extreme fatal or mortal injuries in the impact". Toxicology results for the pilot were unremarkable and identified no substances that would have affected his judgement or ability to control the aeroplane. Toxicology testing of the tandem masters gave a positive result for Δ^9-tetrahydrocannabinol (THC) for 2 of them. For one of them, the level was found to be 5 micrograms per litre of blood and was considered by the pathologist to be consistent with that person having consumed the equivalent of a single cannabis cigarette within 3 hours of the accident. The amount of THC found in the blood of the other tandem master was too low to quantify.

3.5. Aircraft information

3.5.1. ZK-EUF had been manufactured in New Zealand in 1980 by Pacific Aerospace Industries, later Pacific Aerospace Limited, as a Fletcher FU24-954 model aeroplane, serial number 281. The aeroplane was powered initially by a Lycoming IO-720-A1B piston engine and was certificated by the CAA in the restricted airworthiness category[5] for agricultural topdressing operations.

Flight controls

3.5.2. The Fletcher aeroplane was equipped with conventional flight controls. Directional control on the ground was by a steerable nose wheel connected to the rudder pedals. Pitch control was achieved through elevators fitted to the empennage.[6] The elevator was connected by cables running through a number of pulleys to the pilot's stick or control column (see Figure 4). Pulling back on the control column pitched the nose up and pushing forward on the control column pitched the nose down relative to the pilot. The amount and rate of any change in pitch were dependent on how much the pilot moved the control column or stick and the airspeed of the aeroplane. For a given amount of control input, the faster the aeroplane was flying, the greater would be the change in pitch attitude.

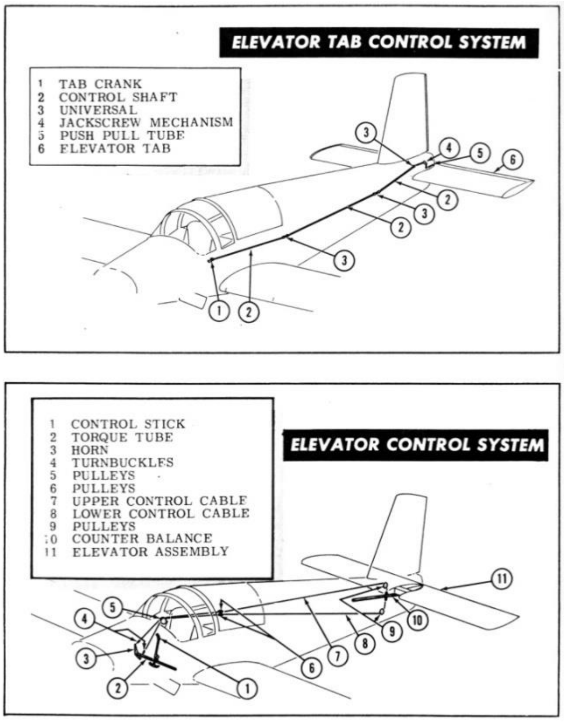

Figure 4
Fletcher flight control systems (Courtesy of Pacific Aerospace Limited)

3.5.3. To prevent the controls moving about when the aeroplane was unattended, a control lock was fitted below the instrument panel in front of the pilot's seat (see Figure 5). To lock the controls, the control column would be moved fully forward to sit in a protruding "H" shaped bracket that would be pulled out from below the instrument panel. A pin would be inserted through 2 holes in the bracket to hold the control column in place. Soon after the accident the aeroplane owner commented that he never used the control lock between flights and the pilot used a bungee cord to hold the control column forward when getting in and out of the cockpit.

[5] There were 3 types of airworthiness category: standard, restricted and special. See the Glossary for more information.
[6] All-moving elevators or tailplanes, like those installed on the FU24, are also called "stabilators", a combination of the words stabiliser and elevator.

3.5.4. An elevator trim system was fitted to assist the pilot and ease elevator control forces when operating in a range of speeds and loading conditions. Fletcher aeroplanes had either electrically or manually operated trim controls. The trim control for ZK-EUF was manual, with a rotating handle located on the left side of the cockpit, aft of the power-control lever (see Figure 6). The trim could therefore be moved with the pilot's left hand while at the same time the right hand held the control column. The trim took about 25 turns of the handle for full travel.

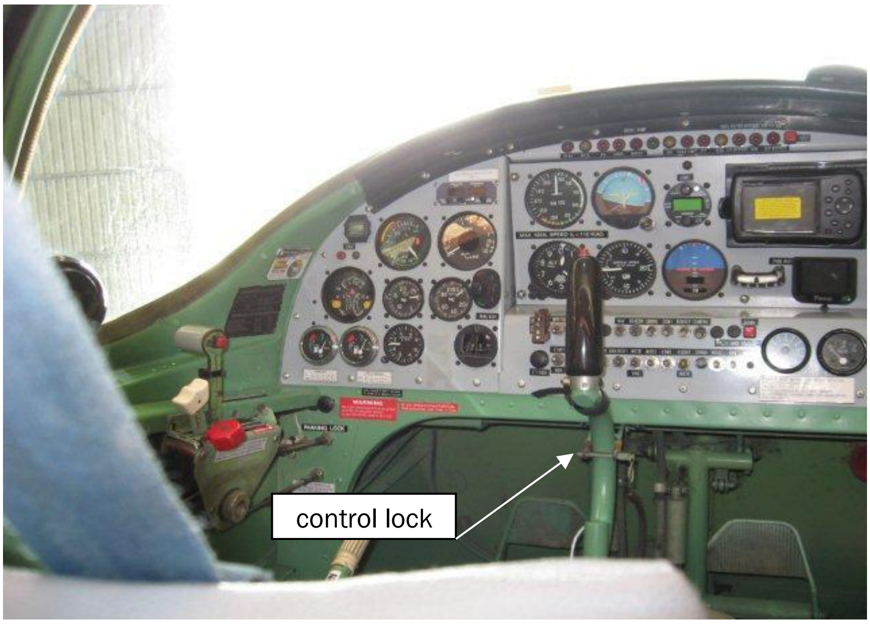

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Figure 5
Control lock (Courtesy of M Feeney)

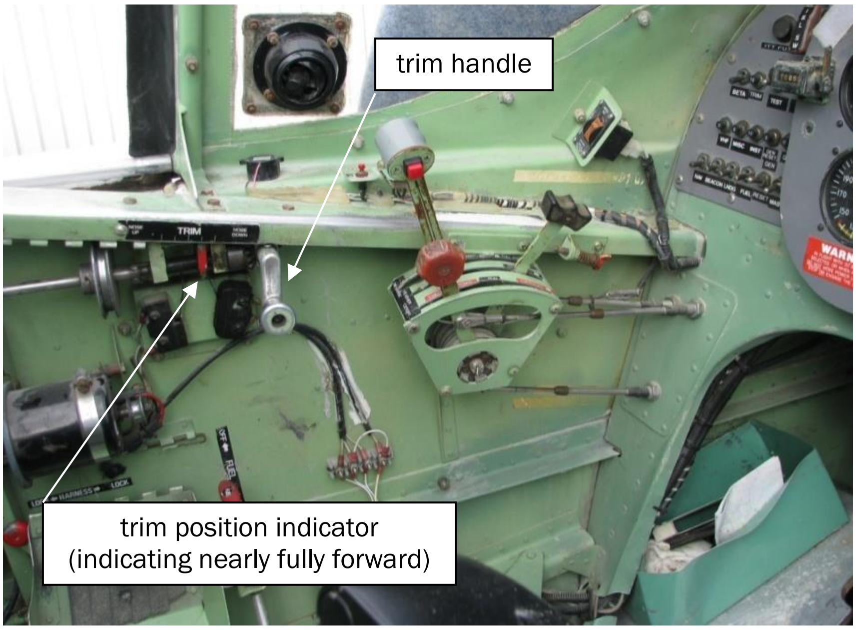

Figure 6
Trim handle

3.5.5. The elevator trim worked in the natural sense, in that the trim would be moved in the direction in which the pilot was applying the required force. For example, with a rear centre of gravity the nose of an aeroplane would want to pitch up, so the pilot would apply forward elevator by pushing forward on the control column. The forward pressure could be relieved by the pilot winding forward on the trim handle. It is normal practice to set the trim before take-off to balance the anticipated load that would come on the control column once the aeroplane became airborne.

3.5.6. The aeroplane owner reported that with 3 and especially 4 tandem pairs the aeroplane was tail-heavy, meaning the weight was concentrated towards the rear of the aeroplane. Therefore the normal take-off configuration consisted of 2 notches of flap[7] and the elevator trim set between ¾ and fully forward. The landing configuration was normally 2 notches of flap and elevator trim set about $^2/_3$ aft.

3.5.7. The aeroplane owner recalled that about 2 weeks before the accident the pilot had rejected a take-off part-way down the runway and returned to the loading area before taking off successfully on the second attempt. The pilot had later said that he had forgotten to reset the elevator trim for take-off after the previous landing. The error was detected early in the take-off roll so he had stopped the take-off, returned to the start point and reset the trim before taking off. As a result of the incident the operator placed a label on the instrument panel to remind the pilots to check the trim position before take-off.

3.6. Civil Aviation Rules and the Regulator

Aircraft modifications

3.6.1. The CAA issued type certificates[8] for approved aircraft types manufactured in New Zealand. Exceptions included experimental and homebuilt aircraft, and other isolated examples. For aircraft designed overseas, the CAA generally accepted the type certificates issued by the States-of-Design, thus ensuring direct access to continuing airworthiness information. The CAA was responsible for ensuring the airworthiness of New Zealand-manufactured aircraft before issuing type certificates. The type certificate issued for the Fletcher FU24 series of aeroplanes permitted the aeroplanes to be categorised in either the standard or the restricted category of airworthiness.

3.6.2. The type acceptance process was important to provide the CAA with the operating and maintenance data that was essential to support and control the operation of an aircraft, engine or propeller type. It also enabled the CAA to have access to and promulgate applicable airworthiness requirements, called airworthiness directives, for the type. Any major changes to the type therefore needed some level of CAA involvement depending on the scope of the project, as outlined below.

3.6.3. A change to the form or function of an aircraft or other aviation product could be achieved and approved by one of the following methods:

a. Changes to the type certificate
b. Supplemental type certificates (STCs)
c. Repairs
d. Modifications.

Type certificates

3.6.4. A change in type certificate was likely to be required for a change in type certificate category or type design. Such a change might have also included new operating limitations, for example new power or speed limitations. A change in type certificate was the most complex of the 4 processes and required CAA review and final approval by the Director of Civil Aviation.

[7] The flap lever operated in a similar manner to a traditional car handbrake. By pulling up on the handle the pilot was able to select one of the 3 flap settings available, with full flap being 3 notches.
[8] Also includes type acceptance certificates.

Supplemental type certificates

3.6.5. STCs could be issued where design changes were not significant enough to require a change to the type certificate. They could be proposed by anyone, but still required approval by the Director. Rule Part 21, Subpart E prescribed the rules and responsibilities for the issue of an STC (CAA, 2009). The approval of an STC also permitted numerous aircraft to be modified, and enabled the holder of the STC to gain royalties by on-selling the approved technical data to enable the modification. That data could include drawings, changes in the flight manual and additional maintenance requirements for the aircraft.

3.6.6. In October 1998 the Fletcher FU24 aeroplane was modified under STC 98/21E/15 with the installation of a Walter M601D-11 turbine engine. ZK-EUF was the first Fletcher aircraft to be converted by Turbine Conversions Limited, a company later purchased by Super Air Limited (the engineering company) and that was involved in the certification programme for the STC. A total of 24 FU24-950 and -954 aeroplanes were converted under the STC and the aeroplane type typically became known as the Walter Fletcher. At the time of the accident, 17 Walter Fletchers were still on the Civil Aviation Register, with 4 of them (including ZK-EUF) used for parachuting operations.

3.6.7. As the Walter Fletcher became more common, there were several accidents involving pilots who had not long before gained their aircraft type ratings. The CAA determined that the primary cause of these accidents was pilots being unfamiliar with the operation of the turbine-propeller combination, in particular the use of reverse thrust on approach to land. In about April 2000 the CAA and the engineering company, in an attempt to reduce the accident rate, inserted an amendment into the flight manual for the Walter Fletcher. The amendment stated that:

> Because of the extensive changes to the original design it is a requirement of the STC that the pilot flying this aircraft must have completed a type rating course that is acceptable to the NZ Civil Aviation Authority, or the applicable national airworthiness authority of the State of Registry.

3.6.8. The CAA advised the Commission that it had not been the intention of the amendment to require a full "auditable" conversion course specifically approved by the CAA for the Walter Fletcher. Rather, the flight manual entry was to ensure that pilots completed conversion courses that satisfactorily met the objectives of civil aviation rules for aircraft type ratings (CAA, 2008a). This included the requirement for an applicant to have passed an approved basic gas turbine knowledge examination and have a full understanding of the use of reverse thrust on approach. The CAA reported that the accident rate had subsequently reduced.

