Report 10-001: Aerospatiale-Alenia ATR 72-212A, ZK-MCP and ZK-MCJ,
severe turbulence encounters, about 50 nautical miles north of Christchurch, 30 December 2009

The Transport Accident Investigation Commission is an independent Crown entity established to determine the circumstances and causes of accidents and incidents with a view to avoiding similar occurrences in the future. Accordingly it is inappropriate that reports should be used to assign fault or blame or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

The Commission may make recommendations to improve transport safety. The cost of implementing any recommendation must always be balanced against its benefits. Such analysis is a matter for the regulator and the industry.

Final Report

Aviation inquiry 10-001
Aerospatiale-Alenia ATR 72-212A, ZK-MCP and ZK-MCJ, severe turbulence encounters, about 50 nautical miles north of Christchurch, 30 December 2009

Approved for publication: December 2010

Transport Accident Investigation Commission

About the Transport Accident Investigation Commission and this report

The Transport Accident Investigation Commission (the 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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Important notes

Nature of the final report

This final report may not be used to pursue 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.

Ownership of report

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.

Submissions

Submissions were received from the operator, Airways Corporation of New Zealand and one of the air traffic controllers, the Civil Aviation Authority and the Meteorological Service of New Zealand Limited. Their submissions were considered during the preparation of the final report.

Figure 1 Aerospatiale-Alenia ATR 72-212A, ZK-MCP
(photograph used with permission)

Source: mapsof.net

Figure 2 Location of incidents

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Abbreviations

AIP	Aeronautical Information Publication New Zealand
Airways	Airways Corporation of New Zealand Limited
ATC	air traffic control
ATR 72	Aerospatiale-Alenia ATR 72-212A
Commission	Transport Accident Investigation Commission
G	the acceleration due to gravity
ICAO	International Civil Aviation Organization
kt	knots
MetService	Meteorological Service of New Zealand Limited
nm	nautical mile(s)
pirep	pilot report
Rules	Civil Aviation Rules
UTC	coordinated universal time

Glossary

bug	a moveable marker fitted to an airspeed indicator to show a reference speed
flight level	height expressed in hundreds of feet above a reference datum
G	the acceleration experienced by an object due to the Earth's gravity at sea level (called one G). The total acceleration (often incorrectly called the total force) on an object can be expressed as a multiple of G
load factor	the ratio of the total acceleration experienced by an object and the acceleration due to gravity
SIGMET	information concerning en-route weather phenomena that might affect the safety of aircraft operations
stick-shaker	a device that vibrates the pilots' control columns to provide a tactile (and usually an aural) warning of an approach to a stall

Data summary

Aircraft registrations:	(i) ZK-MCP and ZK-MCJ
Type and serial number:	Aerospatiale-Alenia ATR 72-212A (i) 630 (ii) 624
Number and type of engines:	2 Pratt & Whitney Canada PW127F turboprops
Year of manufacture:	1999 (both)
Operator:	Mount Cook Airline Limited
Date and time:	30 December 2009 at (i) 1219[1] (ii) 1247
Location:	about 50 nautical miles north of Christchurch latitude: 43° south longitude: 173° east
Type of flight:	scheduled air transport
Persons on board:	crew: (i) 4 (ii) 4 passengers: (i) 65 (ii) 66
Injuries:	nil
Nature of damage:	nil
Pilots' licences:	airline transport pilot's licence (aeroplane)
Pilots' total flying experience:	(i) 6500 hours total, 3500 on type (ii) 18 500 hours total, 9000 on type

[1] Times in this report are New Zealand Daylight Time (UTC + 13 hours) expressed in the 24-hour format.

1. Executive summary

1.1. On 30 December 2009, an Aerospatiale-Alenia ATR 72-212A (ATR 72) aeroplane flying between Christchurch and Wellington encountered severe turbulence when about 50 nm north of Christchurch. Approximately 35 minutes later, another ATR 72 aeroplane, also flying from Christchurch to Wellington, encountered severe turbulence in the same general area.

1.2. Although no injuries or damage resulted from these incidents, the Transport Accident Investigation Commission (the Commission) decided to inquire into the adequacy of the meteorological information available to the pilots before and during the flights, the operator and flight crew action taken to minimise the risks of severe turbulence encounters, and the processes followed by the providers of air traffic and meteorological services in response to pilot reports of significant weather hazards.

1.3. The investigation found that the events might have been avoided or been less severe had the operator had a more robust flight dispatch system, and had the air traffic service complied fully with a requirement to pass flight information to pilots on first contact. The Commission made a safety recommendation regarding the clarity of information about hazardous meteorological conditions.

2. Factual Information

2.1. History of the flights

First event, flight NZ5046

2.1.1. At 1301 on 30 December 2009, an ATR 72 aeroplane registered ZK-MCP departed Christchurch Aerodrome as scheduled flight NZ5046 to Wellington. On board were 2 pilots, 2 flight attendants and 65 passengers. The flight was conducted under instrument flight rules along the standard route that followed the east coast of the South Island.

