Fox Glacier Air Accident 2010

A technical critique of the investigation report written by the New Zealand Transport Accident Investigation Commission (TAIC) with guidance for reopening its investigation

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Executive Summary

On 4 September 2010, an FU24 Walter Fletcher working as a parachute drop aircraft crashed at Fox Glacier killing all nine people on board. In May 2012 The New Zealand Transport Accident Investigation Commission (TAIC) released a report into the crash which concluded in its findings that the main reason why it crashed was because the aircraft was loaded too tail- heavy beyond the limits set by the manufacturer.

In August 2012, a coroner heard evidence from an engineer and test pilot which did not agree with the Commission's Finding as to the cause of the crash.

In February of this year, the writer was contacted by TV3 who requested assistance in making a documentary of the investigation story for the *Third Degree* series.

On 1 March 2014, the writer travelled to Fox Glacier and assisted others in exhuming aircraft wreckage which the Commission had allowed to be buried only four days after the accident. The writer also led a passenger load simulation to determine whether or not it was likely that a significant rearward load shift would occur at steep pitch attitudes. The results of the simulation did not agree with a TAIC finding which concluded that a rearward load shift was likely to occur and contribute to the uncontrollable pitch up attitude. The TV3 documentary aired on 26 March 2014 and remains available as a podcast on the TV3 website. Its website link details are: http://www.3news.co.nz/Investigation-casts-doubt-over-Fox-Glacier-crash-findings/tabid/1771/articleID/337522/Default.aspx

As a result of the TV3 *Third Degree* documentary, the relatives of the deceased have requested that TAIC reopen the investigation. TAIC have agreed to review the investigation but appear to have stopped short of promising a comprehensive reopened investigation with a revised report.

TV3 requested this report in order to provide reasons for TAIC to formally re-investigate the Fox Glacier accident.

The writer's view is that the TAIC report is not clear as to how an aft Centre of Gravity (C of G) could have resulted in loss of pitch control at each stage of the accident flight sequence. At the normal take-off point, over half of the runway remaining was available to abort the take-off and the pilot had already demonstrated a decision-making ability to abort. Because of this, together with the fact that the aircraft had the pitch control authority of a full moving tailplane enveloped in take-off power slipstream, it is difficult to understand how an aft C of G alone could have caused an early take-off and then an excessively steep pitch up angle, noting that a significant rearward load shift due to passenger movement was unlikely. Such a question behoves the Commission to address comprehensively in a reopened investigation.

Contrary to assurances given otherwise, the TAIC report breaches several ICAO standards and guidelines. This report concludes with guidance on how a reopened investigation should be conducted.

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Glossary and Abbreviations

Annex 13	Annex 13 to the Convention on International Civil Aviation Organisation (ICAO) containing International Standards and Recommended Practices relating to Aircraft Accident and Incident Investigation, Tenth edition July 2010 and published by ICAO.
AD	Airworthiness Directive.
Doc 9756	Doc 9756 titled 'Manual of Aircraft Accident and Incident Investigation' relating to Reporting, Part IV, first edition 2003 and published by ICAO.
STC	Supplemental Type certificate.
TAIC	The New Zealand Transport Accident and Investigation Commission (sometimes also referred to as 'the Commission' throughout this document.)
The TAIC Report	Report 10-009 being the final report published by the New Zealand Transport Accident and Investigation Commission about the crash of the Walter Fletcher FU-24 ZK-EUF at Fox Glacier aerodrome on 4 September 2010.

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1. Introduction, Background and Purpose

Background and Historical Timeline

1.1.1. The accident occurred on 4 September 2010. The TAIC report into the accident was released for final publication in April 2012 and became available to the public on 9 May 2012.

1.1.2. A coroner's inquest into the accident was held at Greymouth between 13 and 17 August 2012. The coroner's provisional findings were released on 17 August 2012 and the findings were released on 3 May 2013.

1.1.3. Several experts provided evidence to the coroner including a Fletcher test pilot and an engineer. The engineer set up a flight test designed to simulate the loading configuration of the aircraft that crashed at Fox Glacier on 4 September 2010. Although the TAIC report was not discussed at the coroner's inquest, the opinions and evidence that these experts provided to the coroner did not support the causal hypothesis stated in paragraph 5.7 of the TAIC report. Paragraph 5.7 stated that 'the weight and balance of the aeroplane with its centre of gravity at least 0.122m outside the maximum aft limit, would have caused the serious handling issues for the pilot and was the most significant factor contributing to the accident.'

1.1.4. The evidence that these experts provided in addition to other evidence led the coroner to conclude in paragraph 235 of his findings [document CSU-2010-CCH-621-629] that 'Weight and balance issues in themselves cannot be ruled out as causative of the dangerously nose-high attitude of the aircraft at take-off but it is likely that some other factor has also occurred'.

1.1.5. Some time later the *Third Degree* TV3 current affairs series became interested in profiling the story after concerns were expressed to them by senior aviation industry sources.

1.1.6. In February 2014, this writer was contacted by TV3 staff to assist in the production of a documentary on *Third Degree* about the accident and its investigation.

1.1.7. On 1 March 2014, the writer assisted others in exhuming wreckage that had been buried only four days after the accident occurred. The burial of this wreckage had not been documented in the TAIC report.

1.1.8. On 2 March 2014, the writer carried out a passenger loading simulation of an FU-24 Walter Fletcher aircraft at Fox Glacier that was operating as a parachute drop aircraft similar to the accident aircraft. Although this simulation did not possess the rigour of a formal investigation, it nonetheless indicated that with eight parachutists in the passenger compartment, there was very limited room to move and this would have been the case even at steep pitch angles. The

results of this simulation therefore cast doubt on paragraph 5.3 of the TAIC report.