3.6.9. On 22 November 2005, a Walter Fletcher FU24-950, ZK-DZG, suffered an in-flight vertical fin failure 5 kilometres west of Whangarei. The aeroplane became uncontrollable and it struck the ground, killing the pilot and the loader driver. Following that accident, concern was raised about the process followed for the certification of the Walter engine into the Fletcher aeroplane and whether the modification might have contributed to the loss of the vertical fin, perhaps because of structural fatigue. The Commission investigation into that accident found "no evidence that the installation of a more powerful supplemental type certificate-approved turbine engine, in place of a piston engine, had initiated the fatigue cracks in the fin leading edge" (TAIC, 2009).

3.6.10. In respect of the STC process for the installation of the Walter engine, the same investigation found: "The CAA's supplemental type certificate approval process for the turbine engine installation was generally robust and had followed recognised procedures, but the process should have been enhanced by an in-depth evaluation of the fatigue effects on the empennage" (TAIC, 2009).

3.6.11. The CAA advised that: "Up to around 2007, the CAA accepted supplemental type certificate applications from industry directly and often prepared the substantiation/compliance documentation. In general, supplemental type certificates were not common with industry and it was usually a few particular clients who pursued supplemental type certificate approvals. Since the mid 2000's, the CAA has required all applicants for approval of a significant design change (significant in terms of the amount of engineering required to demonstrate compliance) to use the services of a Rule Part 146 Design Organisation. This policy was formalised with the publication of [advisory circular] AC21-08".

Repairs

3.6.12. Repairs were normally required to rectify an individual problem and retain the airworthiness of a product. Rule Part 21, Subpart M prescribed the means for the approval of repair designs.

Modifications

3.6.13. Modifications were probably the most common means of altering the form or function of an aircraft. Modifications normally involved individually approved changes, but under some conditions, for example if an operator had a fleet of the same type of aircraft, a modification could be approved for a whole fleet. CAA Advisory Circular *AC43-9 Modifications, repairs, and the form CAA 337* described acceptable methods of modifying aircraft to ensure compliance with the certification of products and parts (Rule Part 21) and general maintenance rules (Rule Part 43).

3.6.14. A major modification was described in AC43-9 as a modification that could potentially affect the safety of an aircraft or its occupants if, as a result of its embodiment, one or more of the following incidents could occur:

a. Structural collapse

b. Loss of control

c. Failure of motive power

d. Unintentional operation of, or inability to operate, any systems or equipment essential to the safety or operational function of the aircraft

e. Incapacitating injury to any occupant

f. Unacceptable un-serviceability or maintainability.

3.6.15. All modifications required sufficient technical data for an engineering analysis of the project to ensure that it was appropriate and safe to implement. The procedure for developing and implementing a major modification was contained in AC43-9 and was as follows:

a. The data was assessed to determine if it was acceptable technical data or if the data required approval[9]

b. If the data required approval, the descriptive and substantiating data was submitted to the CAA or to a Part 146 aircraft design organisation for approval

c. The CAA or the design organisation would approve the data and advise whether the modification was a major modification or recommend that an STC be raised that was considered more appropriate for the purpose

d. If the modification was determined to be a major modification, the person inspecting and accepting the modification was required to be the holder of an inspection authorisation or an appropriately authorised person under CAA Rule Part 145 to certify the conformity of the modification with the applicable technical data

e. The embodiment of the modification was then recorded in the maintenance records. The maintenance records included the form CAA 337, which was to be completed and a copy forwarded to the CAA (see Figure 7).

[9] The terms "acceptable", "approved' and "technical" data are described in the Glossary to this report.

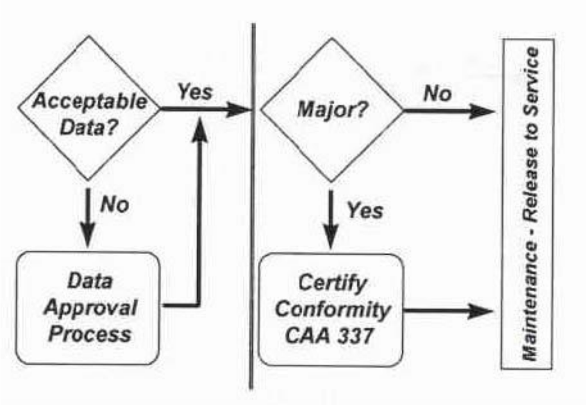

Figure 7
Modification process (CAA Advisory Circular AC43-9, Figure 1)

3.6.16. Modifications could be approved by a design delegation holder, whereas an STC could only be issued by the CAA. Both processes required the same design and airworthiness standards to be met. However, the STC was considered to be more aligned with international practice and allowed the CAA to assess the design changes prior to approval. The CAA could also review any proposed flight manual supplements as part of the STC process.

3.6.17. The modification process was more common as it was considered administratively easier to complete than an STC. It was also more appropriate for most minor modifications, especially one-off design changes. However, it had become increasingly common for some modifications to be on-sold and therefore bypass the CAA review process. The CAA had become concerned about how these modifications were being applied.

3.6.18. On 24 August 2010 (10 days before the accident) the CAA amended the conditions of all design delegation holders. Among the changes was the requirement that all major design changes were to be processed as STCs. The CAA said that there had been a number of reasons for making these changes, which included the need to align to international best practice and for the CAA to be engaged at the beginning of the design process.

3.6.19. The CAA stated that it was the responsibility of an aircraft operator to ensure that an aircraft was appropriately equipped for the type of work the operator was undertaking. It was appropriate for a maintenance provider to install approved aircraft modifications at the request and direction of the aircraft operator. A design delegation holder[10] who proposed a modification needed to confirm that the modification was in compliance with design standards and fit for purpose.

Modification of ZK-EUF for parachuting

3.6.20. The aeroplane owner had purchased ZK-EUF in early 2010 with the intention of having it modified for parachuting operations. The engineering company had previously worked on another Fletcher aeroplane in preparation for modifying it for parachuting, so it agreed to modify ZK-EUF. On 8 March 2010 the engineering company told the CAA that ZK-EUF was to be modified for parachuting and asked the CAA to have ZK-EUF changed from the "restricted" category (used for agricultural operations) to the "standard" category (used for parachuting).

3.6.21. The change of ZK-EUF from an agricultural topdressing aeroplane in the restricted category to a standard category aeroplane to be used for parachuting operations required the embodiment of a number of STCs and major modifications. The Supplemental Type Certificate Data Sheet for the installation of the Walter engine (STC 98/21E/15) stated that: "For operation in the Normal Category[11] the aircraft must be equipped with an alternate air intake door in accordance with Drawing TCL-07-027 and a fuel drain collector system in accordance with Drawing TCL-07-028".The technical data for these 2 modifications was owned and

[10] If a Part 146 design organisation wishes to approve a design change without prior reference to the CAA, it must employ, as a "senior person"[see 4.5.2], the holder of a CAA design delegation, called a design delegation holder.
[11] "Normal Category" was a United States term used in Federal Aviation Rule Part 23 Airworthiness Design Standard, and was understood in New Zealand to have the same meaning as standard category.

controlled by the engineering company and had been approved by the CAA as part of the STC process for the installation of the Walter engine.

3.6.22. On 13 April the CAA replied by email that for an aircraft to be eligible for the standard category the engineering company needed to complete the modifications and supply the CAA with the following documentation:

1. A copy of the worksheets covering the conversion to standard category configuration, including a logbook summary.
2. A copy of the last annual review of airworthiness.
3. A copy of the modifications page from the aircraft logbook.

3.6.23. The engineering company modified ZK-EUF for parachuting operations by firstly removing all the equipment associated with topdressing, such as the hopper and spray equipment. Then, installing a range of major modifications that had been used on other aeroplanes, including some Walter Fletchers, the engineering company configured ZK-EUF for parachuting. These modifications included the installation of a strengthened floor and a parachutist access door in the rear of the aeroplane, internal and external grab rails, and a step (see Figure 8). Two STCs for the fitment of 2 oxygen systems to permit flights up to 16 000 feet were also embodied at this time.

Figure 8
ZK-EUF modifications

3.6.24. The engineering company had previously contracted a Rule Part 146 aircraft design organisation to design a number of aircraft modifications for the engineering company's use in undertaking parachuting conversions on the Walter Fletcher. The contracted organisation included a design delegation holder who designed the modifications.

3.6.25. In addition to the parachuting conversion work, the vertical fin was replaced as part of a continuing airworthiness requirement for the FU24-950 and -954 series of Fletcher aircraft. Also all the flight control cables were replaced and the flight control rigging checked.

3.6.26. On completion of the parachuting conversion, a weight and balance check of the aeroplane was performed. On 25 May 2010 a weight and balance data sheet was filled in and inserted into the flight manual for the aeroplane. The weight and balance data sheet recorded an empty weight of 3103 pounds (1407kilograms [kg]) and a centre of gravity position of 17.57 inches (0.446m) aft of datum. An annual review of airworthiness was also completed. An engineer, who held an inspection authorisation, then signed the relevant CAA 337 forms certifying that the modifications conformed with the technical data as required under Rule Part 43 Subpart E. Records showed that the aeroplane had accrued 17 626 hours at this time.

3.6.27. A copy of the required documentation was forwarded to the CAA, which on 3 June 2010 issued a replacement airworthiness certification for ZK-EUF in the standard category. After a test flight on 1 July, the operator took possession of the aeroplane and flew it to Fox Glacier. Parachuting operations with the aeroplane commenced on 4 July.

3.6.28. An examination of the maintenance logbooks for ZK-EUF found that the following modifications had been carried out to prepare the aeroplane for parachuting operations:

Reference	Description
STC 98/21E/15-TCL-09-028	Installation fuel drain collector assembly
STC 98/21E/15-TCL-08-02	Installation alternate door assembly engine
RA 081	Removal of enlarged hopper outlet
AP 45	Removal of hopper and hatch assembly
98/MOD/249/SASL169	Removal UTS AgNav III GPS
DRG 05-MB25-00-60	Installation lower fuselage steps
SLM 123	Air deflector cargo door
AAE.MOD.157	Installation parachute door
DRG 3-MB25-00-60	Installation top grab rail
ACA3-14 APP270	Installation Garmin SL40, MicroairM760-01 VHF's, Artex ELT

The first 2 changes were STC changes required for the change in category; the rest were classified as modifications.

3.6.29. No record could be found in the logbooks for the fitting of the strengthened floor in the rear of the aeroplane. The engineering company later advised that the floor modification would have been completed using a modification designed specifically for the engineering company and approved by the design delegation holder. The engineering company agreed that there should have been a logbook entry for the floor and this had been an oversight on its part.

3.6.30. An examination of relevant CAA records regarding the parachuting conversion, in particular the technical data for the various modifications embodied on ZK-EUF, showed that most were major modifications that had been developed by the engineering company. The CAA records did not include a copy of the CAA 337 form for the modification of the aeroplane floor, although some information was provided in the attached worksheets submitted.

3.6.31. The engineering company had also made several major modifications developed by other companies that held Rule Part 146 certificates for aircraft design organisations. The modifications for the top grab rail and lower fuselage steps, MB25-00-60 drawings 3 and 5, were originally designed and approved for fitment to a Cresco model of aeroplane. The modification for the fitment of the air deflector door, SL/M 123, was also held by another design organisation. The engineering company later advised that modification AAE.MOD.157 had been purchased from an aviation company that believed it was the rightful owner. It had agreed to sell the engineering company a full set of drawings, stamped with certified stamps and signatures.

3.6.32. The engineering company, in order to use a modification designed by another certified design organisation, was required by civil aviation rules to obtain the approval of that organisation to ensure the modification was able to be embodied on ZK-EUF. This had not been done for some of the modifications and the design organisations concerned were not aware that their modifications had been used on ZK-EUF, for example modification MB25-00-60.

3.6.33. The flight manual for ZK-EUF was also examined. Rule Part 91.111 listed the aircraft flight manual as one of the documents to be carried in the aircraft. However, the aeroplane operator advised that as the aeroplane had been flown by either of the 2 pilots from the same location, it had been decided to keep the flight manual in the operator's office.

3.6.34. The flight manual for ZK-EUF held the aeroplane's current airworthiness certificate, a technical log for recording daily flight hours and the current weight and balance data sheet, as well as the normal operating information for the Walter Fletcher. The flight manual also held 2 STCs containing information on the oxygen systems fitted to the aeroplane, one for the pilot and one for the rear compartment occupants. The flight manual contained no other supplements or material to show that the aeroplane had been converted for parachuting operations.

3.6.35. For the aeroplane to be used for parachuting operations, Rule Part 91.705 (b) (6) required the flight manual to authorise the removal or opening of the rear door in flight (CAA, 2010a). Modification SL/M 123 included such a flight manual supplement but this had not been inserted into the flight manual by the engineering company.