2.1.2. The crew had requested and been cleared by air traffic control (ATC) to cruise at flight level 170[2], above an area of forecast severe turbulence.[3] The captain had anticipated turbulence for much of the flight, so he had instructed that passengers and flight attendants were to remain seated with their seat belts on. The aeroplane was in cloud for most of the climb, and the pilots had activated icing protection and were using the aeroplane radar to avoid areas of heavy rain.

2.1.3. At 1314, when about 50 nm north of Christchurch, the aeroplane encountered severe turbulence at about flight level 150. Recorded aeroplane data showed the airspeed decreased quickly from about 170 knots (kt) to 144 kt, which was below the minimum speed for flight in icing conditions with flap retracted. The angle of attack increased rapidly, which activated momentarily the stick-shaker and caused the autopilot to disengage. The instantaneous rate of descent briefly exceeded 5500 feet per minute. Loose objects on the flight deck were thrown about, and periods of negative G momentarily activated the engine low-oil- pressure warnings.

2.1.4. The wind vector displayed on the flight instruments changed from a 55 kt westerly to a 140 kt southerly in less than a minute. However, the data recorder showed that during the worst 30 seconds of the event, the wind direction swung through 45 degrees and the wind speed varied erratically between 80 and 27 kt before steadily returning towards the earlier value.

2.1.5. Shortly after the stick-shaker activation, the non-flying pilot lowered the flaps to 15 degrees to provide a greater margin above the stall speed in the prevailing icing conditions. However, the flap selection coincided with a large pitch down of the aeroplane that caused the airspeed to increase rapidly to 205 kt, exceeding the limit speed for the flap setting.

2.1.6. The non-flying pilot broadcast an urgency call, prefaced with the appropriate 'PAN PAN', and said they were in severe turbulence and unable to maintain altitude. The controller, who said he did not hear the transmission clearly, replied, 'Mount Cook 46, say again your request'. The pilot repeated the information, but without the PAN prefix this time, and said they would have to manoeuvre 'as required'. The controller replied 'Roger' only.

2.1.7. As the turbulence eased, the pilots continued the climb, although there was a brief, marked reduction in climb performance, possibly due to mountain waves in the lee of the coastal ranges. The pilots then advised that the aeroplane was under control and they were continuing to Wellington. The controller acknowledged with 'Roger'. The pilots offered more information on the conditions and that they had been unable to maintain altitude, to which the controller again replied 'Roger'.

2.1.8. No-one was injured during the turbulence, the worst of which lasted for a little over one minute.

2.1.9. The controller later said there had been a number of pilot reports (pireps) that day of severe turbulence across the South Island and many aircraft had been unable to maintain their assigned altitudes or tracks. Those pireps had been passed to MetService by the relevant controllers using direct telephone lines at their stations. He said he had earlier passed to MetService a report of moderate-to-severe turbulence at flight level 220 that had been sent by an ATR 72 south-bound to Christchurch, and he had thought it unnecessary to pass on the report from NZ5046.

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[2] Flight levels are heights in hundreds of feet above a reference datum. Flight level 160 is 16 000 feet above the datum.

[3] The perceived severity of turbulence is a function of aircraft type and its mass, altitude, configuration and airspeed. The International Civil Aviation Organization (ICAO) classification is given in Appendix A.

2.1.10. At 1319, NZ5046 requested a higher flight level, which was approved by a different controller who had taken over the position in a routine changeover. The replacement controller subsequently cleared NZ5046 to deviate east of track as required.

2.1.11. At 1329, the replacement controller broadcast revised SIGMET reports, including SIGMET 4, which amended an earlier warning of severe turbulence between flight levels 160 and 240, southeast of a line from Kaikoura to Mount Cook. That region included the point where NZ5046 had struck turbulence, but the SIGMET was based on a pirep made 2 hours earlier at a point 84 nm southwest of Christchurch.

2.1.12. At 1340, MetService logged the NZ5046 encounter. The time of the event was not recorded, and the altitude was erroneously given as flight level 170, the aeroplane's initial cruise level.

2.1.13. At Wellington, the captain reported that severe turbulence had been encountered and the flap limit speed exceeded. The data recorder showed that the vertical acceleration range had been from +2.12 G to –0.59 G. The required maintenance inspections found no damage or defects.

Second event, flight NZ5034

2.1.14. On the same day at 1334, another ATR 72, registered ZK-MCJ, departed Christchurch Aerodrome as scheduled flight NZ5034, also bound for Wellington along the same route and at flight level 170. On board were 2 pilots, 2 flight attendants and 66 passengers. The pilots had been told by the operator's flight dispatcher of the earlier flight's encounter with turbulence, so the flight attendants were instructed to remain seated for the flight. The aeroplane weather radar was in use. The same (replacement) controller advised NZ5034 that an unidentified preceding aircraft (almost certainly NZ5046) had encountered severe turbulence and that altitude or track deviations were available if needed.

2.1.15. NZ5034 had already deviated east of the planned route when the pilots requested more direct tracking towards Wellington, which would have taken the flight further east. However, a Boeing 737 descending on the Wellington-to-Christchurch route prevented ATC from approving the request immediately. NZ5034 then requested to climb from flight level 170 to flight level 190 to get above moderate turbulence.