1.1.9. Paragraph 5.3 of the TAIC report stated that 'the aeroplane reached a pitch angle that would have made it highly probable for the unrestrained parachutists to prevent themselves sliding back towards the tail. Any shift in weight rearward would have made the aeroplane unstable'.

1.1.10. The results of this passenger simulation were televised on *Third Degree* on 26 March 2014. It is assumed that the reader of this report has viewed that documentary. It may be viewed retrospectively as a podcast by accessing the TV3 website online. http://www.3news.co.nz/Investigation-casts-doubt-over-Fox-Glacier-crash-findings/tabid/1771/articleID/337522/Default.aspx

Current industry sentiment and Investigation status

1.1.11. The *Third Degree* documentary has generated significant concern amongst the relatives of those who were killed in the Fox Glacier accident and also amongst the New Zealand aviation industry generally.

1.1.12. Although TAIC has agreed to review the investigation it appears to have stopped short of committing to fully and properly reopening the accident, investigating it comprehensively and issuing an amended report.

Purpose of this report

1.1.13. The purpose of this report is to:

a. Properly and fully provide constructive technical criticism of the TAIC report. To date this has only been undertaken to a summarized extent due to the obvious limitations of a television documentary.

b. To openly indicate to TAIC the standard that the public should expect of a comprehensive air accident report and which will be required to return confidence and integrity to TAIC's investigative processes.

c. To provide guidance and justification for a resumed investigation. Without a confirmed causal hypothesis, it is not possible to take positive steps to prevent a recurrence and therefore there is no guarantee that the accident could not recur.

Acknowledgements

1.1.14. The writer wishes to acknowledge the contribution of several experienced safety and accident investigators who have provided helpful comments during the draft review process but for personal and other reasons wish to remain anonymous.

2. Technical Critique

2.1. General

2.1.1. This report critiques the TAIC report into the Fox Glacier accident (abbreviated 'the TAIC report') utilising the standards, guidelines and supporting documents provided by Annex 13 to the convention on International Aviation.

2.1.2. Annex 13 is a document containing International Standards and Recommended Practices about Aircraft Accident and Incident Investigation.

2.1.3. Annex 13 recommends in paragraph 5.3.2 that reference is also made to Doc 9756 which is titled 'Manual of Aircraft Accident and Incident Investigation.' Part IV of this document relates to reporting and is frequently referred to in this report.

2.1.4. This critique has been written from the point of view of the writer who is an experienced forensic engineer and air accident investigator. The author's credentials may be found at the end of this report.

2.2. The Executive Summary of the TAIC report

2.2.1. The Executive summary of the TAIC report states no causes or contributing factors. Paragraph 1.1.3 of the TAIC report infers that a dominant or significant cause was the fact that the centre of gravity was well rear of the aft limit but this is not clearly stated as either a cause or a contributing factor. Without a clear statement of cause, the reader is not sure whether the modification issue mentioned previously in paragraph 1.1.2 is also a cause or contributing factor.

2.2.2. Appendix 1 to chapter 1 of ICAO Doc 9756 states that the report synopsis should include 'a statement of why the accident happened'. Regrettably the Executive Summary in the TAIC report includes no such statement.

2.2.3. The fact that the Executive Summary does not summarise the contributing factors or causes of the accident is a significant deficiency of the TAIC report, particularly given that the TAIC report has no conclusion.

2.3. The 'Conduct of Inquiry' of the TAIC report

Burial of wreckage

2.3.1. Paragraph 2.1 of the TAIC report contains significant errors. Firstly the date in which the wreckage was transported to Christchurch was reported to be 8 September 2010. However TV3 has evidence that this occurred instead on 10 September 2010. Secondly paragraph 2.1 states that 'the wreckage of ZK-EUF was removed to commission facilities.' Instead a significant portion of the wreckage including control cables, some pulleys and the control column were buried four days after the accident occurred.

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2.3.2. Paragraph 3.3 of Annex 13 states 'The state of Occurrence shall take all reasonable measures to protect the evidence and to maintain safe custody of the aircraft and its contents for such a period as may be necessary for the purposes of an investigation. Protection of evidence shall include the preservation, by photographic or other means, of any evidence which might be removed, effaced, lost or destroyed. Safe custody shall include protection against further damage, access by unauthorised persons, pilfering and deterioration.'

2.3.3. A prudent timeframe for 'Such a period as may be necessary' as stated above would be the end of the draft review process after sufficient time has been given for causal theories to be methodically and fully tested by the scrutiny of other experts who may also wish to view the wreckage.

2.3.4. Appendix 2 to chapter 1 of Doc 9756 discusses in paragraph 2 the need to 'convey an attitude of impartiality and write objectively'. Early disposal of evidence puts at risk the ability to convey impartiality and objectivity because it suggests that the investigator's mind was set early in the investigation process before all possible factors had been thoroughly considered.

2.3.5. Burial of the wreckage so early in the investigation process is a serious breach of Annex 13 to the convention on International Civil Aviation.

The draft review process

2.3.6. The TAIC report in paragraph 2.8, states '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'. No other information about the report's draft review process is provided.

2.3.7. ICAO places particular importance on the draft review process and includes recommended guidelines for informal draft review processes and mandatory standards for formal draft review processes in which the contributors come from different ICAO states or countries.

2.3.8. ICAO's recommendations on the informal draft review process may be found in Doc 9756, Appendix 2 to chapter 1, paragraph 4. It discusses the iterative revising process and mentions the value of soliciting comments from other investigators.

2.3.9. ICAO's formal draft review process is clearly and comprehensively stated in chapter 6 of Annex 13. In this process contributions from the following entities are recognised and invited:

a. The designer;

b. The manufacturer;

c. The operator;

d. Any other experts or technical facilities that participated in the investigation.