3.6.36. The weight and balance reference and planning information contained in section 6 of the flight manual had remained unaltered since the parachuting conversion and still referred to the hopper and the rear cargo compartment. In the restricted agricultural airworthiness category, the Walter Fletcher had a maximum certificated take-off weight of 2463kg, with a forward centre of gravity limit of 0.513m aft of datum and a rear limit of 0.645m aft of datum. In the modified standard airworthiness category for parachuting operations the maximum allowable take-off weight was reduced to 2204kg. The forward centre of gravity limit was amended to 0.428m aft of datum, but the aft limit remained the same at 0.645m aft of datum.

3.6.37. Civil Aviation Rules stated that during daylight hours aeroplanes operating under visual flight rules were required to land with a minimum fuel load that would permit a further 30 minutes of flight (CAA, 2010c).

3.6.38. The flight manual limitations section for the Walter Fletcher gave an unusable fuel quantity of 70 litres. However, the current weight and balance data sheet inserted into the flight manual for ZK-EUF recorded an unusable fuel quantity of 50.5 litres. The CAA considered that the flight manual limitation of 70 litres, having been determined as part of the STC process, was the correct quantity and this figure should have been used in all Walter Fletcher basic weight calculations. The additional 20 litres usable for ZK-EUF was a safety bonus that should not have been relied on. The aeroplane owner said that ZK-EUF had used about 60 litres of fuel for an average parachuting flight, and the consumption rate was about 160 litres per hour of flying

3.6.39. The CAA advised that it was "satisfied in principle with the process that ZK-EUF went through when converting from the Restricted Category for agricultural operations to the Standard Category for parachuting operations". The CAA was only concerned with determining that the aircraft was eligible for the Standard Category by having the mandatory modifications required under Note 3 of the Supplemental Type Certificate Data Sheet installed (the Walter conversion) – and that the aeroplane was airworthy and in an approved configuration. The chief engineer of the engineering company assessed the airworthiness. The CAA reviewed the 337 forms that had been signed by the engineer, but did not check all the individual modifications. The CAA did not think there was anything in the list to indicate that any of the modifications would conflict with each other, or not be compatible.

3.6.40. The CAA had relied on the modifications being correctly designed by a design delegation holder, correctly carried out by aircraft maintenance engineers and correctly checked for compliance by an engineer with an inspection authorisation. When reviewing the airworthiness of ZK-EUF after the accident, the CAA agreed that some of the modifications had been approved for use on a limited number of aircraft only, and should not have been made to ZK-EUF without approval. As a result the CAA would not allow another aircraft to undergo a similar conversion unless all modifications were applicable to the aircraft and any deficiencies to the flight manual supplements were addressed.

3.6.41. The CAA agreed that the flight manual supplement issued when the modification for the aeroplane floor was approved did not provide sufficient guidance for a pilot to calculate the weight and balance of the aircraft. The CAA also thought that if some of the modifications that had been made to ZK-EUF were proposed now, they possibly would have to be progressed as STCs based on the changes it had made to the design delegations10 days before the accident. The floor modification was given as a likely example of a major design change requiring an STC and, therefore, CAA approval.

3.6.42. At the time of the accident ZK-EUF had accrued a total of 17 707 hours since manufacture and had 18 hours to run until the next planned maintenance, a 100-hour check. Records and interviews indicated there were no known aeroplane defects or unserviceable equipment that might have contributed to the accident.

Parachuting in New Zealand

3.6.43. Parachuting in New Zealand, and in particular commercial parachuting operations, had grown significantly in the 10 years leading up to the accident involving ZK-EUF. The NZPIA, which represented the largest number of parachuting operators in New Zealand, estimated that its members completed 140 000 parachute descents annually, dropping an estimated 225 000 people. This equated to 85 000 tandem jumps (NZPIA, 2010). In 2010 the total number of tandem jumps by all parachuting operators, including non-NZPIA organisations, was estimated to be 100 000.

3.6.44. At the time of the accident commercial parachuting, hot-air ballooning, gliding, hang gliding and paragliding were all operations that were exempt from the rules that governed air operations for the carriage of passengers or goods by air for hire or reward (CAA, 2008b). Parachuting operations were governed by Rule Part 105 (CAA, 2010b), but this rule only covered the actual parachute jumping and the parachuting equipment and the maintenance of it. Rule Part 91 contained general operating and flight rules that were applicable to all aircraft, but nothing specific to parachute-drop aircraft.

3.6.45. Civil aviation rules required the pilots of parachute drop aeroplanes (Rule Part 61 Subpart N) and tandem masters (Rule Part 105 Subpart A) to hold ratings applicable for their duties. The ratings could be issued and subsequently administered by approved aviation recreation organisations certified by the CAA under Rule Part 149 (CAA, 2007). There was no requirement for regular auditing or inspections of parachuting operators or operations, as would occur for certificated air transport operators such as the many helicopter tourist operators located around Fox Glacier.

Oversight of parachuting

3.6.46. The CAA reported that as parachuting operations were not required to be certified at the time of the accident, there had been no auditing undertaken of the parachuting operators. Further, the CAA stated that it was “not currently resourced to undertake such activity”. Pilot currency requirements were the responsibility of the operator, while tandem master qualifications were administered by the Rule Part 149 parachuting organisation to which the operator was affiliated.

3.6.47. The CAA aviation safety adviser responsible for the South Island confirmed that he had visited the operator about twice annually in the 5 years leading up to the accident. These visits were reported to have been of an informal nature. The adviser stated that there had been concern expressed by some local residents and operators about noise levels and the routes being flown by the operator, and suggestions that parachutists were descending through cloud. These concerns related to the piston-powered aeroplane the operator was flying at the time. The adviser has found no evidence to support the concerns and no findings or file notes had been made as a result of these visits. The aviation safety adviser had last called on the operator on 1 July 2010, while the 2 pilots were away taking delivery of ZK-EUF.

Safety restraints

3.6.48. With the exception of the pilot, none of the occupants of ZK-EUF was wearing a safety restraint or belt. Rule Part 91.207 (e) exempted passengers engaged in parachuting operations from the general requirement to occupy berths or seats and wear safety restraints for take-off and landing.

3.6.49. On 29 November 2001, a Cessna A185E Skywagon ZK-JGI took off from Motueka aerodrome on a local parachuting flight. Shortly after take-off, at about 100 feet (about 30 m), ZK-JGI had a sudden and total power loss. Unable to re-establish power, the pilot guided the aeroplane to a nearby kiwifruit orchard. After clipping trees the aeroplane struck the ground heavily, resulting in the pilot and 4 parachutists receiving serious injuries and one parachutist sustaining minor injuries (TAIC, 2001).

3.6.50. The Commission's investigation of that accident determined that "the seriousness of the injuries sustained by the occupants may have been reduced had they been wearing some form of safety restraint". The Commission therefore recommended to the Director of Civil Aviation that he, in conjunction with the New Zealand Parachuting Federation, "complete a study into the utility of parachutists wearing safety restraints for take-off and landing, and include any resulting recommendations in the rule making process as a petition by March 2003. (018/02)". The recommendation was accepted by the Director.

3.6.51. Following the accident involving ZK-EUF, the CAA advised that a study of passenger restraints had recently been completed in conjunction with industry representatives. As a result the CAA had decided not to mandate the fitment of restraints to "smaller aircraft", typically those carrying 10 or fewer parachutists. There was a continued concern that, for small aircraft in particular, parachutists could become tangled with the restraints, causing the premature release of a parachute or a hang-up on exiting the aeroplane. Both scenarios were reported to have occurred both in New Zealand and overseas.

3.6.52. The wearing of safety restraints during parachuting operations was not compulsory in either the United Kingdom or the United States, but was required in Australia. Anecdotal evidence provided by parachutists and aviation safety personnel in Australia and New Zealand was that the requirement to wear a safety restraint in Australia was commonly ignored and the belts were either removed or folded away.

3.6.53. On 29 July 2006 a de Havilland DHC-6-100 Twin Otter engaged in parachuting operations crashed on take-off in Sullivan, Missouri, United States. The pilot and 5 of the parachutists received fatal injuries and the remaining 2 parachutists were seriously injured. The investigation report by the United States National Transportation Safety Board (NTSB) found that 5 of the 7 parachutists had been likely restrained by a single-point harness system and only one of these survived (NTSB, 2006). The other 2 parachutists had been unrestrained and one survived. Following testing the report concluded "that a single-point restraint system is not sufficient to provide adequate restraint for parachutists".

3.6.54. The NTSB report recommended that the Federal Aviation Administration (FAA) and the United States Parachute Association jointly "determine the most effective dual-point restraint systems for parachutists that reflect the various aircraft and seating configurations used in parachuting operations". Once the most effective dual-point restraint systems had been identified, the United States Parachuting Association was recommended to educate and encourage its members to use them. No update was available at the time of writing this report.

Health and safety

3.6.55. On 5 May 2003 the CAA was designated by "Prime Ministerial designation"[12] to administer the provisions of the HSE Act in respect of the aviation sector, specifically for aircraft while in operation. The CAA's HSE Unit was set up in 2003 and 2 staff members from the Department of Labour were seconded to run the Unit. A memorandum of understanding between the Department of Labour and the CAA was agreed and identified the CAA's tasks as "establishing and monitoring civil aviation and security standards, investigation of incidents and the promotion of aviation safety and security". The memorandum also stated that:

> The CAA's administration of the HSE Act involves providing to employers, employees, self-employed-people and others, who have responsibilities and duties to maintain effective safety mechanisms, applicable to the CAA HSE designation, information, education and advice on occupational safety and health issues, undertaking compliance audits, inspections, and investigations, and may involve issuing notices and taking enforcement actions.

3.6.56. The manager of the HSE Unit confirmed that in meeting its requirements under the HSE Act, the Unit had adopted a flexible approach to investigating incidents and had commenced an audit programme of operators. Since 2003 the Unit had completed about 30 audits of operators each year and participated in regular educational and safety seminars and meetings with various sectors of the aviation industry. The Unit had produced and distributed a variety of educational material, for example a safety booklet for agricultural operators and farmers, jointly produced with the Department of Labour.

3.6.57. The manager stated that the initial focus of the Unit had been on Rule Part 119 air operators and Rule Part 137 agricultural operators, as they were identified as offering the most safety benefits. Rule Part 119 air operators ranged from large airlines to operators of tourist helicopter flights. According to the CAA database, there were 184 Rule Part 119 operators and 104 Rule Part 137 agricultural operators. There were also 115 training and maintenance certificated organisations that were audited when concerns arose.

3.6.58. The manager advised that the audit programme was run in conjunction with the CAA's surveillance policy. Certificated organisations were given "risk ratings" that initiated CAA audit inspections and follow-up audits as required. The manager advised that HSE audits were focused on personal safety and not operational safety. He described operational safety as actions or inactions covered by Civil Aviation Rules. For example, low flying and operating an aircraft outside its flight manual limitations were operational safety issues. Conditions outside Civil Aviation Rules, for example adequate hearing protection and the control of hot drink services by cabin crew members were personal safety issues and therefore came under the HSE Unit's responsibility.

3.6.59. Between 11 and 18 August 2010, in anticipation of the introduction of Rule Part 115 *Adventure Aviation* and to get an indication of the level of safety of parachute operations, the HSE Unit completed audit inspections of4 of the larger parachuting operators located in the central North Island. Rule Part 115 was intended to cover commercial activities previously exempted, including parachute-drop and tandem-parachute operations. The manager commented that he thought the standard of personal safety was good at the 4 operators they had inspected. The manager had no piloting or engineering experience and was not able to comment on operational safety and compliance matters regarding the 4 operators. Follow-up educational material was later passed to the NZPIA for distribution to member organisations.

[12] Supplement to New Zealand Gazette of 1 May 2003, dated 5 May 2003 – Issue No.44, Department of Labour Health and Safety in Employment Act 1992 *Prime Ministerial Designation Pursuant to Section 28B of the Health and Safety in Employment Act 1992.*

3.7. Additional information

Weight and balance

3.7.1. Rule Part 91.109 stated that no person shall operate an aircraft unless it was operated in compliance with the operating limitations specified in the aircraft flight manual. Included within the operating limitations of a flight manual were the weight and balance limitations applicable for that aircraft. To help achieve this requirement an accurate record was required of the aircraft's empty weight and empty weight centre of gravity.

3.7.2. CAA Advisory Circular AC43-2 detailed acceptable practices for the control of aircraft empty weight and balance (CAA, 1997). An aircraft was to be reweighed whenever it was believed that the latest data was inaccurate, or requested in the interests of safety. Typical reasons for reweighing included modifications and repairs, equipment changes, maintenance such as painting, and when records were incomplete or missing.