2.1.16. At 1350, ATC approved the higher level and in the same transmission gave NZ5034 its arrival clearance for Wellington. The crew's read-back of the clearance was interrupted when they encountered severe turbulence while in cloud, about 51 nm north of Christchurch.

2.1.17. The aeroplane's data recorder showed that, coincident with a wind shift through 55 degrees and 34 kt over 20 seconds, the aeroplane pitched up then sharply down, giving a vertical acceleration change of 2.5 G in less than 1.5 seconds. The stick-shaker activated momentarily and the engine low-oil pressure warning for one of the engines also illuminated briefly.

2.1.18. A minute later, ATC asked NZ5034 to read back the arrival clearance, and was told 'Standby'. ATC then asked the Boeing 737 to report its flight conditions and was told that there was 'moderate-to-severe turbulence at times'. The controller then advised controllers of the adjacent ATC sectors that he was applying increased vertical separation between flights. The crew of NZ5034 did not broadcast an urgency message advising of the severe turbulence.

2.1.19. After landing at Wellington, the captain reported the severe turbulence event, which he also described as extreme and the worst he had experienced in 40 years of flying. The data recorder showed that the vertical acceleration range had been from +1.84 G to –0.73 G. The required maintenance inspections found no damage or defects.

2.1.20. No-one was injured on NZ5034, although one of the flight attendants later reported minor neck discomfort that might have been related to the event.

2.2. Personnel information

2.2.1. Both pilots of NZ5046 had captain rank, but NZ5034 had a normal crew composition of captain and first officer. All had extensive airline experience in New Zealand and in flying ATR 72s.

2.2.2. The ATC controllers were employed by Airways. The controller of NZ5046 when the aeroplane struck the severe turbulence had been issued with a New Zealand air traffic controller licence on 8 April 2009, but he had had 10 years' prior experience as a controller overseas. He held the appropriate controller ratings and a valid medical certificate. His previous annual proficiency assessment had been completed on 19 October 2009. On 30 December 2009 he commenced duty at 0830 and was scheduled to finish at 1600. He had worked from 1330 until 2030 the previous day, with 2 days off duty before that.

2.3. Aircraft information

2.3.1. The ATR 72 was a high-wing aeroplane powered by 2 turboprop engines and various versions had been in service with the operator since 1994. The operator's configuration seated 66 passengers, in addition to the 2 pilots and 2 flight attendants.

2.3.2. The aeroplane load factor limits were +2.5 G to -1.0 G with the flaps retracted, and +2 G to 0 G with any flap extended.

2.3.3. The operator's standard procedure was to 'bug' the minimum enroute airspeed for the flaps-up configuration in icing conditions. The bug gave pilots an immediate visual cue for the minimum speed, which varied directly with the aeroplane weight.

2.3.4. The ATR 72 was fitted with a Honeywell Primus® 660 weather radar, which, like other modern weather radars, was designed primarily to detect water droplets rather than turbulence. The display was colour-coded according to the rain intensity. The handbook noted there was a '100% probability of light turbulence occurring in any area of light rain' and that the probability of any severity of turbulence increased as the rain intensity increased (Honeywell, 1999).

2.4. Meteorological information

2.4.1. According to Civil Aviation Rules (Rules), the pilot-in-command was responsible for obtaining and becoming familiar with the current meteorological information relevant to the proposed flight, and the operator was responsible for ensuring that the appropriate information (which would include known potentially hazardous meteorological conditions) was made available to the pilot-in-command to prepare for that flight.[4] The operator was required to use meteorological information that had been provided for aviation purposes by an aviation meteorological service organisation certificated under Rules Part 174.[5]

2.4.2. The primary meteorological service organisation in New Zealand was MetService, which was certificated by the Civil Aviation Authority to provide forecasts, disseminate meteorological information, provide briefings and routine reports, and provide a meteorological watch service 'over meteorological conditions affecting aircraft operations' (Airways, 2010a, p.GEN 3.5-2, effective 19 November 2009).

2.4.3. An analysis provided by MetService showed that at midday on 30 December 2009, an anticyclone was centred east of Tasmania and a deep trough of low pressure lay east of New Zealand. At sea level, a strong southwest air flow covered the South Island and a cold front was situated north of Christchurch. The trough was present through a deep layer, which included the planned cruise levels of these flights, with the maximum wind speeds present over a broad swath from Fiordland to Canterbury.

2.4.4. The operator had a contract with MetService for the provision of web-based flight briefings that were updated 3 times an hour. The briefing accessed by the pilots of the first flight had been issued at 1136 and warned of occasional moderate turbulence below flight level 160 south of a line from Nelson to Woodbourne (Blenheim), and severe turbulence as follows:

> SIGMET 24, issued 0844, valid between 0844 and 1244, severe turbulence forecast below flight level 140 about the ranges south of Nelson to Woodbourne. Intensity no change.

[4] Rules 91.217, Pre-flight action, and 121.59, Flight preparation.
[5] Rule 121.153, Meteorological information.