2.3.10. It is an ICAO requirement for these entities to be given the opportunity through their respective states, to comment on the draft report. Paragraph 6.3 of Annex 13 clearly states: 'if the state conducting the investigation receives comments within 60 days of the date of transmittal letter, it shall either amend the draft Final Report to include the substance of the comments received or, if desired by the state that provided comments, append the comments to the Final Report'.

2.3.11. Below paragraph 6.3, a supplementary Note 2 states 'Comments to be appended to the Final Report are restricted to non-editorial specific technical aspects of the Final Report upon which no agreement could be reached'.

2.3.12. The significance of the ICAO draft review process is that if agreement cannot be reached, the decision to include alternative theories or comments in or appended to the Final Report is the discretion of the contributor(s), not the report editor.

2.3.13. It is interesting to note that contributions from the regulator and the relatives of the deceased are not required to be formally invited during the draft review process.

2.3.14. In the context of the Fox Glacier accident, the designer (original designer and design modifier), manufacturer and operator are all domiciled in New Zealand and therefore strictly speaking, the accident context may be argued to fall outside chapter 6 of Annex 13. However, clearly the ICAO principles that apply between ICAO states should also apply between contributors located within a single state if best practices are to be followed.

2.3.15. The TAIC report in paragraphs 2.2, 2.3 and 2.4 includes references to communication with the aircraft manufacturer, 'the company involved in the original modification of the aeroplane and subsequent parachuting conversion' and the parachuting operator.

2.3.16. In paragraph 2.8, the TAIC report states that a draft Final Report was 'sent to interested persons for comment' but provides no information about who the interested persons were and whether or not agreement was reached with each person. The TAIC report has provided no indication as to whether its draft review process has followed the guidelines referred to in Annex 13 and Doc 9756. This is considered a serious omission of the section titled 'Conduct of Inquiry'.

Engineering expertise

2.3.17. In paragraph 2.6, the TAIC report states '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'. This paragraph does not state the extent to which this engineer was familiar with technical details of the aircraft type involved in the accident, nor does it advise the details of the technical advice that was provided. This is considered a serious omission of the 'Conduct of Inquiry' section of the TAIC report.

2.3.18. This section of the TAIC report does not state how the wreckage was examined in order to be able to later find in paragraph 5.1 that 'there were no technical defects that may have contributed to the accident'.

2.3.19. This section of the TAIC report does not state how the differences between witness accounts were considered, reconciled and surmised. Though TAIC chose not to divulge detailed witness accounts - presumably to preserve confidentiality, it would still have been possible to indicate to the reader the process used to conclude information from the many witness accounts.

2.4. Factual section of the TAIC report

2.4.1. Paragraph 3.1.2 of the TAIC report refers to nine flights that the accident aircraft flew that morning. However no mention is made of the loading configuration of those flights - specifically the number of parachutists. This is a significant omission. If all or most of those flights were carried out with eight parachutists and therefore with a similar loading configuration as the accident flight but without any known incidents or control difficulties, then that is significant and relevant and should have been noted.

2.4.2. Paragraph 3.1.5 of the TAIC report refers to the accounts of two witnesses who 'thought the aeroplane got airborne earlier than it normally did'. Much appears to have been made of these two accounts which differ to the accounts of eight other witnesses. The report does not explain why the accounts of these two witnesses were accepted in favour of the other eight witnesses with respect to the location of aircraft lift-off.

2.4.3. Paragraph 3.2.4 of the TAIC report refers to a 'detailed examination' at the 'secure facility' of the 'cockpit area, engine, propeller and empennage,' but does not explain the process and expertise used to carry this out. A comprehensive examination would have needed the expertise of a maintenance engineer who was familiar with the FU24 Walter Fletcher. Some reconstruction of the damaged items to determine breakup sequence would also have been of interest. That activity would have needed other tradesmen to assist.

2.4.4. Section 1.12 of Appendix 1 to chapter 1 of Doc 9756 titled 'Wreckage Information' provides comprehensive guidelines on how to set out wreckage and impact information. This would be pertinent had there been more information available from the wreckage assessment.

2.4.5. Paragraph 3.2.5 of the TAIC report states that 'the elevator control and elevator trim components displayed no evidence of binding or fraying' but does not explain the engineering process used to assess this. This statement lacks clarity and consistency when compared with a later statement in paragraph 4.2.8 which states 'there was no evidence of binding or fraying of the control cables that could have restricted their movement, but the impact damage and the fire prevented this possibility being ruled out'.

2.4.6. Paragraph 3.5.2 of the TAIC report includes no mention about the exposed nature of the flight controls in the cockpit. This is relevant because of the risk that foreign objects could have fallen in amongst the pulleys, cables and control horns and jammed the flight controls.

2.4.7. Also omitted from the description of flight controls in paragraph 3.5.2 is mention that the elevator consisted of a full moving tailplane and not a hinged flap or control surface, the latter being more common on light aircraft. This is relevant to the cause of the crash because the TAIC report maintains the cause was due

to poor control in pitch attitude due to the aircraft centre of gravity being located too aft,and a moving tailplane would provide the pilot greater control authority in pitch mode than a hinged control surface particularly at low speed. The designer, test pilot and/or experienced Fletcher pilot would be able to provide further comment on this. Regrettably there is no evidence in the TAIC report that advice on this point was sought from these experts.

2.4.8. Although a footnote to paragraph 3.5.2 does mention that the elevator consists of a moving tailplane and uses the term 'stabilator' the analysis section does not explain the significance of this to the causal hypothesis of the accident. The moving tailplane or stabilator would provide greater pitch control authority than an elevator which pivots about a hinge located at the rear of a fixed tailplane.