3.7.3. The weight and balance data sheet current for the aeroplane at the time of the accident gave the empty weight as 3103 pounds (1407kg), the datum reference as the leading edge of the centre wing, and the longitudinal centre of gravity position as 17.57 inches (0.446m) aft of the datum.

3.7.4. A review of the history of ZK-EUF identified that at manufacture the aeroplane had had a basic weight of 1208.3kg and a centre of gravity position of 0.359m aft of datum. Following the installation of the Walter engine in October 1998, ZK-EUF was reweighed and the basic weight was determined to have increased to 1318.6kg and the centre of gravity position moved forward to 0.3576m aft of datum.

3.7.5. In February 2004 ZK-EUF was repainted. The aeroplane was reweighed and the weight was determined to have increased to 1389.8kg and the centre of gravity moved aft to 0.3724m aft of datum. The next reweigh, the last before the modification for parachuting, was in September 2006 following modifications to the instrument panel. The aeroplane weight was determined to be 1421.6kg, and the centre of gravity was at 0.3954m aft of datum.

3.7.6. An examination of the documentation for ZK-EUF, including all the modification data, determined that the change in basic weight after the parachuting modification, from 1421.6kg to 1407kg, was correct as recorded. The change in centre of gravity position from 0.3954m to 0.446m was also correct as recorded when considering the equipment removed was located near the centre of gravity, and the newly installed floor, grab rails and steps were all aft of the centre of gravity. The equipment used to weigh ZK-EUF was also confirmed to be suitable and its calibration was current at the time of the reweigh in June 2010.

3.7.7. The weight and balance section of the flight manual described "the procedure for establishing weight and balance (relative to a reference datum) of the empty aeroplane". The section recorded the centre of gravity limitations, standard moment arms and load envelope. Two generic sample forms, one using metric units and one using imperial units, were available for calculating the weight and moment arm for agricultural operations (see Figure 9).

3.7.8. An examination of the operator's booking diary and loading receipts showed that since the introduction into service of ZK-EUF the aeroplane operator had flown about 193 revenue flights or loads. Of these about 74 loads had had 8 parachutists, 16 loads had had 7 parachutists, 86 loads had had 6 parachutists and 17 loads had had 4 parachutists.

3.7.9. The aeroplane owner commented that it was standard practice not to complete a weight and balance sheet for each flight and none had been done since the commencement of parachuting operations using ZK-EUF. The 2 pilots had completed several weight and balance calculations as part of their conversion training and type rating. The calculations had been done using the loading chart in the flight manual and the weight and balance data for the Walter Fletcher used for their conversion training, not for ZK-EUF. The calculations reportedly used a range of loads, including 8 parachutists. For their calculations the pilots had used an average weight of 70kg per person, plus the weight of the parachuting rigs.

3.7.10. The aeroplane owner commented that as part of the induction into service of ZK-EUF, there had been discussions with another Walter Fletcher parachuting operator about their loading practices. The other operator had previously been in communication with the CAA regarding the use of a standard passenger weight as described in CAA Advisory Circular AC119-4 for air transport operations (CAA, 2005). The other operator had completed a 3-month survey in early 2010, weighing every passenger to determine an average passenger weight. The other operator had determined that the average weight of the passengers was less than 70kg, but elected to use 70kg as the mean for calculations. That information was passed to the CAA which, at the time of the accident, had not responded.

3.7.11. The other operator was confident that the 70kg figure was accurate to use as a standard weight unless a passenger appeared to be heavier than normal, in which case they would be weighed. Weighing would also be necessary in such a case to ensure that the weight limits of the parachuting rigs were not exceeded.

3.7.12. The other operator had then completed a series of weight and balance calculations for a range of fuel loads and parachutists. It was assumed for each calculation that the passengers were positioned as far forward as possible, and with the heaviest tandem pairs most forward. The weight and balance was determined to be within limitations for all loading conditions, although with 8 passengers the centre of gravity would be close to the aft limit. The other operator's aeroplane, although similarly equipped to ZK-EUF with a sliding door, internal and external grab rails, oxygen system and external steps, weighed 74kg less. The centre of gravity was 0.3429m aft of datum, 0.1031m further forward than the centre of gravity for ZK-EUF.

3.7.13. The aeroplane owner, aware of the results of the 3-month trial, considered that as the demographic of the passengers for both operators was the same, the same standard passenger weights could be used for their operation. Further, because the 2 aeroplanes were so similar in configuration, provided a similar loading policy of having the heaviest passengers as far forward as possible was followed, ZK-EUF would also be within its weight and balance limitations. For these reasons the aeroplane owner did not conduct any load calculations before utilising ZK-EUF in the parachuting role.

Turbine Conversions Ltd.
FU24 -950 Series / M601D

Flight Manual and
Pilots Operating Handbook

Weight and Balance Loading Form (Metric).

Aircraft:- ZK - ____________

Item	Weight (kg)	Arm (m)	Moment (kg-m)
Empty Weight			
Pilot		-0.056	
Observer		-0.056	
Fuel		+0.249	
Hopper		+0.940	
Cargo			
Total			

Note - Loading Options.

1. Avia VJ8.508D-AG/99B propeller fitted in place of /99A propeller, no change in the weight and balance loading.
2. Installation of Cockpit Bleed Air Heater, +2.36 kg at -1.041 metres.

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Figure 9
ZK-EUF weight and balance loading form (metric)

3.7.14. The basic weights and centre of gravity positions for the other 2 Walter Fletcher aeroplanes used for parachuting also varied from those of ZK-EUF. A summary of the basic weights and centre of gravity positions for all 4 modified aeroplanes follows:

Aeroplane	Basic weight	Centre of gravity position
ZK-NZS	1306kg	0.314m
ZK-DJE	1333kg	0.343m
ZK-EUD	1343kg	0.380m
ZK-EUF	1407kg	0.446m

Weight and balance calculations

3.7.15. As part of this investigation, more than 50 weight and balance calculations for ZK-EUF were completed using a range of conservative passenger weights and loading combinations. The weights used included the standard weight of 70kg and a range of assumed actual weights based on recent medical information and autopsy reports. For each of the calculations with 8 parachutists on board, the aeroplane was determined to be over its maximum weight limit and the centre of gravity outside the rear limit. See Appendix 1 for a summary of the calculations.

Special parachuting investigation report

3.7.16. On 16 September 2008 the NTSB adopted a "Special Investigation Report on the Safety of Parachute Jump Operations"(NTSB, 2008). As part of that investigation the NTSB had reviewed some 32 fatal accidents involving parachuting aircraft since 1980, involving the loss of 172 parachutists and pilots. The report referenced United States Parachuting Association safety records from 1992 to 2007, showing that "about 30 parachutists per year were killed in jumping mishaps". In the same timeframe, NTSB accident data showed "about 5 parachutist fatalities per year resulted from accidents involving parachute operations aircraft".

3.7.17. The Special Investigation Report identified the following 3 recurring safety issues:

- inadequate aircraft inspection and maintenance
- pilot performance deficiencies in basic airmanship tasks, such as pre-flight inspections, weight and balance calculations, and emergency and recovery procedures
- inadequate FAA oversight and direct surveillance of parachuting operations.

3.7.18. Eight of the aircraft involved in the 32 accidents were determined not to be airworthy at the time of the accidents. While some of these were for minor maintenance discrepancies, the scale of the non-compliance raised concerns about poor maintenance and quality assurance practices. Parachuting, like some other short, repetitive operations, was conducive to greater aircraft and engine wear. Operators, therefore, needed to comply strictly with manufacturers' requirements and recommendations.

3.7.19. The report found that "a disturbing common denominator in nearly all of the accidents reviewed is that the pilots, most of whom were commercial or airline transport pilots, were deficient in basic airmanship tasks", including "complying with aircraft weight and balance limitations". The report determined that "in 9 of the 12 accidents involving airplanes that were loaded beyond their maximum allowable gross weights or outside the cg [centre of gravity] limits, the weight and balance issue was found to be a cause or factor".

3.7.20. The FAA's oversight and surveillance of parachute-jump operators was found by the NTSB to "have been inadequate to ensure operators are properly maintaining their aircraft and safely conducting operations". Many of the parachuting operators had displayed unacceptable deficiencies that would or should have been detected during FAA inspections.

Cannabis in aviation

3.7.21. Civil aviation rules stated that:

> No crew member while acting in his or her official capacity shall be in a state of intoxication or in a state of health in which his or her capacity so to act would be impaired by reason of his or her having consumed or used any intoxicant, sedative, narcotic, or stimulant or preparation (CAA, 2010d).

3.7.22. The Australian Transport Safety Bureau (ATSB) published a report into an accident on 26 September 2002, where an aircraft crashed shortly after take-off, killing all 6 occupants (ATSB, 2002). The ATSB investigation found that the pilot had cannabis metabolites, opiates and paracetamol in his blood. As part of the investigation the ATSB commissioned a research report on cannabis and its effects (ATSB, 2004).

3.7.23. The research report summary stated the following:

> Cannabis is a commonly used recreational drug, which has widespread effects within the body. Smoking is the most common form of administration. The adverse effects of cannabis on behaviour, cognitive function and psychomotor performance are dose-dependent and related to task difficulty. Complex tasks such as driving or flying are particularly sensitive to the performance impairing effects of cannabis.
>
> Chronic cannabis use is associated with a number of adverse health effects and there is evidence suggesting the development of tolerance to chronic use as well as a well-defined withdrawal syndrome. There is also evidence that the residual effects of cannabis can last up to 24 hours. Significantly, the modern dose of cannabis is much more potent than in the past, when the majority of the research was conducted. As such, the reported adverse health effects may well be conservative.

> Although only a limited number of studies have examined the effects of cannabis on pilot performance, the results overall have been consistent. Flying skills deteriorate, and the number of minor and major errors committed by the pilot increase, while at the same time the pilot is often unaware of any performance problems. Cannabis use in a pilot is therefore a significant flight safety hazard.

3.7.24. The research report stated that "after alcohol and tobacco, and excluding caffeine, cannabis is the third most popular recreational drug". The level of THC found in the blood of cannabis users varies widely between individuals and can be influenced by factors like frequency of use and experience, and when smoked the size and potency of the cannabis cigarette and smoking technique. According to the pathologist, the subjective symptoms of cannabis intoxication usually peaked 10 to 15 minutes after smoking cannabis, but the effects could last about 1.5 to 4 hours.

3.7.25. The Commission has recently made a recommendation to the New Zealand Ministry of Transport regarding the use of performance-impairing substances in the transport industries (marine report 09-201). In late 2005 the Ministry of Transport established the Substance Impairment Group to look at the issue in respect of all transport modes. The Group, made up of representatives from the air, sea, road and rail transport sectors, was "charged with scoping the problem and making recommendations to the Minister of Transport to initiate any required changes in legislation".

3.7.26. The Substance Impairment Group was last convened in 2009. In 2010, the Ministry of Transport advised the Minister of Transport that it would investigate the feasibility of implementing a compulsory post-accident and -incident alcohol and drug testing regime in the aviation, maritime and rail transport sectors. The Ministry advised the Commission that it intended to commence this work during the 2011/12 fiscal year. This work would involve further liaison with the Substance Impairment Group.

4. Analysis

4.1. General

4.1.1. The accident flight started as a routine parachute drop. The circumstances were similar in many ways to other routine flights conducted using the same aircraft. The weather conditions were suitable for the flight, and the weight and distribution of the tandem masters and passengers would not have been significantly different from those of previous flights.

4.1.2. The following analysis discusses what might have happened to cause the crash and also looks at several other contributing safety issues. These safety issues include:

- aspects of the way the operator and aeroplane owner operated the aircraft
- the management of the weight and balance of the aircraft
- problems with the process for converting the aircraft for parachuting
- the CAA's oversight of the conversion to parachuting
- the CAA's oversight of the parachuting industry
- the wearing of restraints in parachute-drop aircraft.

4.1.3. Although not contributing to this accident, the issue of performance-impairing substances being detected in 2 of the tandem masters is discussed along with the wider ramifications for the industry.

4.2. The flight

4.2.1. The circumstances of the accident flight were consistent with a loss of control of the aeroplane during the take-off sequence. There was no evidence of any technical failure, and the engine was capable of providing full power throughout the short flight. The possibility of the pilot having become incapacitated was considered to be unlikely because he was fit and in good health, and the flight path of the aeroplane indicated that he was attempting to manoeuvre it out of the dive.

4.2.2. The pilot had refuelled the aeroplane during the lunch break and the weather was still fine and calm. The passengers were briefed in preparation for their drop and boarded after the aeroplane engine had been started. While the exact seating positions could not be confirmed, there was nothing to suggest that the seating arrangement was any different from that adopted on previous occasions. The short taxi from the refuel position to the runway and the initial part of the take-off roll were normal.