2.4.5. The briefing also warned of occasional moderate turbulence at the relevant time between flight levels 160 and 260 south of a line from Westport to Kaikoura, and noted that a SIGMET for severe turbulence was possible. Isolated embedded cumulonimbus ('thunderstorm') clouds were forecast adjacent to the planned routes of the flight. No significant icing was forecast.

2.4.6. At 1144, as a result of a pirep made at 1130 by an aeroplane then 84 nm southwest of Christchurch, the anticipated SIGMET was issued. This read, in part:

> SIGMET 28, valid between 1144 and 1544, New Zealand Flight Information Region, forecast severe turbulence between flight levels 160 and 240 southeast [of a line from] Kaikoura to Mount Cook. Moving northeast at 30 kt. Intensity no change.

2.4.7. The area described in SIGMET 28 included the locations of the 2 ATR incidents.

2.4.8. MetService issued a revised flight briefing to the operator at 1201. The included route forecast was essentially the same as that in the 1136 briefing, but SIGMET 24 was replaced by SIGMET 27, which raised the top of the lower band of severe turbulence to flight level 160.

2.4.9. At 1205, SIGMET 31 was issued, extending the region of forecast lower-atmosphere severe turbulence to the North Island. SIGMET 31 read, in part:

> SIGMET 31, valid between 1205 and 1605, forecast severe turbulence below flight level 160 about the ranges north of Nelson-Woodbourne, south of Taupo. Intensity no change.

2.4.10. Ten minutes prior to the estimated departure time of a flight, one of the operator's dispatchers would send the latest weather package and related flight information to a personal digital assistant-type device in the aeroplane. This procedure could provide crews with relevant flight information received since they had prepared for their flights. The devices were used by crews to access the information only when the aeroplanes were parked.

2.4.11. Whether the pilots of either flight had read SIGMET 28 and 31 was not determined. The pilots did not recall precisely which SIGMETs they had read, and the time that web-based weather briefings were accessed, and by whom, was not recorded by the operator. The operator could not confirm that the latest weather packages had been sent prior to departure to the devices on NZ5046 and NZ5034, and did not ordinarily require crews to retain printed briefing papers.

2.4.12. The operator later advised that it was exploring ways to improve the content and delivery of flight information to crews before departure.

2.4.13. At 1327, which was after NZ5046 had already encountered turbulence and when NZ5034 was about to depart, MetService re-issued SIGMET 28 as SIGMET 4[6] and issued SIGMET 5, which in effect combined SIGMETs 27 and 31. SIGMET 5 read, in part:

> SIGMET 5, valid between 1327 and 1727, New Zealand Flight Information Region, forecast severe turbulence below flight level 160 about the ranges south of Taupo. Intensity no change.

2.4.14. The forecast wind for the route was south-westerly, increasing from 70 kt to 90 kt between flight levels 150 and 190. The wind recorded on the aeroplane data recorders was, for the first flight, similar to that forecast, but was generally at a lower speed for the second flight.

2.4.15. If SIGMETs were to be adequate, accurate and timely, MetService needed real-time information such as pireps. The Aeronautical Information Publication New Zealand (AIP) required pilots to make pireps immediately when:

> hazardous meteorological conditions are encountered or observed which, in the opinion of the pilot are, or may become severe enough to warrant a SIGMET, regardless of any reports from other aircraft and regardless of any SIGMET issued (Airways, 2010a, p.GEN 3.5-25, effective 5 June 2008).

[6] SIGMETs were sequentially numbered from the start of the UTC day.

2.4.16. Airways was certificated to disseminate meteorological information and to supply routine meteorological reports. The AIP listed SIGMETs, but not pireps, among the information that ATC would advise to affected aircraft within their areas of responsibility (Airways, 2010a, p.GEN 3.5), but Airways' did require controllers to pass pireps to (Airways, 2010b, p.MET 2):

- other aircraft likely to be affected
- other [air traffic service] units whose area of responsibility is adjacent to the reported conditions, and
- MetService.

2.4.17. The ICAO standard for ATC to forward pireps to the meteorological watch office was 'without delay' (ICAO, 2007b, paragraph 5.8). Airways expected controllers to forward pireps to MetService 'as soon as practicable', but Airways later informed the Commission that its standard would be aligned with that of ICAO.

2.4.18. On 30 December 2009, MetService logged the receipt of 14 pireps, including 9 for severe turbulence. Of those, 5 were made between 1215 and 1445 and related to encounters west and north of Christchurch. All but one of those reports were passed to MetService by ATC staff. The pirep made by NZ5046 at 1314 was not logged by MetService until 1340.

2.4.19. MetService said that the preparation of SIGMETs was the highest priority of the aviation forecasting desk. Therefore, the receipt of information that suggested the criteria for the issue of a SIGMET had been met was also given top priority. If a pirep were consistent with a current SIGMET, the report would be considered to validate the SIGMET and no further action would be taken. If there were no relevant SIGMET or the pirep indicated that a SIGMET required amendment, a new issue or amendment would be completed as soon as practicable. The sequence of SIGMETs issued and pireps received by MetService on 30 December 2009 is shown in Appendix B.