2.4.9. Another significant omission from paragraph 3.5.2 of the TAIC report relates to the effect of propeller wash on the ability of the tailplane to provide pitch control. At take-off, the aircraft engine would be set at its full rated power and so even though the aircraft may be stationary or still accelerating in speed, the tailplane being directly in line with propeller slipstream would still benefit from significant airflow passing over it. So the last sentence of paragraph 3.5.2 which reads 'For a given amount of control input, the faster the aeroplane was flying, the greater would be a change in pitch attitude' should be modified to reflect that a significant degree of pitch control would still be available when the aircraft had only begun to accelerate on its take-off roll because of propeller slipstream at the take off power setting.

2.4.10. An interesting and relevant question on this point relates to the alternative case on landing when airspeed lowers and the engine is at idle. Pitch control authority would be less than in the take-off case because of less propeller slipstream. Interestingly this does appear to be an issue on landing, but it is due to the aircraft load distribution being nose heavy, not tail heavy. A placard on the instrument panel of another Walter FU-24 Fletcher reads 'CAUTION ON STEEP STRIPS WITH FWD C of G LIMIT'. This is a relevant fact which is omitted from the TAIC report.

2.4.11. Paragraph 3.5.4 of the TAIC report explains the operation of the elevator trim system. The text appears to be inconsistent with Figure 6 to which it refers. The text states that the accident aircraft was installed with a manual system and a rotating handle that 'took about 25 turns of the handle for full travel'. However the photograph in Figure 6 appears to show an electric trim system. This should be reviewed in a reopened investigation.

2.4.12. Paragraph 3.6.25 of the TAIC report states: 'All of the flight control cables were replaced and the flight control rigging checked'. No further details of this activity are mentioned. Of interest would be the process used to check the flight control rigging.

2.4.13. Paragraph 3.6.25 of the TAIC report states '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 delegation holder'. Later in paragraph 3.6.30 the TAIC report states 'The CAA records did not include a copy of the CAA form 337 for the modification of the aeroplane floor'.

2.4.14. The TAIC report includes no further information about the modified floor. The modified floor could be relevant to the cause of the crash because in some small apparently innocuous way, the modified floor could have interfered with the run of the cables or control system supports. If no drawings are available about the modified floor design then it would probably have been possible to have derived 'as built' drawings from parts of the floor found in the wreckage. The TAIC report provides no advice that interference from the modified floor on the control system run was considered.

2.4.15. Please refer to paragraphs 3.6.39, 3.6.40 and 3.6.41 of the TAIC report. This records opinions of the regulator and uses words and phrases such as 'did not think', 'thought', 'agreed' and 'should not have', to record contributions from the regulator, the New Zealand CAA. Opinions are normally reserved for the analysis section. This principle may be referred to in Doc 9756 appendix 1 to chapter 1 and section 1 titled 'Factual Information'. This states at the end of the section that 'the significance of the facts should not be explained in the factual information part. Such discussion should be presented in the analysis part'.

2.5. Analytical section of the TAIC report

2.5.1. Paragraph 4.2.1 of the TAIC report states that there was no evidence of any technical failure. However given that significant parts of the control system were buried only four days after the accident, it is difficult to accept that all reasonable steps were taken to rule out the possibility of technical failure.

2.5.2. This is a significant omission of the TAIC report because a technical failure would generate a loss of control and paragraph 4.2.1 states that 'the circumstances of the accident flight were consistent with a loss of control of the aeroplane during the take-off sequence'.

2.5.3. Paragraph 4.2.3. of the TAIC report states 'what was different was that the aeroplane may have become airborne early, and that as the aeroplane became airborne it continued to pitch-up'. Here the TAIC report appears to be quoting from the factual section of its report but it is not clear whether this event has been deduced by some kind of analysis or that it has been determined from the evidence of witnesses, or both. The word 'may' suggests some uncertainty about whether or not the aircraft became airborne early - less than the balance of probabilities.

2.5.4. Paragraph 4.2.4. of the TAIC report sets out possibilities for the 'pitch-up'. For reasons unknown, the possibility of a control system failure due to a cable failure is not considered, even though later in paragraph 4.2.8 the TAIC report concedes that with respect to binding or fraying of the control cables, 'the impact damage and fire prevented this possibility being ruled out'.

2.5.5. Earlier the TAIC report in paragraph 3.2.5 stated that 'the elevator control and elevator trim components displayed no evidence of binding or fraying'. Paragraphs 3.2.5 and 4.2.8 when read together are not clear. Further clarification is needed. The type of clarification that would assist the reader is listed below and could have been included as an appendix to the TAIC report.

a. A schedule of cable breaks and frays properly named and identified and if not identifiable, tagged as such;

b. Identification of the control cables that were damaged by fire;

c. A description of the type of expertise used to determine whether these frays or breaks were pre-existing as suggested in paragraph 1.12.3 of appendix 1 to chapter 1 of Doc 9756.

2.5.6. TAIC report paragraph 4.2.4. In this paragraph the possibility of the control column being locked during take-off is discussed and considered however the possibility of the control system jamming due to a component failure or Foreign Object Damage (FOD) is not adequately considered.

2.5.7. Interference due to FOD is considered a possibility because control cables and control horns are visible from within the cockpit and it would be possible for items to become entangled with components of the control system. The TAIC report has not evaluated this possible scenario. In criticising the operator for failing to keep the flight manual in the aircraft in reach of the pilot, TAIC has not considered the risk of the flight manual itself becoming dislodged and falling into the control system and causing a control system failure.. One industry source has commented that this type of problem has occurred in the past and referred to the risk of seat belts, pens or in flight oxygen equipment from falling into the exposed control system components and causing a control system malfunction.