4.2.3. What was different was that the aeroplane may have become airborne early, and that as the aeroplane became airborne it continued to pitch up. The pitch up was not stopped and continued until the aeroplane became nearly vertical. To stop the initial pitch-up the pilot would have needed to apply sufficient forward elevator to counter the change in pitch attitude. The amount of elevator control required would have depended on the longitudinal stability of the aircraft and elevator effectiveness, the latter being a function of how much forward elevator the pilot managed to put in and the airspeed. The slower the airspeed, the less air flow over the elevator and the less effective it would be.

4.2.4. The following possibilities for the pitch up were considered:

- the pilot deliberately getting airborne early and pulling up steeply
- the flight controls being jammed or locked, preventing the pilot moving the elevator control
- the trim not being correctly set, thus catching the pilot unawares
- the centre of gravity being excessively rearwards and beyond the controllability limits of the aeroplane
- the parachutists moving rearwards during the acceleration to take-off or during the initial pitch-up, which would have shifted the centre of gravity further aft and further outside the control limits of the aeroplane

- a combination of any of these factors.

4.2.5. The pilot was an experienced parachute-drop pilot and was thought by his peers to be competent and responsible. He was reported as fit and healthy, and in preparation for a full day's flying had retired early the previous night. With a short break before the accident flight he should not have been fatigued. No reason was offered that might have suggested his decision-making ability was impaired.

4.2.6. Considering his experience, the pilot should have been aware that the centre of gravity was well aft and therefore he needed to avoid any abrupt manoeuvres, especially at low speed. Further, he would probably have incurred the wrath of the tandem masters had he deliberately undertaken a steep departure from take-off. The pilot was, therefore, unlikely to have deliberately got airborne early and immediately pitched the nose of the aeroplane upwards.

4.2.7. The aeroplane owner noted that during the take-off roll, forward elevator input was used to stop nose-wheel shimmy and counter the effects of the aft centre of gravity. Therefore, while the pilot may not have intended to pitch the nose of the aeroplane up high, the possibility that he relaxed the forward pressure on the control column late in the take-off roll to allow it to lift off gently earlier cannot be discounted.

4.2.8. The replacement of the control cables as part of the engineering work converting the aeroplane for parachuting was routine work and not an indication of any previous control problem. There was no evidence of any binding or fraying of the control cables that could have restricted their movement, but the impact damage and fire prevented this possibility being ruled out.

4.2.9. The control lock was not located during the site examination and so the possibility of the pilot becoming airborne or attempting to become airborne with the controls locked cannot be fully excluded. The engineering company and aeroplane owner submitted that this may have been the cause of the accident. However, this was considered unlikely for the following reasons:

- The weather conditions were calm and there was no obvious requirement for the pilot to lock the controls during the lunch break
- It was not normal practise to use the control lock.
- The pilot typically used a bungee cord if required to hold the control column forward for easier ingress and egress.
- If the control column was locked, the pilot should have noticed this when he:
  a. re-entered the cockpit and prepared to start the engine,
  b. moved the aeroplane forward onto the runway,
  c. pressed the transmit button on top of the control column to radio other aircraft in the area that ZK-EUF was about to take-off, and
  d. when he began to feel the forces on the controls as airspeed increased in the early stages of the take off roll.

4.2.10. If the pilot had locked the controls and forgotten to unlock them before commencing the take-off roll, their locked position would have helped to hold the aeroplane nose down on take-off and the aeroplane would not have become airborne early. Also, if the lock or bracket had given way or suddenly released while the pilot was pulling hard back on a locked control column, the flight path would have been different from the witness accounts that the aeroplane became airborne then steadily pitched up. Finally, the direction of the tear in the 2 holes of the supporting bracket was down and forward, which was not consistent with the pilot pulling rearwards on a locked control column. For this reason the damage to the control lock bracket most likely occurred during the impact.

4.2.11. A post-accident examination of the wreckage confirmed that the elevator trim was set to nearly fully forward – the normal take-off position. The setting of the trim was a pre-take-off checklist item. As with most small aircraft, the pilot would have memorised the checklist.

With training and experience these checklists can become semi-automated and pilots can forget items, especially when distracted.

4.2.12. The possibility of the pilot taking-off with the trim incorrectly set cannot be totally excluded. The aeroplane owner submitted that he had forgotten to reset the trim on other aircraft several times and the pilot may have done likewise. However, this was considered unlikely for the following reasons:

- The pilot had erred once, two weeks before the accident, and should have been alert to setting the trim correctly before take-off.
- The operator had added a prominent label to remind pilots about the trim
- If the trim was incorrectly set, the pilot should have recognised the situation early in the take-off roll and stopped the take-off, as he had done before.
- The trim required about 25 turns of the handle to move it through its full range. There would have been little time to reset the trim and the pilot would have more likely been using both hands to try and control the aeroplane.
- As the aeroplane headed towards the ground the pilot would have wanted to pull back on the elevator and an aft trim would have assisted that and so there would have been no need to move the trim forward.

4.2.13. Weight and balance calculations confirmed that the weight of ZK-EUF at take-off was 2221 kg– 17 kg over the maximum allowable weight. While the overloading was of concern, the aeroplane had sufficient power to carry the additional weight, as acknowledged when it was permitted to carry up to 2463 kg in the restricted agricultural role. The weight (mass) alone was therefore not considered to be an initiator of the accident, but would have increased the rate of pitch-up after getting airborne.

4.2.14. The calculated centre of gravity during take-off was 0.122m rear of the aft limit (0.767m from datum) and may have been further rearward because the calculation was based on conservative figures. Twelve centimetres might not appear to be much, but with an allowable range of 0.428m to 0.645m, or less than 22 centimetres, it was more than 55% rearwards of the aft limit and would have had a detrimental effect on the controllability of the aeroplane. However, the operator's trip records indicated that they had flown 193 parachuting revenue flights in the preceding 2 months, and that 74 of those had had 8 parachutists on board.

4.2.15. To determine what was different between the accident flight and the 74 other flights with 8 parachutists, a statistical analysis exercise using the Monte Carlo method[13] was undertaken. The actual weights of parachutists recorded by 2 other parachuting operators in about a 3-month period were used, and a base weight of 70.8 kg and a standard deviation of 11.9 kg applied. It was assumed that the 2 heaviest tandem masters and 2 heaviest parachutists had been paired and positioned forward of the 2 lighter tandem pairs. Five thousand random samples were generated and the aft centre of gravity limit for ZK-EUF was exceeded on all samples. In 5% of the samples, the aft limit was exceeded by more than 0.120m.

4.2.16. At 0.122m rear of the aft limit, the centre of gravity on the accident flight was within the 5% grouping, and therefore likely to have been further aft than the centre of gravity on nearly all previous flights with 8 parachutists. At a minimum of 0.122m rear of the aft limit, the centre of gravity on the accident flight was possibly the most rearward centre of gravity of any of the aeroplane owner's previous flights.

4.2.17. With 8 persons in the rear of the aeroplane, there would have been little room to move or slide about during the take-off and climb. There were some footholds located about the cabin for people to use to brace themselves, and a hand rail along the right inside wall of the aeroplane could also have been used. Video footage of other flights showed no inclination for people to slide about during the take-off roll. Nevertheless, as the aeroplane continued to pitch up there would have come a point when the parachutists were not able to hold on and would have

[13] The Monte Carlo method uses a class of computational algorithms based on repeated random sampling.

fallen towards the rear of the cabin. Safety restraints would have prevented this. By falling to the rear of the aeroplane the centre of gravity would have shifted further aft and made the aeroplane more uncontrollable.

4.2.18. The most likely reason for the loss of control was the centre of gravity being well rear of the aft limit, and possibly the most rearward it had ever been. This may have caught the pilot unawares and the aeroplane became airborne, possibly early and at too low a speed for the pilot to have sufficient elevator control to stop the ensuing pitch-up. The only option available to the pilot at this stage was to close the throttle immediately while the aeroplane was less than a few metres into the air. This window of opportunity was small and some damage and injury might still have occurred.

Findings

There were no technical defects identified that may have contributed to the accident and the aeroplane was considered controllable during the take-off roll, with the engine able to deliver power during the short flight.

The aeroplane's centre of gravity was at least 0.122m rear of the maximum permissible limit, which created a tendency for the nose to pitch up. The most likely reason for the crash was the aeroplane being excessively out of balance. In addition, the aeroplane probably became airborne early and at too low an airspeed to prevent uncontrollable nose-up pitch.

The aeroplane reached a pitch angle that would have made it highly improbable for the unrestrained parachutists to prevent themselves sliding back towards the tail. Any shift in weight rearward would have made the aeroplane more unstable.

4.3. Parachuting conversion

4.3.1. Several variants of the Fletcher FU24 and its derivative the Cresco had been converted to parachuting. The turbine-powered Fletchers provided an economical option for parachuting operators to expand their business, provide greater capacity, quicker turn-around times and reduced noise footprint when compared to piston-powered aeroplanes. ZK-EUF was the fourth and most recent Walter Fletcher aeroplane to be converted from an agricultural role to parachuting. The engineering company had been involved to varying degrees with each of the 4 Walter Fletcher conversions.

4.3.2. Civil Aviation Rule Part 43 General Maintenance Rules, specifically 43.69 and 43.153, directs people performing maintenance or engineering work on an aircraft to correctly record the work performed. This is to ensure that there is an accurate record for the Civil Aviation Authority, and other interested individuals or organisations, to confirm the engineering status of the aircraft. The documentation helps interested persons to confirm the airworthiness of the aircraft and to confirm compliance with other relevant Civil Aviation Rules.

4.3.3. The available evidence indicated the workmanship involved in the conversion of ZK-EUF was to a good standard and the aeroplane owner was satisfied with the finished product. However, examination of the engineering documentation associated with the conversion soon identified anomalies in the process that meant the aeroplane did not comply with civil aviation rules. Some examples of these anomalies are described below.

4.3.4. The engineering company had not obtained permission to use several of the modifications embodied on the aeroplane, specifically the installation of the top grab rail, the lower fuselage steps and the fitment of the air deflector door as required by Civil Aviation Rule 21. The agreement of the owner of a modification was required to ensure the fitment of the modification would not have a detrimental effect on the airworthiness of an aircraft. There may have also been financial implications.

4.3.5. The documentation covering the modification of the aeroplane was incomplete, as no reference to the strengthened floor in the passenger cabin was recorded on the CAA Form 337 and was only to be found in the worksheets.

4.3.6. The engineering company had not amended the aircraft flight manual to allow the opening of a door in-flight as required in Civil Aviation Rule Part 91. The latest weight and balance data sheet and oxygen supplements had been inserted in the flight manual, but other than that it had not been changed to reflect the new role the aeroplane was about to perform. The flight manual now contained obsolete data and information related to its former agricultural role. The engineering company should have amended the flight manual as required.

4.3.7. The flight manual also contained an anomaly in the unusable fuel quantity. The flight manual limitations section stated the total fuel capacity for the aeroplane, including unusable, and the usable fuel quantity. This gave an unusable fuel quantity of 70 litres for level flight. However, the weight and balance data sheet stated 50.5 litres. Although the latter figure was the result of actual testing, the more conservative figure for the Walter Fletcher fleet should have been used because this was the CAA-approved figure. This anomaly had been there since the installation of the Walter engine and possibly reflected a lack of understanding of the civil aviation rules by the engineering company.

Findings

The engineering company that modified ZK-EUF for parachuting operations did not follow the proper processes required by civil aviation rules and guidance. Two of the modifications had been approved for a different aircraft type, one modification belonged to another design holder and a fourth was not referred to in the aircraft maintenance logbook.

The flight manual for ZK-EUF had not been updated to reflect the new role of the aeroplane and was limited in its usefulness to the aeroplane owner for calculating weight and balance.

Regardless of the procedural issues with the project to modify ZK-EUF, the engineering work conducted on ZK-EUF to convert it from agricultural to parachuting operations in the standard category was by all accounts appropriately carried out.

4.4. The operator

4.4.1. The purchase and conversion of ZK-EUF by the aeroplane owner had reflected the growing popularity of parachuting, and in particular tandem jumping, both locally and nationally. The use of the Walter turbine-powered aeroplane had proved successful with other parachuting operators, so the aeroplane owner had assumed that following the pilots' conversion training the aeroplane could immediately be put into operation.

4.4.2. The aeroplane owner had relied on the engineering company to complete the modification and re-categorisation of the aeroplane in accordance with the relevant civil aviation rules. The aeroplane owner had not had the expertise to check on the engineering company processes, so had accepted the aeroplane along with the incomplete flight manual without question.

4.4.3. The aeroplane owner had put ZK-EUF into operation before it had documented standard operating procedures, which were being written at the time of the accident. The aeroplane owner had relied on previous experience of operating a piston-powered parachuting aeroplane and the information gleaned from other Walter Fletcher parachuting operators.