2.4.20. The MetService criteria for the amendment of a forecast of turbulence (or icing) were:

> Newly expected occurrence; error in expected position of phenomena; intensity increasing; intensity decreasing from severe to light or nil, or from moderate to nil (Airways, 2010a, p.GEN 3.5-44, effective 9 April 2009).

2.5. Air traffic services

2.5.1. Air traffic services included ATC, flight information services and an alerting service. The separation and control of aircraft were the first priority for controllers, but they were also tasked with providing flight information services. Any relevant information that could affect the safe and efficient conduct of flights was to be passed 'as soon as practicable' to flights known to be affected by the information. That information included SIGMETs and 'significant information received from other flights' (Airways, 2010b, p.RAC 10-1, effective 12 April 2007).

2.5.2. An air traffic service provider was required by the Rules to have procedures that ensured that available and relevant flight information, such as SIGMETs, was provided to aircraft that were provided with an ATC service.[7]

2.5.3. The AIP (Airways, 2010a) stated, in part (p.GEN 3.3-7, effective 30 July 2009):

> On first contact with [air traffic services], the pilot of an IFR aircraft commencing a flight for which a flight plan has been filed will be provided with flight information … received within the 90 minutes preceding the activation of the plan.

2.5.4. A flight plan was activated when an aircraft took off. In practice, the time between a crew briefing for a flight and their making first contact with ATC, usually to request permission from aerodrome control to start engines or to taxi for take-off, was less than an hour. Airways advised that meteorological and other flight information was retained for 90 minutes after being received and the information was not necessarily offered to all aircraft when they first contacted ATC. The Commission was unable to determine whether the involved ATR crews had been

[7] Rule 172.93, *Flight information service*.

offered the latest SIGMET by ATC before start-up, but other updates were broadcast by ATC on the area control frequency, as noted in paragraph 2.1.11.

2.5.5. Airways later informed the Commission that it was reviewing its procedures to ensure the 90-minute requirement was met.

2.5.6. The ATC radars in New Zealand did not display weather and radar controllers relied on MetService information and pireps to form pictures of the locations of adverse weather.

2.5.7. An alerting service was provided by Airways to initiate and/or assist in search and rescue action for any flight known or thought to require assistance. The 3 alerting service phases were (Airways, 2010b, p.RAC 7-4, effective 17 March 2005):

> **Uncertainty**: when uncertainty exists as to the safety of an aircraft and its occupants
> **Alert**: when apprehension exists as to the safety of an aircraft and its occupants, and
> **Distress**: when there is a reasonable certainty that an aircraft and its occupants are threatened by grave and imminent danger and require immediate assistance.

2.5.8. Airways' procedures (Airways, 2010b) required that 'except when no doubt exists for the safety of an aircraft and its occupants, an uncertainty phase shall be declared when … [it is] experiencing hazardous meteorological conditions', and that 'an alert phase shall be declared when … [it] is known or believed to be experiencing impaired operating efficiency to the extent that it is having difficulty in maintaining height' (p.RAC 7-6, effective 17 March 2005).

2.5.9. The AIP (Airways, 2010a) defined urgency as 'a condition concerning the safety of an aircraft, or of some person on board or within sight, but which does not require immediate assistance. The pilot of an aircraft reporting an urgency condition must transmit on the air-ground frequency in use at the time the urgency signal PAN PAN, preferably spoken three times, followed by the urgency message' (p.ENR 1.15-2, effective 25 November 2004).

2.5.10. All communications between the incident flights and ATC were conducted on very high-frequency radio that was unaffected by the weather conditions at the time. Airways staff considered that the traffic density during these occurrences was light.

2.6. Additional information

2.6.1. The operator had no direct guidance in its manuals on the planning or conduct of flights in areas where moderate or severe turbulence was observed or forecast. Final selection of a route and altitude, and the precautions taken enroute, were the prerogative of the pilot-in-command. Most airlines recommended avoiding flight through known or forecast severe turbulence, and larger airlines with specialist flight planning sections might pre-select routes to avoid forecast turbulence (and the potential unplanned diversions) because fuel and load planning were critical.

2.6.2. The reports on the CAA's audits of the operator's Enroute Operations and Management and General Operations from 2005 until 2010 were reviewed. No findings or observations relevant to these events were found.

2.6.3. A review of the CAA occurrence database found that about 50 notifications of turbulence, other than wake turbulence, were made between November 2005 and November 2010. Half of the reports described the encounter as severe, but only 2 reports said a PAN call had been made and only one report referred to a SIGMET. The text of the notifications generally did not provide sufficient information to assess the role of forecasts and flight planning in the occurrences.

2.6.4. The operator's recurrent training programme for 2010 specified that each pilot would be trained in stall identification and recovery in icing and non-icing conditions, and in the identification of and recovery from unusual attitudes in icing conditions during their 6-monthly simulator check (Mount Cook, 2009). Each pilot performed 2 or 3 recoveries in these sessions.

2.6.5. Some of the involved pilots said that the unusual attitudes in the simulator scenarios were surprisingly similar to those experienced during the severe turbulence.