2.5.8. Despite several incidents and Airworthiness Directives (AD's) having been issued in recent years with regard to faulty components of the Fletcher flight controls, a fault of this type was not discussed in the analysis section of the TAIC report.

2.5.9. Another possibility that has not been considered in paragraph 4.2.4 of the TAIC report is a failure of some part of the engine control and/or its mounts. Such a failure could contribute to a difficulty in controlling the aircraft..

2.5.10. Paragraph 4.2.15 of the TAIC report attempts to show by reference to statistical calculations that the accident flight was one of the most aft loaded weight configurations that the pilot would have flown. However it does not use calculations or flight testing results to verify that the accident load configuration would have been sufficiently tail-heavy for the aircraft to lose pitch control.

2.5.11. Refer to paragraph 4.2.16 of the TAIC report. This paragraph is unclear. The first sentence assigns the degree of certainty to the centre of gravity of the accident flight being the most aft of all previous eight parachutist flights as 'likely'. However the next sentence assigns a weaker term - 'possible' to a very similar situation. Paragraph 4.2.18 also uses the term 'possibly' to describe the same situation. At best paragraph 4.2.16 is unclear. At worst it lacks consistency.

2.5.12. Refer to Paragraph 4.2.17 of the TAIC report. This paragraph is also unclear. The first sentence states that 'with eight persons in the rear of the aeroplane, there would have been little room to move or slide about during the take-off or climb'. Later in the same paragraph, the TAIC report states that '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 fallen to the rear of the

cabin'. An obvious question is how could the parachutists have fallen to the rear of the cabin if there was little room to move or slide about? These two sentences are not consistent as they stand. At the very least, further clarification is needed.

2.5.13. Refer to 4.2.18 of the TAIC report. This paragraph states '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'. This paragraph attempts to assert a cause of the crash but with weak words such as 'possibly' and 'may'.

2.5.14. Doc 9756 in appendix 1 to chapter 1, paragraphs 3.2.4 and 3.2.5 and also appendix 2 to chapter 1 paragraph 2.2.7., recommends definite statements for use in reporting a cause or at least the words 'probable' or 'likely'. Paragraph 3.2.5 recommends against citing possible causes. Therefore the words 'possible' and 'may' in paragraph 4.2.18 of the TAIC report are too weak to support a causal statement.

2.5.15. Paragraph 4.2.18 of the TAIC report asserts the cause of loss of control due to 'the centre of gravity being well rear of the aft limit' but provides insufficient substantiation. No aeronautical principles, calculations, opinions from other experts such as the aircraft designer or Fletcher test pilot or even anecdotal reports of similar loading scenarios are quoted or discussed in order to support this view.

2.5.16. The same criticism could be said of the next key phrase in paragraph 4.2.18: 'the aeroplane became airborne…. at too low a speed for the pilot to have sufficient elevator control to stop the ensuing pitch-up.' If the aircraft was trimmed correctly – and paragraph 4.2.12 states that was likely, then the aircraft should have had sufficient elevator authority to effect control. The aircraft had a full moving tailplane immersed in propeller slipstream at take-off power and that should have been sufficient to allow the pilot to control it in pitch mode and prevent it from pitching up undesirably. If there was any doubt on that point then calculations and/or flight testing should have been able to address the question.

2.5.17. The next sentence of paragraph 4.2.18 states '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 in the air. This window of opportunity was small and some damage and injury might still have occurred.' Regrettably the TAIC report does not inform the reader of the runway length and facility available to the pilot in the event of an aborted take-off even after the wheels had become airborne.

2.5.18. According to information supplied by the present operator, there would have been approximately 550m available to land the Fletcher at the normal take-off point. Beyond this 550m point was a hedge and farm paddock. The TAIC report advises in paragraph 3.5.6 that the flap setting for take-off was the same as the flap setting for landing and so at the take-off point, a landing configuration had already been set. The accident aircraft had reverse thrust capability and was designed for short field operations. The TAIC report does not quote any

calculations to support its inference that it would have been difficult for the accident aircraft to safely land after becoming airborne.

2.5.19. Without additional substantiation, paragraph 4.2.18 of the TAIC report succumbs to the constructive criticism that ICAO offers in appendix 2 to chapter 1 of Doc 9756 when highlighting the common traps of report drafting. Paragraph 4.2 states some of these traps as:

a. Oversimplification: linking two events as if one caused the other when the relationship is more complex;

b. Asserted conclusion: drawing conclusions from insufficient data;

c. Post hoc fallacy: assuming that because one event follows another, the second event was caused by the first.

Regrettably it is possible to see these traps in effect as the TAIC report attempts to link the aft centre of gravity to the cause of the crash without concrete evidence or more complete substantiation.

2.5.20. Doc 9756 appendix 1 to chapter 1 in section 1.15 that is titled 'Survival Aspects' states in paragraph 1.15.2: 'The location of crew members and passengers in relation to injuries sustained should be stated. The failure of structures such as seats, seat belts and overhead bins should be described. Also, the use and effectiveness of safety equipment should be reported. Aspects pertinent to the crashworthiness of the aircraft should be addressed, as well as occupant survivability in relation to impact forces and fire'. Regrettably the TAIC report has not addressed this aspect of the accident.

Omissions

2.5.21. In addition to the omissions already discussed, the following information has also been omitted from the TAIC report:

2.5.22. The engine mounts and functionality of the engine. The TAIC report includes no assessment of the engine mounts or engine functionality and expresses no consideration to the possibility of an engine control failure or engine structural problem contributing to the loss of pitch control of the aeroplane.