4.4.4. Each flight started with a fuel quantity of 160 litres. Between 50 and 70 litres would be consumed depending on the altitude climbed to, which resulted in a fuel quantity at landing of between 90 litres and 110 litres. Assuming the best case that 50.5 litres were unusable and using a typical consumption rate of 160 litres per hour of flying, the amount remaining was sufficient for between 15 minutes and 20 minutes of further flight. Using the CAA-approved figure of 70 litres unusable, the time remaining for flight was half of that (7 to 10 minutes). Civil aviation rules required at least 30 minutes to be remaining.

4.4.5. The aeroplane owner accepted the use of a lower fuel reserve, believing that a flight would only take off in good weather and that with no other aeroplane operators using the aerodrome there was unlikely to be any delay in landing. This, however, made little allowance for other possible situations or emergencies that might have required the pilot to remain airborne for longer than expected. The decision to remove the flight manual from the aeroplane may also have been based on good intentions, but had not been thought through. The flight manual contained relevant aircraft information to which a pilot might need quick access during flight. That is a reason for civil aviation rules requiring it to be on board.

4.4.6. The conversion training for the 2 pilots was adequate and comparable with that for other pilots with similar experience. The pilot's previous turbine experience enabled him to become quickly competent in the aeroplane.

4.6.1 The standard passenger weights appeared suitable for use with ZK-EUF. The weight of the 9 people on board ZK-EUF, not including their parachuting rigs, was estimated to be about 640 kg (71 kg per person). An average weight of 71 kg per person was close to that determined by the second parachuting operator that also flew a Walter Fletcher. The tandem masters in this case weighed on average about 5 kg more than the passengers, which meant that the average weight of the passengers was less than 71 kg. Using a standard passenger weight rather than weighing each person was therefore reasonable.

4.4.7. During their conversion training on another FU24 parachute aeroplane, the 2 pilots had each completed several weight and balance calculations for the loads being flown at the time, so they were familiar with weight and balance calculations. The calculation they made would have shown them that carrying 8 people in the back of the Walter Fletcher took it close to its aft centre of gravity limit. This should have prompted them to make the same calculations for their own aeroplane instead of assuming the 2 aeroplanes were the same.

4.4.8. The weight and balance data for ZK-EUF varied significantly from that in the other 3 Walter Fletcher aeroplanes used in parachuting. It was between 64 kg and 101 kg heavier and had a centre of gravity between 0.066m and 0.132m further aft. The basic weight and balance calculations completed by the engineering company holder were considered to be accurate. The weight differences between ZK-EUF and the other 3 aeroplanes arose from their different agricultural spraying and sowing equipment being fitted to each aeroplane and possible additional protection to the underside of the aeroplane. These had all added weight further aft.

4.4.9. Had the aeroplane owner completed a weight and balance calculation for ZK-EUF, even using average weights and the chart and information available in the flight manual, they would have found that the aeroplane was near its maximum allowable weight and outside the aft centre of gravity limit for all loads involving 8 parachutists.

Findings

The weight and balance of the aeroplane, with its centre of gravity at least 0.122m outside the maximum aft limit, would have caused serious handling issues for the pilot and was the most significant factor contributing to the accident.

ZK-EUF was 17 kg over its maximum permissible weight on the accident flight, but was still 242 kg lighter than the maximum all-up weight for which the aeroplane was certified in its previous agricultural role. Had the aeroplane not been out of balance it is considered the excess weight in itself would have been unlikely to cause the accident. Nevertheless, the pilots should have made a full weight and balance calculation before each flight.

The aeroplane owner and their pilots did not comply with civil aviation rules and did not follow good, sound aviation practice by failing to conduct weight and balance calculations on the aeroplane. This resulted in the aeroplane being routinely flown overweight and outside the aft centre of gravity allowable limit whenever it carried 8 parachutists.

The empty weight and balance for ZK-EUF was properly recorded in the flight manual, but the stability information in that manual had not been appropriately amended to reflect its new role of a parachute aeroplane. Nevertheless, it was still possible for the aeroplane operator to initially have calculated the weight and balance of the aeroplane for the predicted operational loads before entering the aeroplane into service.

The aeroplane owner did not comply with civil aviation rules and did not follow good, sound aviation practice when they: used the incorrect amount of fuel reserves; removed the flight manual from the aeroplane; and did not formulate their own standard operating procedures before using the aeroplane for commercial parachuting operations.

4.5. The role of the regulator

4.5.1. The conversion of ZK-EUF for parachuting involved the removal of its agricultural equipment and the installation of a number of STCs and modifications – both major and minor. The Walter Fletcher was originally certified in both the restricted and standard airworthiness categories. The conversion of the aeroplane, therefore, did not require a new type certificate to be issued but did in the opinion of the Commission require the CAA to ensure that the work had been correctly carried out.

4.5.2. The Director of Civil Aviation delegated the function of approving design changes to "certified design organisations" that employed CAA "design delegation holders" as "senior persons". The Director also delegated the function of oversight of the modification work to engineers with "inspection authorisations". The Director was able to delegate these functions under section 23B of the Civil Aviation Act. The delegations made those organisations and persons accountable to the Director for that work, but in the opinion of the Commission did not absolve the Director's responsibility. Just as an organisation is responsible for the performance of its contractors, so too was the Director responsible for ensuring these delegation holders were performing the tasks in line with civil aviation rules and good, sound aviation engineering practice. It was incumbent on the Director therefore to maintain some form of control or oversight of the STC and modification processes.

4.5.3. In this case the engineering company contracted a certified design organisation, and its chief engineer held an inspection authority. This meant that the engineering company could have in effect submitted its own data to assess itself, approved that data as acceptable, classified the modification as minor or major and, if major, certified conformity with the Civil Aviation Rules, undertaken the work and signed off the work using its own inspection authority. If it had not been for the requirement to return the aircraft to the standard category, all of this could have taken place without recourse to the CAA.

4.5.4. The CAA said that in approving the change in airworthiness category it was only concerned that the aeroplane was airworthy and that the 2 STC modifications had been embodied (the requirement for a fuel drain and the installation of an alternate air intake door to the engine). It was not the CAA's role under the relevant rule to approve the role or use of an aircraft. The CAA said that the responsibility for ensuring the aeroplane was safe to fly rested with the aircraft owner.

4.5.5. There are 2 issues with this approach. The first is that the aeroplane owner did not, and was not required to, have the expertise to judge whether the modification was appropriate. Like the Director, the aeroplane owner left that to the engineering company and the design delegation holder to exercise their obligations and requirements under the Rules as they saw fit. The second issue is that the parachuting operation was essentially unregulated.

4.5.6. The information requested from the engineering company by the CAA was adequate as a basis for approving the change in airworthiness category, provided the information was complete and correct. The CAA was subsequently satisfied that the requirements had been met and approved the change in category. While this was in accordance with the current rules and practices, an opportunity was not taken by the CAA to review the full documentation provided to help ensure that the aeroplane owner, who had never flown a turbine-powered aircraft before, was about to operate an aeroplane that was fit for purpose. Had the CAA done so it might have noted that there was both incorrect and missing documentation. It might also have required the flight manual to be amended to ensure that it contained the information that pilots required in order to operate the aeroplane safely, such as the procedures for opening a door in-flight and for calculating the centre of gravity.

4.5.7. This accident highlighted how critical it is for a regulator to maintain a good oversight of the modification and airworthiness of aircraft. Special-purpose aircraft, especially those undergoing one-off type modifications, required additional attention to ensure airworthiness standards were maintained.

4.5.8. The Commission considered the question, should major modifications and STCs be referred back to the original type certificate holder? The Commission considered this from a safety and standards point of view and has not taken commercial considerations into account. To help with this question a comparison was made with how other countries dealt with the issue. The process in New Zealand was found to be similar to those of other countries that manufacture aircraft.

4.5.9. In New Zealand the Director of Civil Aviation can require a design delegation holder to consult the type certificate owner over a major modification or STC, but this is entirely at the Director's discretion (Rule Part 21.123). If the designer has sufficient data to consider adequately what effect a modification would have on the aircraft in line with civil aviation rules, it might not be necessary to consult the type certificate holder. However, it would seem the prudent thing to do in some cases to alleviate any doubt.

4.5.10. There are analogies with almost all other modes of transport. When someone is wanting to modify a car, bus, train or ship they are rarely required to consult the manufacturer first. There is usually the simple requirement that after modification the vehicle must meet the standards of the day.

4.5.11. The CAA now says that it would not approve a similar conversion in the future without ensuring that the modifications were applicable to the aircraft being converted and that the flight manual was amended to reflect the new role. The CAA now says also that some of the modifications made when converting ZK-EUF to parachuting should have been completed as STCs rather than as major modifications. The CAA's amendment of the conditions governing all design delegation holders, while it primarily was intended to align New Zealand with best international practice, should result in better management of the STC and modification process. The design delegation holder amendment was issued on 24 August 2010, after ZK-EUF had been modified but before the accident. This has been acknowledged as a safety action that would otherwise have resulted in a recommendation by the Commission.

Findings

The Director of Civil Aviation delegated the task of assessing and overseeing major modifications to Rule Part 146 design organisations and individual holders of "inspection authorisations". The delegations did not absolve the Director of his responsibility to monitor compliance with civil aviation rules and guidance.

The delegations increased the risk that unless properly managed the CAA could lose control of 2 safety-critical functions: design and inspection. The Director had not appropriately managed that risk with the current oversight programme.

> The CAA had adhered strictly to its normal practice and was acting in accordance with civil aviation rules when approving the change in airworthiness category from special to standard. However, knowing the scope, size and complexity of the modifications required to change ZK-EUF from an agricultural to a parachuting aeroplane, it should have had greater participation in the process to help ensure there were no safety implications.
>
> There was a flaw in the regulatory system that allowed an engineering company undertaking major modification work on an aircraft to have little or no CAA involvement by using an internal or contracted design delegation holder and a person with the inspection authorisation to oversee and sign off the work.

4.6. Regulatory oversight of the parachuting industry

4.6.1. Parachuting operators were not certificated and there were no rules that fully governed the operation, other than Rule Part 105 and the common general operating rules of Part 91. Parachuting operators were, therefore, not subject to inspections and audits. The CAA had not established a risk profile for the industry.

4.6.2. With nearly 100 000 tandem jumps being undertaken annually, the parachuting industry had grown significantly in recent years. New parachuting operations had been established to meet the increased demand, and previously small, mainly recreational, operators had expanded into medium-sized commercial businesses. The CAA had recognised this evolution and had identified the need to develop rules to better regulate these operations. However, in the meantime these operations had flourished unchecked.

4.6.3. Some parachuting operators were flying larger and more powerful aircraft, often carrying more passengers, than some certificated small commuter operators. Despite this the CAA directed minimal additional resources towards ensuring the safe conduct of these activities throughout the long process of developing a rule. The biennial visits by the CAA aviation safety adviser were irregular and informal, and would not have identified the causal factors that led to this accident.

4.6.4. The United States special report on parachuting operators highlighted 3 recurring safety issues that were relevant to the parachuting industry in New Zealand in general and this accident in particular. These issues included aircraft maintenance, pilot performance and regulatory oversight.

4.6.5. Commercial parachuting operations were based on repetitive, short-cycle flights that involved extended high-power settings for the climbs, immediately followed by rapid descents. This placed increased demands on aircraft and engines that, with the possible exception of topdressing, might not otherwise normally have occurred. Although no technical failure was identified in this accident, operators and pilots need to ensure that aircraft are correctly maintained and operated at all times. The CAA also needs to be actively involved with the industry to ensure that proper maintenance practices are adhered to.

4.6.6. The Walter Fletcher was a different type of aeroplane from the Cessna aeroplane the owner had flown before. It was heavier, more powerful, able to carry more parachutists and capable of reaching drop altitudes more quickly. It also had a turbine engine that required different handling skills and, because of the flight profile adopted by the aeroplane operator, it had to be refuelled between each load. The introduction of the aeroplane into service therefore needed to be carefully managed.

4.6.7. The pilot of ZK-EUF was considered to be a competent pilot. He was experienced in the parachuting role and had recently completed conversion training that had included several parachute-drop flights under the observation of an instructor. He was, therefore, current as a parachuting pilot.

4.6.8. Pilots were required to undergo regular checks to ensure that their general aircraft piloting skills, emergency drills and aviation and aircraft knowledge were up to standard. However, once a pilot had obtained a parachute-drop rating, provided they maintained their currency by completing 6 parachute drops in the preceding 12 months, there was no requirement for an independent check by a qualified examiner.

4.6.9. The operator was not certificated. Parachuting, like other adventure aviation activities, was not subject to the same CAA regulatory oversight that applied to commercial air operators. The CAA was relying on the implementation of Rule Part 115 to help ensure that these types of operator developed appropriate procedures and were part of the safety audit process. The introduction of Rule Part 115 had, however, suffered several delays over the years but entered into force on 10 November 2011 (refer to the "Safety actions" section of the report for more detail).