3. Analysis

3.1. Two ATR 72 aeroplanes from the same operator encountered turbulence 35 minutes apart, in about the same location but at altitudes separated by 2000 feet. The flight loads recorded on the flight data recorders and the difficulty that the pilots had briefly in controlling the aeroplanes indicated that the turbulence was severe. The focus of this inquiry was on the effectiveness of the system for the reporting and updating of severe weather information that could affect aircraft operations.

3.2. The operator had made current weather information available to both crews to enable them to plan their flights. However, which weather briefings were used could not be confirmed, and it was possible that neither crew was aware of SIGMETs 28 and 31, which directly affected the planned routes and levels of their flights. Both crews had expected moderate turbulence to be present along the route, and had therefore chosen to cruise at flight level 170, above the turbulent level forecast in SIGMET 24. That SIGMET was to expire before NZ5046 departed Christchurch, but the weather situation and the term 'intensity no change' would have alerted the pilots to the likelihood that the SIGMET would be re-issued.

3.3. There were 3 ways in which a flight crew could receive SIGMETs before departure. The first was from the operator's flight briefing package (usually accessed less than an hour before departure); the second was from the personal digital assistant device on the aeroplane 10 minutes before departure (provided the dispatcher had sent the information); and the third was by the first air traffic controller offering them information that had been received by ATC in the preceding 90 minutes.

3.4. Limitations in the operator's dispatch system for updating flight information might have been a cause of the crews not receiving updated weather information, including SIGMET 28, after they had completed briefing. Although the information was automatically collated, a flight dispatcher had to send it manually. However, the crew of NZ5034 did know that the preceding NZ5046 had encountered severe turbulence.

3.5. The Rules indicated that the responsibility for ensuring that crews had the latest weather information was shared by the operator and the pilot-in-command, and ATC where an ATC service was provided. The Airways procedure for providing this information when a pilot made first contact was a useful defence against 'last minute' changes that might affect a flight, and therefore the procedure warranted strict compliance.

3.6. Had the crews been aware of SIGMET 28, even as late as when they were about to taxi for departure, they might have been prompted to revise their flight plans and might have avoided or reduced the severity of the turbulence encounters.

3.7. The intended actions of the operator and Airways to improve their respective systems for passing information to flight crews should ensure that in future crews receive the most current flight information, including weather warnings, before departure.

3.8. The complete avoidance of flight into an area of forecast severe turbulence was not always practical, because the forecast strength and location of the hazard were sometimes inaccurate. Hence, pireps were essential to allow MetService and similar agencies to advise of observed areas of turbulence and to improve their forecasts.

3.9. Experience, such as that which the involved pilots had gained from years of flying over the South Island, gave pilots an appropriate level of respect for weather hazards and guided them in route and flight level selection to minimise their risks. For the flights involved, an additional route was available further east of the coast, but it was not requested by either crew. At the time they were flight planning, the eastern route might have looked less likely to be affected by turbulence, although pireps from south-bound aeroplanes showed it had been similarly affected.

3.10. The report of loose objects on one flight deck suggested pilots should take more care to secure items under their control, just as they expect the cabin and its occupants to be secured.

3.11. The use of minimum speed bugs on the airspeed indicator was effective in providing the pilots with an immediate cue to the degraded performance and, in the case of NZ5046, to the need to extend flap promptly. In spite of the subsequent unavoidable exceedance of the flap limit speed, extending the flap likely prevented a more extreme upset.

3.12. The suggestions by some of the pilots that the aeroplanes' behaviour during the turbulence was very similar to that experienced in earlier simulator training proved the value of such training. The pilots' prior experience likely assisted them to recognise and promptly recover from the upsets without incurring injury or damage.

3.13. The first controller did not hear the PAN call from NZ5046, and as PAN was not used when the crew repeated their message, he did not recognise that their situation was one of urgency. The crew advised that they were unable to maintain altitude, but the controller did not clear the flight to deviate from altitude as required, which would have been the expected response, especially as he had been aware that other aeroplanes had had a similar need during his shift. Rather than show he understood the situation, the controller acknowledged the calls from NZ5046 with 'Roger', a term that only means 'I have received all of your last transmission'.

3.14. The passive controlling contrasted with that of the replacement controller who offered NZ5034 some flexibility of route and altitude, and later advised controllers of adjacent sectors that he was increasing the minimum vertical separation between aeroplanes that could be subjected to altitude excursions.

3.15. Airways required all pireps to be passed to MetService, but the first controller said he decided not to pass on the pirep from NZ5046 because he had earlier passed on one from an ATR. The pirep from NZ5046 was also received at a time when the controller was likely briefing the incoming controller. The decision to not pass it on did not appear to have affected the timeliness or accuracy of later SIGMETs.

3.16. Airways also required controllers to pass pireps to other aircraft that could be affected, presumably because one could not rely on potentially affected pilots overhearing the initial transmissions of pireps. However, pireps were not in the AIP list of information that ATC would pass to aircraft. If the AIP page GEN 3.5 were amended to include pireps in the list of in-flight services, pilots might better appreciate the mutual benefit of making reports whenever a severe meteorological phenomenon was encountered.

3.17. Comparison of the MetService pirep log with the issued SIGMETs showed that MetService had conformed to its stated criteria for the issue and timeliness of SIGMETs.