2.5.23. Tests and Research, as mentioned in section 1.16 of appendix 1 of chapter 1, Doc 9756. No calculations, flight tests or computer simulations have been included to confirm or challenge the TAIC report's hypothesis that the crash occurred because the aircraft's centre of gravity was aft of limits.

2.5.24. No information has been included about the pilot's currency. This is normally reported in terms of number of flying hours in the last 90 days, both on and off type. Although this is normally quoted in air accident reports, the pilot's currency has not been questioned in the TAIC report and therefore this may have limited relevance depending on how the investigation will proceed in the future.

2.5.25. The pilot's checklist was reported to have been located amongst the wreckage but the TAIC report includes no mention of this under 'Wreckage Information'. Sometimes checklists can contain interesting and relevant information pertinent to the causal hypothesis. For example the checklist would be relevant if there

was a check requiring the pilot to check for loose items in the cockpit that could fall into the flight controls and cause a control malfunction.

2.5.26. Incidents and Airworthiness Directives (AD's) relating to the aircraft control system. There have been several incidents and AD's relating to failures of the aircraft controls of both Fletcher and Cresco aircraft. The TAIC report has not referred to these or discussed their possible relevance.

2.6. Conclusion and Findings of the TAIC report

Conclusion

2.6.1. The TAIC report has no conclusion and therefore contradicts the appendix to Annex 13. Although this appendix approves the modification of the recommended format to suit the circumstances of the accident, deletion of the conclusion is not considered appropriate to the context of the accident.

2.6.2. The Appendix to Annex 13 states under paragraph 3 Conclusion: 'list the findings, causes and contributing factors established in the investigation. The list of causes should include both the immediate and the deeper systemic causes'.

2.6.3. Annex 13 in its glossary defines 'causes' as 'Actions, omissions, events, conditions, or a combination thereof, which led to the accident or incident. The identification of causes does not imply the assignment of fault or the determination of administrative, civil or criminal liability'.

2.6.4. The appendix to Annex 13 also refers to Doc 9756 which contains several helpful references to 'conclusions,' 'findings' and 'causes'. These references are quoted in part below:

a. Appendix 1 chapter 1, paragraph 2.1, titled 'Analysis'. 'The purpose of the analysis is to provide a logical link between the factual information and the conclusions that provide an answer as to why the accident happened'.

b. Appendix 1 chapter 1, section 3 discusses conclusions. Paragraph 3.1 states 'some States present the causes of the accident separately from the findings under their own heading. Other States indicate in the list of findings which of the findings were causes of the accident, for example by adding after such a finding "(causal factor)" or "(contributory factor)". The TAIC report has done neither.

c. Paragraph 3.2.2 in the same chapter states 'Any condition, act or circumstance that was a causal factor in the accident should be clearly identified. Seen together, the causes should present a picture of all the reasons *why* the accident happened…the causes should be presented in a logical order, bearing in mind that it is essential that all the causes be presented. The causes should be formulated with preventive action in mind and linked to appropriate safety recommendations'.

d. Despite the emphasis on determining causes, paragraph 3.2.5 states that 'when there is insufficient evidence to establish why an accident happened, there should be no hesitation in stating that the causes remain undetermined.'

2.6.5. Clearly ICAO requires that a key objective be the determination of causal factors and strongly suggests that a conclusion is necessary for collating, rationalising and assembling the causal factors in a meaningful narrative. The purpose of the conclusion is to interpret the findings in a holistic manner. Or it should summarise the difficulties of doing so if this has not been possible to do so conclusively.

Findings

2.6.6. Paragraph 5.1 of the TAIC report states that 'there were no technical defects identified that may have contributed to the accident' however because of the wreckage burial so early in the investigation and there is no evidence of specialist engineering input in assessing the wreckage, this part of the finding is in doubt.

2.6.7. The second phrase of paragraph 5.1 states that 'the aeroplane was considered controllable during the take-off roll.' If this was so, then the early take-off stated in the next finding must have been a deliberate action on the part of the pilot however this is not supported, proven or concluded in the analysis. If the early take-off was unintentional, then the pilot must have lost control of the aircraft during the take-off roll and the controllability of the aircraft during the take-off roll must be in doubt.

2.6.8. Paragraph 5.2 of the TAIC report states that 'The most likely reason for the crash was the aeroplane being excessively out of balance' and that this 'created a tendency for the nose to pitch-up'. As stated previously, this lacks evidence, substantiation and is not sufficiently supported in the analysis section. The phrase 'most likely reason for the crash' is a causal statement but it is not identified with the word 'cause' as recommended by ICAO guidelines.

2.6.9. Paragraph 5.2 of the TAIC report also states 'the aeroplane probably became airborne too early'. Paragraph 3.2.4 of appendix 1 to chapter 1 states 'the causes statement is usually a reiteration of statements made at or near the end of the analysis and in the findings. For example, if the analysis and the findings state that a cause related event or circumstance was "probable" then the causes statement should contain the same qualifier (probable)'. Paragraphs 4.2.3 of the TAIC report ascribes 'may' to the prospect of the aircraft becoming airborne early and in paragraph 4.2.18, the TAIC report assigns 'possibly' to the prospect of the aircraft becoming airborne early. Therefore the certainty of paragraph 5.2 regarding the aircraft 'probably' becoming airborne early is not supported by the uncertainty previously ascribed in the analysis where 'may' and 'possibly' are used.

2.6.10. Paragraph 5.2 of the TAIC report goes on to state that the aeroplane became airborne 'at too low an airspeed to prevent uncontrollable pitch-up'. This is referring to the hypothesis that the aeroplane had insufficient airspeed flowing over the tailplane to effect sufficient control in the pitch mode. However as mentioned earlier, there is insufficient evidence and substantiation in the analysis section of the TAIC report to support this finding.