4.6.10. The Director of Civil Aviation believed he had limited powers under the Civil Aviation Act to regulate parachuting activities. The Commission agrees that there were some limitations, but the mechanism was there in section 15(1)(b) of the Civil Aviation Act, which gives the Director the power to require any person that:

> ". . .operates, maintains, or services, or does any other act in respect of any aircraft, aeronautical product, aviation-related service, air traffic service, or aeronautical procedure to undergo or carry out such inspections and such monitoring as the Director sees necessary in the interests of civil aviation safety and security."

4.6.11. The limitation was that the Director, in exercising a special power, would need to have a reasonable belief that the interests of civil aviation safety were at risk. To form that belief someone would have had to bring the matter to his attention if it was not covered by routine monitoring. The operation of parachute-drop aircraft was not covered by routine monitoring and nothing untoward with the operation had been notified to the Director, so he had had no reason to intervene.

4.6.12. Alternatively, under the designation for the CAA to administer the HSE Act, ZK-EUF was the place of work for the pilot and tandem masters involved in the accident. Certain aspects of the Fox Glacier aerodrome operation also came under this purview if the safety of those on board the aircraft were compromised by some act or omission. They, like the operator, were subject to the HSE Act and therefore had a collective responsibility to ensure it was a safe working environment. As the designated authority to administer the HSE Act for the aviation sector, the CAA also had an obligation to promote safe work practices and educate participants and aviation document holders – operators and licensed and qualified personnel such as pilots and tandem masters.

4.6.13. The CAA did make available material such as the Good Aviation Practice publications, to help educate pilots and operators generally. Included within this series of publications was the "Weight and Balance" booklet that the aeroplane owner reported he had never read.

4.6.14. The CAA's HSE Unit had sampled the parachuting industry in anticipation of the adoption of the new Rule Part 115. With their limited experience and focus, the HSE Unit staff members were limited to looking at personal safety issues, which they considered to be of a good standard. As a result no concerns were raised for further investigation.

4.6.15. The HSE Unit focused its attention on personal responsibility, while operational responsibility was left to be overseen by the CAA's audit, inspection, safety information and enforcement personnel. The HSE Unit was able to undertake some 30 audits per year, and with more than 400 certificated organisations the priority was understandably to focus on those sectors or operators that were at greater risk or had the potential for greater injury, for example medium and large passenger aircraft. These were identified through the CAA's risk management scheme and were generally part of the CAA's regular audit programme.

4.6.16. As far as the HSE Act is concerned, there is no differentiation between operational safety and personal safety. If an operational safety matter affected the safety of employees in the workplace, the Director had the power to intervene under his designation. Given the growth in the parachuting industry and the length of time taken to develop Rule Part 115, this would have been a prudent measure.

> **Findings**
>
> The level of parachuting activity in New Zealand warranted a stronger level of regulatory oversight than had been applied in recent years.
>
> The CAA's oversight and surveillance of commercial parachuting were not adequate to ensure that operators were functioning in a safe manner.
>
> The CAA had mechanisms through the Director's powers under the Civil Aviation Act and his designated powers under the HSE Act to effectively regulate the parachuting industry pending the introduction of Rule Part 115.

4.7. Performance-impairing substances

4.7.1. Although the consumption/ingestion of cannabis was not contributory to this accident, the presence of THC in 2 of the tandem masters, albeit one of very low level, was a concern. The tandem masters on board ZK-EUF were not crew members of the aeroplane. However, a parachute when in use was considered by the CAA to be an aircraft and the tandem masters each held a rating issued under Civil Aviation Rules. They were therefore subject to Rule Part 19.7, prohibiting the use of performance-impairing substances.

4.7.2. The role of tandem master was critical to the safe conduct of a parachuting descent. Tandem masters, like pilots, needed to be fully alert to conduct their routine duties and react appropriately in case of an emergency. All transport modes have complex tasks, and participants need to be fully fit and healthy to complete those tasks safely.

4.7.3. Although the intent of Rule 19.7 is clear, the matter of what impairment means is subjective in the absence of any laws that prescribe limits, such as those in existence for alcohol and road users. The issue has been raised in other Commission reports (such as marine report 09-201) and a recommendation made to the Secretary for Transport to address the issue.

> **Finding**
>
> An alcohol and drug testing regime needs to be initiated for persons performing activities critical to flight safety, to detect and deter the use of performance-impairing substances.

4.8. Safety restraints

4.8.1. Proper safety restraints have been shown to reduce flailing injuries and save lives in those accidents deemed survivable. However, the impact forces sustained when ZK-EUF struck the ground in a near-vertical angle would not been survivable even if typical safety harnesses had been fitted and worn.

4.8.2. Even if the parachutists had been wearing safety restraints, it is unlikely this would have prevented the accident, because the evidence suggests the aircraft became uncontrollable as soon as it became airborne. The passengers in the back would not likely have slid towards the tail until the aircraft had pitched up to a steep angle, at which point it would have been unrecoverable at such a low altitude.

4.8.3. The reluctance of some parachutists to wear safety restraints for fear of getting caught up was based on others' experiences and was understandable. Any enforced requirement to wear restraints risks being ignored as a result. Single-point restraints may stop people sliding about, but have proven not to be effective in moderate and high-energy accidents.

4.8.4. The joint study by the FAA and United States Parachute Association, when completed, may provide guidance on what, if any, form of safety restraint may promote accident survivability for parachutists. Meanwhile the Commission's safety recommendation on the matter remains open until further work has been completed to weigh the benefits against the costs.

Findings

In this case the impact was not survivable and the passengers wearing safety restraints would not have prevented their deaths, but in other circumstances the wearing of safety restraints might reduce injuries and save lives.

Safety harnesses or restraints would help to prevent passengers sliding rearward and altering the centre of gravity of the aircraft. It could not be established if this was a factor in this accident.

5. Findings

5.1. There were no technical defects identified that may have contributed to the accident and the aeroplane was considered controllable during the take-off roll, with the engine able to deliver power during the short flight.

5.2. The aeroplane's centre of gravity was at least 0.122m rear of the maximum permissible limit, which created a tendency for the nose to pitch up. The most likely reason for the crash was the aeroplane being excessively out of balance. In addition, the aeroplane probably became airborne early and at too low an airspeed to prevent uncontrollable nose-up pitch.

5.3. The aeroplane reached a pitch angle that would have made it highly improbable for the unrestrained parachutists to prevent themselves sliding back towards the tail. Any shift in weight rearward would have made the aeroplane more unstable.

5.4. The engineering company that modified ZK-EUF for parachuting operations did not follow proper processes required by civil aviation rules and guidance. Two of the modifications had been approved for a different aircraft type, one modification belonged to another design holder and a fourth was not referred to in the aircraft maintenance logbook.

5.5. The flight manual for ZK-EUF had not been updated to reflect the new role of the aeroplane and was limited in its usefulness to the aeroplane owner for calculating weight and balance.

5.6. Regardless of the procedural issues with the project to modify ZK-EUF, the engineering work conducted on ZK-EUF to convert it from agricultural to parachuting operations in the standard category was by all accounts appropriately carried out.

5.7. The weight and balance of the aeroplane, with its centre of gravity at least 0.122m outside the maximum aft limit, would have caused serious handling issues for the pilot and was the most significant factor contributing to the accident.

5.8. ZK-EUF was 17 kg over its maximum permissible weight on the accident flight, but was still 242 kg lighter than the maximum all-up weight for which the aeroplane was certified in its previous agricultural role. Had the aeroplane not been out of balance it is considered the excess weight in itself would have been unlikely to cause the accident. Nevertheless, the pilots should have made a full weight and balance calculation before each flight.

5.9. The aeroplane owner and their pilots did not comply with civil aviation rules and did not follow good, sound aviation practice by failing to conduct weight and balance calculations on the aeroplane. This resulted in the aeroplane being routinely flown overweight and outside the aft centre of gravity allowable limit whenever it carried 8 parachutists.

5.10. The empty weight and balance for ZK-EUF was properly recorded in the flight manual, but the stability information in that manual had not been appropriately amended to reflect its new role of a parachute aeroplane. Nevertheless, it was still possible for the aeroplane operator to initially have calculated the weight and balance of the aeroplane for the predicted operational loads before entering the aeroplane into service.

5.11. The aeroplane owner did not comply with civil aviation rules and did not follow good, sound aviation practice when they: used the incorrect amount of fuel reserves; removed the flight manual from the aeroplane; and did not formulate their own standard operating procedures before using the aeroplane for commercial parachuting operations.

5.12. The Director of Civil Aviation delegated the task of assessing and overseeing major modifications to Rule Part 146 design organisations and individual holders of "inspection authorisations". The delegations did not absolve the Director of his responsibility to monitor compliance with civil aviation rules and guidance.

5.13. The delegations increased the risk that unless properly managed the CAA could lose control of 2 safety-critical functions: design and inspection. The Director had not appropriately managed that risk with the current oversight programme.

5.14. The CAA had adhered strictly to its normal practice and was acting in accordance with civil aviation rules when approving the change in airworthiness category from special to standard. However, knowing the scope, size and complexity of the modifications required to change ZK-EUF from an agricultural to a parachuting aeroplane, it should have had greater participation in the process to help ensure there were no safety implications.

5.15. There was a flaw in the regulatory system that allowed an engineering company undertaking major modification work on an aircraft to have little or no CAA involvement by using an internal or contracted design delegation holder and a person with the inspection authorisation to oversee and sign off the work.

5.16. The level of parachuting activity in New Zealand warranted a stronger level of regulatory oversight than had been applied in recent years.

5.17. The CAA's oversight and surveillance of commercial parachuting were not adequate to ensure that operators were functioning in a safe manner.

5.18. The CAA had mechanisms through the Director's powers under the Civil Aviation Act and his designated powers under the HSE Act to effectively regulate the parachuting industry pending the introduction of Rule Part 115.

5.19. An alcohol and drug testing regime needs to be initiated for persons performing activities critical to flight safety, to detect and deter the use of performance-impairing substances.

5.20. In this case the impact was not survivable and the passengers wearing safety restraints would not have prevented their deaths, but in other circumstances the wearing of safety restraints might reduce injuries and save lives.

5.21. Safety harnesses or restraints would help to prevent passengers sliding rearward and altering the centre of gravity of the aircraft. It could not be established if this was a factor in this accident.

6. Safety actions

6.1. General

6.1.1. The Commission classifies safety actions by 2 types:

(a) safety actions taken by the regulator or an operator to address safety issues identified by the Commission during an inquiry that would otherwise result in the Commission issuing a recommendation

(b) safety actions taken by the regulator or an operator to address other safety issues that would not normally result in the Commission issuing a recommendation.

6.1.2. The following safety actions are not listed in any order of priority.

6.2. Safety actions addressing safety issues identified during an inquiry

6.2.1. On 11 October 2011 the Minister of Transport signed the new Civil Aviation Rule Part 115 Adventure Aviation (Certification and Operations). Part 115 (initial issue) entered into force on 10 November 2011. Transitional arrangements in Part 115 require commercial tandem parachute and parachute-drop aircraft operators conducting operations immediately before 10 November 2011 to comply with Part 115 by 1 May 2012. CAA resources have been increased as a result.

7. Recommendations

7.1. General

7.1.1. The Commission may issue, or give notice of, recommendations to the persons or organisations that it considers the most appropriate to address the identified safety issues.

7.1.2. In the interests of transport safety it is important that these recommendations are implemented without delay to help prevent similar accidents or incidents.

7.2. Recommendations

7.2.1. On 13 September 2010 the Commission made the following urgent safety recommendations:

7.2.2. The Commission recommends that the Director of Civil Aviation as a matter of urgency alerts all pilots and operators using the Fletcher FU24-954 aircraft for parachuting operations that when loaded with 6 or more passengers it is possible for the aircraft CG to be aft of the allowable limit, and that this could result in control difficulties, and that parachutists should be seated in the forward cabin area, preferably restrained to prevent them inadvertently moving rearward. (037/10)

On 20 September 2010 the General Manager of the General Aviation Group of the CAA replied in part:

> As we have already advised the Commission, the CAA issued Emergency Airworthiness Directive (AD) DCA/FU24/179 on 11 September 2010, to address the safety issues that you identify in your letter. The AD was sent immediately to all operators of Fletcher series aircraft conducting parachute operations. We accept that this is based on information gained early in the investigation and the issue of the AD should be considered to be immediate interim action pending completion of your investigation.
>
> AD DCA/FU24/179 Parachuting Operations – Limitation and C of C Determination requires;
>
> 1. Amendment of the Aircraft Flight Manual (AFM) to restrict maximum occupancy of the cabin aft of F.S 118.84 to six persons. This may be accomplished by inserting a copy of the AD into the AFM adjacent to the applicable supplement for parachuting operations.
>
> 2. No parachuting operation is to be conducted with any number of occupants, unless for each individual flight:
>
>   a. A weight and balance calculation is performed to establish that the aircraft Centre of Gravity will remain within AFM limits for the duration of the flight, and
>
>   b. The calculation uses actual weights for all occupants and their equipment, and
>
>   c. The calculation accounts for the positions of all occupants. The occupants' positions shall be taken as the most aft positions that result from the rearmost members of the group sitting against the aft cabin wall and subsequent occupants located immediately forward of them, unless a means of restraint is provided to prevent the occupants moving rearwards from their normal position, and
>
>   d. A record of the Centre of Gravity determination is kept for each parachuting operation.
>
> The effective date of the AD is 11 September 2010 and compliance with 1 and 2 above is required before further parachute-drop operations and before every parachute-drop operation, respectively.