3.18. The meteorological situation generated turbulence over a wide area of the country, and pireps confirmed the general accuracy of the forecasts. MetService used the pireps to refine the series of SIGMETs issued for limited regions and altitude bands, until a point was reached in the early afternoon where some regions could be combined and the number of SIGMETs reduced. Hence, SIGMETs 27 and 31 were combined into SIGMET 5.

3.19. It was important that pilots and flight dispatchers interpreted SIGMETs correctly, because the abbreviated text, although standardised, could be misleading. For example, in SIGMET 5 it was clear that 'south of Taupo aerodrome' included the southern half of the North Island, particularly with the attached reference to observed severe turbulence near Napier. However, the SIGMET applied to all of the New Zealand Flight Information Region and therefore included all of the South Island. The correct interpretation was not obvious unless one analysed the sequence of issues and amendments.

3.20. Greater use of plain language, within the constraints of international conventions, would assist in making SIGMETs easier to read. The Commission made a recommendation to the Director of Civil Aviation that he address the safety issue whereby SIGMETs can be misleading or lack clarity because of insufficient reference to recognisable geographic regions.

4. Findings

Findings are listed in order of development and not in order of priority.

4.1. An accurate pre-flight weather briefing package was provided by MetService and the pilots of both flights made appropriate initial selections of route and flight level based on the briefings that they likely used. However, whether the pilots were aware of the later issue of SIGMET 28, which directly affected their planned flights, was not known.

4.2. Had the pilots been aware of SIGMET 28 before departing, they might have revised their flight plans and the turbulence encounters might have been avoided, or less severe.

4.3. The severe turbulence encounters did not result in any injury because the pilots had anticipated moderate turbulence and had instructed their passengers and cabin crew to remain seated.

4.4. The dislodging of items in the flight deck of one aeroplane was a reminder to pilots to prepare their flight decks in the same way that they instructed the cabin to be prepared for turbulence.

4.5. The value of the operator's unusual-attitudes training was proven by the pilots' prompt recognition and recovery from the upsets, which also avoided aeroplane damage.

4.6. Although the controller of Flight NZ5046 did not recognise that the flight was in a state of urgency, because he did not hear the pilot call 'PAN', the controller's brief response to the subsequent information that the crew was having difficulty maintaining altitude did little to assist them to manage the severe turbulence event.

4.7. The severe turbulence encounters were reported by pilots, as required, to ATC without delay, and post-flight to the operator's maintenance staff.

4.8. The delay in ATC passing the pirep from NZ5046 to MetService had no bearing on the subsequent encounter by NZ5034, but suggested the procedure within ATC could be improved.

4.9. MetService conformed to its stated criteria for the issue and timeliness of SIGMETs.

4.10. The interpretation of SIGMETs could be improved by clearer reference to recognisable geographic regions.

5. Recommendations

General

5.1. The Commission may issue, or give notice of, recommendations to any person or organisation that it considers the most appropriate to address the identified safety issues, depending on whether these safety issues are applicable to a single operator only or to the wider transport sector. In this case, a recommendation has been issued to the Director of Civil Aviation.

5.2. In the interests of transport safety, it is important that recommendations are implemented without delay to help prevent similar accidents or incidents occurring in the future.

Recommendation

5.3. On 31 August 2010, the Commission made a preliminary recommendation that the Director of Civil Aviation address the following safety issue:

> The interpretation of SIGMETs could be improved by the use of clearer reference to geographical regions, although the requirement to conform to ICAO Standards and Recommended Procedures is appreciated (045/10).

On 10 September 2010, the Director of Civil Aviation replied, in part:

> The Authority accepts in principle the proposed safety recommendation.

6. References

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Appendix A: Turbulence Reporting Criteria Table

Light	Conditions less than moderate turbulence. Changes in accelerometer readings less than 0.5 G at the aircraft's centre of gravity.
Moderate	Conditions in which moderate changes in aircraft attitude and/or altitude may occur but the aircraft remains in positive control at all times. Usually, small variations in airspeed. Changes in accelerometer readings of 0.5 G to 1.0 G at the aircraft's centre of gravity. Difficulty in walking. Occupants feel strain against seat belts. Loose objects move about.
Severe	Conditions in which abrupt changes in aircraft attitude and/or altitude occur; aircraft may be out of control for short periods. Usually, large variations in airspeed. Changes in accelerometer readings greater than 1.0 G at the aircraft's centre of gravity. Occupants are forced violently against seat belts. Loose objects are tossed about.

Source: ICAO, 2007b, appendix 1, p.A1-4.