2.6.11. Paragraph 5.3 of the TAIC report states that 'the aeroplane reached a pitch angle that would have made it highly improbable for the unrestrained parachutists to prevent themselves from sliding back towards the tail'. Given that earlier in the analysis section in paragraph 4.2.17 the TAIC report concedes that 'there would have been little room to move or slide about during the take-off and climb', this finding is inadequately supported.

2.6.12. Paragraph 5.6 of the TAIC report states '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'. Given that the TAIC report was unable to determine the modified floor design and it does not address the possibility of interference between the modified floor and the control system, this finding is inadequately supported.

3. Justification and Guidance for a resumed investigation

3.1. General

3.1.1. There are several problems with TAIC's investigation and its report. These are discussed below.

3.1.2. Firstly significant technical evidence submitted at a Coroner's inquest disagrees with one of the key findings of the TAIC report, namely that the rearward loading of the aeroplane 'would have generated severe handling issues for the pilot and was the most significant factor of the accident'.

3.1.3. Secondly, significant wreckage was buried only four days after the accident, before sufficient time could have been given to comprehensively examine it. This is in contravention to a mandatory standard set out in Annex 13 to the Convention on International Civil Aviation.

3.1.4. Thirdly, the TAIC report has breached several recommendations on reporting provided by Annex 13 and one of its referenced documents, Doc 9756.

3.1.5. Fourthly, the results of a passenger loading simulation carried out by the writer on 2 March 2014, disagree with another TAIC finding that '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'. The results of the simulation indicated that only limited movement would have been possible and not highly probable and therefore not deserved of the emphasis ascribed in the TAIC report.

3.1.6. With these issues outstanding, it is difficult to have confidence in the causal findings of the TAIC report and that steps are able to be taken to prevent a similar accident from recurring in the future.

3.1.7. Therefore there is justification to invest in vigilance in order to mitigate the risk of this accident from recurring.

3.1.8. There is also a need for confidence and integrity to return to TAIC's investigation processes so that future air crash investigation and prevention in New Zealand can be performed satisfactorily.

3.1.9. Therefore it is recommended that the investigation be re-opened fully. At first glance it might appear that all evidence available has been scrutinised and it will not be possible to establish new findings, however that is a short-sighted view.

3.1.10. This section outlines opportunities for seeking new evidence and information and recommends processes to be followed in reopening the investigation.

3.2. 'New' Evidence

3.2.1. ICAO requires an investigation to be re-opened if new evidence has become available. Chapter 5 of Annex 13 states in paragraph 5.13: 'If, after the investigation has been closed, new and significant evidence becomes available, the State which conducted the investigation shall reopen it.'

3.2.2. To the public reader of the TAIC report, the technical evidence presented at the Coroner's inquest that puts in doubt the key causal findings of the TAIC report is 'new' information. However much of this may have already been put to the Commission informally. If that is the case, TAIC may not believe that it is compelled by Annex 13 to reopen the investigation.

3.2.3. Although the passenger simulation that was carried out by the writer on 2 March 2014 produced a result that contradicted one of the TAIC findings -paragraph 5.3, it may consider as paragraph 4.2.17 indicates, that it was already aware that there was limited space between parachutists for a payload of eight parachutists. Therefore TAIC could argue that this information is not new and therefore it should not be compelled under Annex 13 to reopen the investigation.

3.2.4. However the problems stated previously in section 3.1 above are considered sufficient on their own to reopen the investigation. It needs to be comprehensively reinvestigated otherwise the accident could recur and additional people could perish.

3.3. Wreckage: Re-examination and Reconstruction

3.3.1. The wreckage needs to be examined comprehensively. This means assembling the wreckage that was exhumed on 1 and 2 March 2014 and reassembling it together with the wreckage that was previously recovered in order to attempt to understand the breakup sequence.. It is hoped that this exercise will also uncover any pre-existing defects and/or damage that occurred as a result of a possible foreign object jam that could have caused a control system failure and also the accident. This exercise will also help to understand aspects that detracted from survivability and which could lead to recommendations for improvements.

3.3.2. Examination and reconstruction of the wreckage should be undertaken with the assistance of a Licensed Aircraft Maintenance Engineer who is rated on and familiar with the FU-24 Walter Fletcher aircraft.

3.3.3. Examination of the wreckage should also be undertaken with the assistance of a metallurgist who is able to advise on the condition of cable breaks, frays and other defects in order to determine whether or not they existed before the accident and therefore whether they were causative.

3.3.4. With respect to the wreckage items that were buried, many of these may have experienced several overload events: the crash event, the burial, the exhumation and possibly also an overload event that could have contributed to loss of control before the crash event. However the difficulties that this may present should not be sufficient reason to avoid this exercise.

3.3.5. Reconstruction will probably require the assistance of carpentry tradesmen in order to construct wood and chicken wire props to support and contain individual wreckage items.

3.4. A review of the Fletcher control system

3.4.1. The Fletcher has been a successful work horse and has served New Zealand's agricultural industry well over several decades. The day-to-day operational circumstances of an agricultural context can impose loads on aircraft components which the designer did not intend or could perceive as inevitable. Moreover the effect of turbulence on fatigue is not always easy to quantify. Over time this could produce loads on aircraft components that could lead to failures.

3.4.2. In recent years, several incidents and Airworthiness Directives (AD's) on both the Fletcher and Cresco control systems have occurred. Control system items on the FU-24 Walter Fletcher which have attracted attention include control columns, push rods, control cables, elevator hinges and attachment fittings and elevator control horn attachment fittings.

3.4.3. If operational loading was sufficient to have generated the kind of incidents and defects in the Fletcher and Cresco control systems that have already been reported, then it may have also been possible for this to have caused a control system failure that contributed to the Fox Glacier crash.