7.2.3. The Commission recommends that the Director of Civil Aviation as a matter of urgency reviews the approvals granted for the FU24-954 aircraft with a view to amending the Flight Manual to allow more accurate determinations of aircraft centre of gravity. This review should also extend to other conversions of Fletcher and Cresco aircraft. (038/10)

On 20 September 2010 the General Manager of the General Aviation Group of the CAA replied in part:

> The CAA intends to issue a further Emergency Airworthiness Directive (DCA/FU24/180 Parachuting – Flight Manual Supplement Approval) to be applicable to all FU24 series aircraft modified to conduct parachute operations. It will address the issue that it may be possible in some parachute configurations to exceed the aircraft's aft Centre of Gravity limit. In doing so, CAA will review all AFM parachute operation supplements, including those approved by delegation holders or foreign authorities to ensure that they provide adequate determination of the Centre of Gravity position.
>
> In addition to the ADs, CAA has commenced a broader safety review of parachuting operations, to establish if there are other safety issues arising. The review includes existing parachuting flight manual supplements, pilot training and type ratings for FU24 series aircraft, the provision of operational information to pilots, clarification of aircraft loading limitations and a review of the necessity of seating and/or restraint systems for parachutists.

7.2.4. On 22 March 2012, the Commission made the following recommendations to the Director of Civil Aviation:

The modification of ZK-EUF by the engineering company was not in keeping with required engineering practices and the supporting documentation was both incomplete and inaccurate. The Commission recommends the Director takes the necessary action that ensures that high engineering standards are maintained by this and other aircraft maintenance organisations (005/12).

The operator's fuel management policy, control of the flight manual and failure to ensure the aeroplane was being operated within its centre of gravity limits may be an indication of wider non-compliance issues. The Commission recommends that the Director takes the necessary action that ensures all parachuting operators are conforming to Civil Aviation Rules and operating safely (006/12).

In approving the change in airworthiness category, the CAA did not review all the required documentation and so missed the opportunity to ensure the aeroplane was fit for the purpose. The Commission recommends that the Director takes the necessary action that ensures there is a thorough and coordinated oversight when accepting aircraft modifications and approving changes in category, especially for specialised operations like parachuting (007/12).

The wearing of appropriate seat restraints can reduce injury and save lives. The Commission recommends that the Director monitor the outcome of the joint FAA/USPA study and determine if any findings are applicable for the New Zealand parachuting industry (008/12).

The owner's introduction into service of ZK-EUF was not in accordance with Civil Aviation rules and there was no assistance or oversight provided by the CAA to ensure it was safely completed. The Commission recommends that the Director ensure there is a coordinated and proactive approach by relevant departments within the CAA to ensure safety efforts are best directed to promote the coordinated safe management of flying activities (009/12).

Parachute-drop pilots can fly for many years without external validation of their parachuting related skills. The Commission recommends that the Director initiate a regular checking requirement to help ensure drop pilots remain skilled and current, similar to other commercial operators (010/12).

7.2.5. On 13 April 2012 the General Manager of the Safety Information Group of the CAA replied:

> (005/12) Accepted. Newly introduced risk based surveillance processes will improve the effectiveness of the CAA's audits, through better targeting and focus on 'risk issues'.
>
> (006/12) Accepted. Following the accident, the CAA carried out a series of spot checks on commercial parachuting operations, paying particular attention to flight manual data and the application of weight and balance limitations. In addition to this activity, the implementation of Civil Aviation Rule Part 115 (Adventure Aviation) will require tandem parachute operators to be certificated, and enable closer oversight of such operations.
>
> (007/12) See Comment. This recommendation addresses 2 separate issues. First, with respect the review of documentation required for a change from 'restricted' to 'standard' category, the Director will consider whether physical aeroplane inspections are warranted when an aircraft changes category. However, the resources and other implications of such inspections will need to be identified and evaluated before the Director accepts the recommendation in full.

Second, with respect to aircraft modifications, the CAA has amended the conditions of all design delegation holders, which has the effect of the CAA being able to exercise closer oversight of any major design changes. These changes took effect on 24 August 2010.

> (008/12) Accepted. The Director will monitor the outcome of the joint FAA/USPA study, and consider their applicability/relevance to the New Zealand aviation environment.
>
> (009/12) See comment. The CAA is currently undergoing a major change programme to ensure that it is able to target its resources more effectively, and conduct its activities more consistently. To this end, the thrust of the recommendation is accepted.

The CAA also notes that the introduction of Civil Aviation Rule Part 115 will enable the CAA to exercise closer oversight of organisations conducting commercial parachute operations, which in part address elements of the recommendation.

> (010/12) See comment. The Director will consider the recommendation in light of the changes that are being brought about by the introduction of Civil Aviation Rule Part 115.

7.2.6. On 22 March 2012 the Commission made the following recommendation to the Secretary for Transport:

The use of performance impairing substances is known to have a detrimental effect on the ability of people to safely operate in critical transport environments. The Commission recommends that the Secretary for Transport promotes the introduction of a drug and alcohol detection and deterrence regime for persons employed in safety critical transport roles (011/12).

On 3 May 2012, the General Manager Aviation and Maritime replied, in part:

> I accept the specific recommendation 011/12 directed to the Secretary for Transport.
>
> I also urge the Commission to note the existing health and safety in employment regulatory regime, where drugs and alcohol are specifically mentioned in the definition of "hazard". This regime already places obligations on both employers and employees.
>
> Since the Fox Glacier accident the Minister of Transport has approved a new Rule Part 115 that entered into force in November 2011. The Rule requires adventure aviation operations to be certified by 1 May 2012. Adventure aviation organisations, including commercial parachuting, now face the risk that their safety certification can be suspended and removed for safety violations. This

gives such operators a stronger incentive to ensure they address alcohol and drug taking safety risks in their organisations.

Over the next two years the Government will be considering rule amendments that would require aviation organisations to introduce safety management systems. This would require certificated operators to assess and mitigate all safety risks relevant to their operation. This risk of intoxication of personnel by drugs and alcohol would clearly be a safety risk that we would expect both operators and the Civil Aviation Authority (when certifying and auditing aviation organisations) to be actively addressing under an SMS regime. Decisions will also be made in the near future to ensure that the Civil Aviation Authority is resourced to transition to the ICAO-endorsed SMS approach which has widespread industry support.

Whilst recognising that where the illegal use of drugs is involved, changing individual behaviour will be challenging, the Ministry will encourage the Civil Aviation Authority to step up its effort to alert the aviation community through education of the risks that drugs pose to the safety operation of aviation undertakings. This will require an ongoing effort.

As you are aware, the Ministry has developed a Transport Regulatory Policy Statement that specific rule changes may not always be the best interventions to achieve desire safety outcomes. Non-regulatory interventions can often be more appropriate. In this regard we appreciate the Commission's recommendation to promote a drug and alcohol detection and deterrence regime, rather than to implement a regime.

The Ministry of Transport has in the past sponsored an inter-agency Substance Impairment Group. This looked at whether or not compulsory random drug and alcohol testing, and specific breath alcohol limits, should be required by regulation in the aviation, marine and rail transports modes. In part because of a lack of data, we were not convinced at that time that the costs would outweigh the benefits. We will, however, monitor international experience in this regard and, in particular, the recent relevant changes in the Australian aviation regime.

8. Key lessons

8.1. The investigation findings and recommendations provided reminders of the following practices that contribute to aviation safety:

- no 2 aircraft of the same model are exactly the same, even if they look that way; therefore pilots must do weight and balance calculations for every individual aeroplane and before each flight

- modifying aircraft is a safety-critical process that must be done in strict accordance with rules and guidelines and with appropriate regulatory oversight

- good rules, regulations and recommended practices are key to ensuring safe commercial aviation operations

- operators need to ensure that aircraft are being operated in accordance with prescribed rules and guidelines, and flown within their operating limitations

- aircraft operations need to be accompanied by relevant and robust procedures

- maintaining flight safety requires active participation by all sectors of the industry and a co-ordinated pro-approach by all elements of the regulator.

9. Citations

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Appendix 1: Weight and balance calculations

1. A standard fuel weight of 90 kg was used, based on the reported normal fuel load of 160 litres for each flight and making a small allowance for fuel used for the start and taxi. The 160 litres included the 50.5 litres unusable fuel shown in the weight and balance data sheet and that was included in the 1407 kg basic weight of the aeroplane. A conversion figure of 0.8168 kg per litre was used as this was the figure used by the STC holder during the weight and balance calculations on completion of the modifications in June.[14] The tandem parachuting rig for each tandem pair was known to weigh 20 kg. For this calculation, the 20 kg was distributed between the tandem master (15 kg) and passenger (5 kg).

2. The first calculation used the loading chart contained in the flight manual, with an average pilot and passenger weight of 70 kg, plus the weight of the equipment. For the calculations, 4 parachutists were considered to be positioned about the hopper and 4 parachutists positioned about the cargo door. To calculate the final arm or centre of gravity position, the total moment was divided by the total weight. The calculation was as follows:

Item	**Weight (kg)**	**Arm (m)**	**Moment (kg-m)**
Empty Weight	1407	+0.446	+627.522
Pilot	75	-0.056	-4.2
Observer	-	-0.056	-
Fuel	90	+0.249	+22.41
Hopper	320	+0.940	+300.8
Cargo	320	+2.290	+732.8
Total	**2212** (max 2204 kg)	**+0.759** (aft limit +0.645)	+1679.332

3. The second calculation used the same loading chart, but with individual pilot, tandem master and passenger weights based on autopsy reports and medical records where available. The heaviest 2 tandem master and passenger combinations were assumed to be at the front. Where exact weights were not available, the estimated weights were rounded down. The figures were as follows:

Item	**Weight (kg)**	**Arm (m)**	**Moment (kg-m)**
Empty Weight	1407	+0.446	+627.522
Pilot	75	-0.056	-4.2
Observer	-	-0.056	-
Fuel	90	+0.249	+22.41
Hopper	329	+0.940	+309.26
Cargo	320	+2.290	+732.8
Total	**2221** (max 2204 kg)	**+0.7599** (aft limit +0.645)	+1687.792

[14] 109.5 litres x 0.8168 kg = 89.4396 kg (rounded to 90).

4. A further series of centre of gravity calculations was made using the distributed seating locations when 4 tandem masters and 4 passengers were carried. Seating positions were based on the information provided by the operator, including video recordings of previous flights with 4 tandem pairs, and measurements obtained with the assistance of other Walter Fletcher parachuting operators. The first calculation used an average weight of 70 kg per person, plus 15 kg for each tandem master and 5 kg for each passenger. The figures were as follows:

Item	Weight (kg)	Arm (m)	Moment (kg-m)
Empty weight	1407	+0.446	+627.522
Pilot	75	-0.056	-4.2
Fuel	90	+0.249	+22.41
2 tandem masters plus 15 kg each	170	+0.787	+133.79
2 passengers plus 5 kg each	150	+1.003	+150.45
One tandem master plus 15 kg	85	+1.562	+132.77
One passenger plus 5 kg	75	+1.752	131.4
One passenger plus 5 kg	75	+3.048	+228.6
One tandem master plus 15 kg	85	+3.251	+276.335
Total	**2212** (max 2204 kg)	**+0.768** (aft limit +0.645)	+1699.077

5. A second calculation used the same seating positions with the estimated weights of the tandem masters and passengers plus their parachuting equipment.

Item	Weight (kg)	Arm (m)	Moment (kg-m)
Empty weight	1407	+0.446	+627.522
Pilot	75	-0.056	-4.2
Fuel	90	+0.249	+22.41
2 tandem masters plus 15 kg each	184	+0.787	+144.808
2 passengers plus 5 kg each	145	+1.003	+145.435
One tandem master plus 15 kg	90	+1.562	+140.58
One passenger plus 5 kg	70	+1.753	+122.71
One passenger plus 5 kg	75	+3.048	+228.6
One tandem master plus 15 kg	85	+3.251	+276.335
Total	**2221** (max 2204 kg)	**+0.7673** (aft limit +0.645)	+1704.2

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