Appendix B: SIGMET issued and PIREP received by MetService, 30 December 2009

WSNZ21 NZKL 291615 NZZC SIGMET 19 VALID 291615/292015 NZKLNZZC NEW ZEALAND FIR SEV TURB FCST BLW FL100 ABT/E OF RANGES N OF NZWS/NZWB S OF NZNP/NZNR NC	WSNZ21 NZKL 291616 NZZC SIGMET 20 VALID 291616/292016 NZKLNZZC NEW ZEALAND FIR SEV TURB FCST BLW FL120 ABOUT/E OF RANGES S OF NZNS/NZWB NC		
WSNZ21 NZKL 291941 NZZC SIGMET 23 VALID 291941/292341 NZKLNZZC NEW ZEALAND FIR SEV TURB FCST BLW FL100 ABT/E OF RANGES N OF NZNS/NZWB S OF NZAP NC	WSNZ21 NZKL 291944 NZZC SIGMET 24 VALID 291944/292344 NZKLNZZC NEW ZEALAND FIR SEV TURB FCST BLW FL140 ABT RANGES S OF NZNS/NZWB NC		Two PIREPs at 1035 and 1054 NZDT (2135 and 2154 UTC) of wind shear and mod. turb. 30-40 nm north of NZCH
WSNZ21 NZKL 292247 NZZC SIGMET 29 VALID 292247/300247 NZKLNZZC NEW ZEALAND FIR SEV TURB FCST BLW FL100 ABT/E OF RANGES N OF NZNS/NZWB S OF NZAP NC	NZZC SIGMET 27 VALID 292239/300239 NZKLNZZC NEW ZEALAND FIR SEV TURB FCST BLW FL160 ABT RANGES S OF NZNS/NZWB NC	WSNZ21 NZKL 292244 NZZC SIGMET 28 VALID 292244/300244 NZKLNZZC NEW ZEALAND FIR SEV TURB OBS AT 2230Z 84NM SW OF NZCH BTN FL180/200 FCST SEV TURB FL160/240 SE OF NZKI/NZMC/NZMO MOV NE 30KT NC	PIREP at 1133 NZDT (2233 UTC) about sev. turb. 84nm SW of NZCH mentioned in SIGMET 28
WSNZ21 NZKL 292305 NZZC SIGMET 31 VALID 292305/300305 NZKLNZZC NEW ZEALAND FIR SEV TURB OBS AT 2300Z 25NM SW OF NZNR AT FL160 FCST SEV TURB BLW FL160 ABT RANGES N OF NZNS/NZWB S OF NZAP NC			PIREP at 1202 NZDT (2302 UTC) about sev. downdrafts 25nm SW of NZNR mentioned in SIGMET 31. PIREP at 1215 NZDT (2315 UTC) of sev. turb. 40-50nm W of NZCH corroborates SIGMET 28
WSNZ21 NZKL 300027 NZZC SIGMET 5 VALID 300027/300427 NZKLNZZC NEW ZEALAND FIR SEV TURB OBS AT 2300Z 25NM SW OF NZNR AT FL160 FCST SEV TURB BLW FL160 ABT RANGES S OF NZAP NC		WSNZ21 NZKL 300027 NZZC SIGMET 4 VALID 300027/300427 NZKLNZZC NEW ZEALAND FIR SEV TURB OBS AT 2230Z 84NM SW OF NZCH BTN FL180/200 FCST SEV TURB FL160/240 SE OF NZKI/NZMC/NZMO MOV NE 30KT NC	PIREP at 1340 NZDT (0040 UTC) of sev. turb. 50nm N of NZCH corroborates SIGMET 4. PIREPs at 1425, 1447 NZDT (0125, 0147 UTC) of sev. turb. NZCH / Kaikoura corroborates SIGMET 4. PIREP at 1448 NZDT (0148 UTC) of mod. turb. near NZCH. PIREP at 1633 NZDT (0333 UTC) of mod. to sev. turb. near NZWB and NZWN.
WSNZ21 NZKL 300420 NZZC SIGMET 9 VALID	WSNZ21 NZKL 300422 NZZC SIGMET 10 VALID	WSNZ21 NZKL 300413 NZZC SIGMET 8 VALID	PIREPs at 1831 and 1835 NZDT (0531

300420/300820 NZKLNZZC NEW ZEALAND FIR FCST SEV TURB BLW FL160 ABT/E RANGES S OF NZNP/NZGS NC	300422/300822 NZKLNZZC NEW ZEALAND FIR SEV TURB FCST BLW 8000FT ABOUT/E RANGES NZNP/NZGS TO NZAA NC	300413/300813 NZKLNZZC NEW ZEALAND FIR FCST SEV TURB FL160/220 ABOUT/E SOUTH ISLAND RANGES N OF NZWF MOV NE 20KT NC	and 0535 UTC) corroborates SIGMET 8.

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07-006	Hawker Beechcraft Corporation 1900D, ZK-EAK, landing gear malfunction and subsequent wheels-up landing, Woodbourne Aerodrome, Blenheim, 18 June 2007
07-010	Fletcher FU24-950, ZK-DZG, in-flight vertical fin failure, loss of control and ground impact, 5 kilometres west of Whangarei (Pukenui Forest), 22 November 2005
07-011	Cessna A152 Aerobat, ZK-KID, impact with terrain, Te Urewera National Park, 23 kilometres south-east of Murupara, 26 October 2007
07-012	Fletcher FU24-950EX, ZK-EGV, collision with terrainnear Opotiki, 10 November 2007

Price $24.00

ISSN 1179-9080 (Print)
ISSN 1179-9099 (Online)