3.4.4. Although not yet proven, a control system failure, similar to some of the incidents that have already occurred and which have produced AD's could result in an accident flight path that would be consistent with eyewitness reports of the Fox Glacier accident flight path.

3.4.5. It is therefore recommended that the Fletcher control system be subject to a comprehensive design and operational review. This is an exercise in vigilance.

3.4.6. This should include a review of the modifications of the three other known Walter Fletcher aircraft that have been modified for parachuting operations.

3.5. Calculations, load simulations and flight tests

3.5.1. An aircraft designer either from the manufacturer or modifier companies or both should be engaged to undertake calculations to determine whether or not the aircraft should have had sufficient control authority in pitch mode to resist an extreme pitch-up action that the witnesses observed. This should be carried out at several points along the accident flight path; early in the take-off roll, at the normal take-off point and also in the early stages of the climb. Calculations should also be assessed for the normal take-off trim and adverse take-off trim positions.

3.5.2. These calculations should be able to quantify the effect of a full moving tailplane in take-off power slipstream. Although the calculations may only be able to provide an approximate result, they may nonetheless be strongly indicative and useful.

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3.5.3. The passenger load simulation that this writer undertook on 2 March 2014, should be repeated with the rigour of a comprehensive investigation. It may be possible to construct a wooden structure to replicate the Fletcher cabin so that the possibility of a load shift at steep angles of attack can be simulated on a tilt platform.

3.5.4. The results of the flight test that Super Air Ltd undertook in August 2012 and later submitted to the Coroner should be reviewed and repeated if necessary.

3.5.5. It may also be possible to undertake Foreign Object 'jamming trials' on a fully operational Walter Fletcher in order to highlight the risk or possibility of a foreign object causing a control system failure.

3.5.6. Inclusion of this information is referred to as 'Tests and Research' in section 1.16, appendix 1 to chapter 1 of Doc 9756 and should be included in the report of a reopened investigation.

3.6. Compliance with ICAO standards and guidelines

3.6.1. Compliance with ICAO standards and recommendations are strongly advised.

3.6.2. Doc 9756, though not mandatory by ICAO, should be followed closely.

3.6.3. If some of the ICAO guidelines and standards are not to be followed, then the report into the reopened investigation should state exactly what ICAO guidelines and standards have not been complied with.

3.7. Draft Review Process

3.7.1. The review of the draft report of the resumed investigation should follow the recommended guidelines and principles set out in Annex 13.

3.7.2. The aircraft designer, the companies and/or individuals involved in the modifications of the aeroplane and the operator should be invited to review the report draft of the resumed investigation. Other technical experts may also be invited. Under the principles set out in Annex 13, the decision to include or append technical comments to the Final Report is at the discretion of these expert contributors, not the TAIC report editor.

3.7.3. Given the public interest in this investigation and the fact that the families of the deceased have a stakeholder interest in a comprehensive outcome, it may be prudent for TAIC to invite an expert to represent the interests of the families of the deceased, during the draft review process.

4. Conclusion

4.1.1. This report has showed several instances where the TAIC report has not followed the standards and guidelines mandated and recommended by ICAO. These are summarized below:

a. Significant wreckage was not given safe custody as required by Annex 13. Instead it was buried four days after the accident.

b. The TAIC report does not have a conclusion and does not clearly identify causes as recommended by Doc 9756 of ICAO.

c. Some of the report findings do not have the same certainty qualifier as the analysis can support (e.g. 'probably' versus 'possibly') as recommended by Doc 9756.

4.1.2. The TAIC report does not rule out the possibility of mechanical damage or interference to the control system and given the early burial of some of the control system items, its investigative processes that were undertaken to explore this possibility are in doubt.

4.1.3. The TAIC report does not clearly set out methodically and comprehensively how each of the accident stages progressed, with reference to technical calculations, flight tests and opinions of other experts. Some of the key outstanding questions that it has been unable to address are:

a. If there was limited room for the occupants to move about on the take-off roll and climb, how is it 'highly probable' that they would have slid towards the tail at steeper climb angles and to an extent that was relevant to the causal hypothesis?

b. The report infers that the aircraft began its climb too early on the take-off roll before sufficient airspeed had been gained to effect pitch control. However it does not reconcile or relate this to the provision of a full moving tailplane in propeller slipstream at take-off power.

4.1.4. The TAIC report attempts to show with reference to statistical calculations that the accident flight was the most aft loaded flight that the pilot had flown. However it does not use calculations or flight testing results to verify that the accident load configuration would have been sufficiently tail heavy for the aircraft to lose pitch control.

4.1.5. Some of the unanswered questions referred to above have been addressed by experts who provided evidence during the Coroner's inquest. Their responses disagree with the causal findings of the TAIC report.

5. Author Credentials

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Andrew McGregor is a Chartered Professional Mechanical Engineer and director of Prosolve Ltd, a company specialising in forensic engineering and air accident investigation. He is also a holder of a New Zealand Commercial Pilot's Licence and an FAA Airline Transport Pilot's Licence with nominally 2500 hrs experience. His engineering experience in New Zealand is derived from three decades of heavy fabrication design and project management in the New Zealand dairy, steel and pulp and paper industries. He trained in air accident investigation at Cranfield University in 2000 and since then has been investigating complex industrial failures and air accidents throughout New Zealand and the Pacific. In 2007 he was Investigator in Charge (IIC) under ICAO of an investigation into a Robinson R44 helicopter which crashed off the coast of Nadi, Fiji. The cause of the crash was metal disbonding of one of the main rotor blades. The results of the investigation led the NTSB to issue five recommendations and the FAA revised its advisory circular AC20 107 from Rev A to B in order to recognize the importance of environmental durability.

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