Australian Government

Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY INVESTIGATION REPORT

Aviation Safety Occurrence Report – 200506266

Final

In-flight breakup
28 km north of Condobolin, NSW
2 December 2005
VH-PYN
Piper Aircraft Corporation PA-31-350

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CONTENTS

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Abstract

At 1122 Eastern Daylight-saving Time on 2 December 2005, a Piper Aircraft Corporation PA-31-350 Chieftain aircraft, registered VH-PYN, departed Archerfield, Qld, on a private flight to Griffith, NSW. On board were the pilot, an observer-pilot, and two passengers. The enroute weather was forecast to include occasional thunderstorms. At 1127, a SIGMET was issued advising of frequent observed thunderstorms south of Coonamble, NSW. Air traffic services did not pass the SIGMET information to the pilot of the aircraft, nor did their procedures require the information to be passed. There was no request from the pilot for weather information at any stage during the flight.

After the aircraft passed Coonamble, the pilot reported diverting left of track due to weather. The aircraft then came within air traffic control radar coverage, which showed it flying parallel to track at 10,000 ft, at a groundspeed of 200 to 220 kts. At 1350, the aircraft disappeared from radar and no further radio transmission was received from the pilot. At about 1400, the wreckage of PYN was found approximately 28 km north of Condobolin.

The wreckage trail extended for more than 4 km. The wings, outboard of the engine nacelles, the right engine, and sections of the empennage, had separated from the aircraft in flight. The remaining structure impacted the ground inverted and was destroyed by a post-impact fire. No evidence was found that aerodynamic flutter, in-flight fire or explosion, or lightning strike damage contributed to the circumstances that led to the break-up. However, the extent and nature of the damage precluded a complete examination of the aircraft and its systems.

There was evidence that immediately before the accident, the aircraft was likely to have been surrounded to the east, west, and south by a large complex of storms. The aircraft was not fitted with weather radar.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an operationally independent multi-modal Bureau within the Australian Government Department of Transport and Regional Services. ATSB investigations are independent of regulatory, operator or other external bodies.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The ATSB performs its functions in accordance with the provisions of the Transport Safety Investigation Act 2003 and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to enhance safety. To reduce safety-related risk, ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated.

It is not the object of an investigation to determine blame or liability. However, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to proactively initiate safety action rather than release formal recommendations. However, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation, a recommendation may be issued either during or at the end of an investigation.

The ATSB has decided that when safety recommendations are issued, they will focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on the method of corrective action. As with equivalent overseas organisations, the ATSB has no power to implement its recommendations. It is a matter for the body to which an ATSB recommendation is directed (for example the relevant regulator in consultation with industry) to assess the costs and benefits of any particular means of addressing a safety issue.

About ATSB investigation reports: How investigation reports are organised and definitions of terms used in ATSB reports, such as safety factor, contributing safety factor and safety issue, are provided on the ATSB web site www.atsb.gov.au.

1 FACTUAL INFORMATION

1.1 History of the flight

On 2 December 2005, at 1122 Eastern Daylight-saving Time[1], a Piper Aircraft Corporation PA-31-350 Chieftain aircraft, registered VH-PYN (PYN), departed Archerfield, Qld, on a private flight to Griffith, NSW. The flight was planned under the instrument flight rules (IFR). On board the aircraft were the pilot, two passengers and an observer-pilot who was on the flight to gain knowledge of the aircraft operation. The aircraft tracked direct to Moree and then Coonamble at 10,000 ft, in accordance with the flight plan. At 1303, the pilot amended the destination to Swan Hill, Vic, tracking via Hillston, NSW.

At 1314, the pilot advised air traffic control that the aircraft had passed overhead Coonamble at 1312 maintaining 10,000 ft, and was estimating Hillston at 1418. At 1316, the pilot reported that he was tracking 5 NM (9 km) left of track due to weather. At 1337, the pilot advised that he was diverting up to 20 NM (37 km) left of track due to weather. At 1348, the pilot reported that he was diverting 29 NM (54 km) left of track, again due to weather. No further radio transmission from the pilot was heard.

At about 1400, police received a report that an aircraft had crashed on a property approximately 28 km north of Condobolin, NSW. The extensively burned wreckage was subsequently confirmed as PYN. Other wreckage, spread along a trail up to 4 km from the main wreckage, was located the following day.

Examination of air traffic control recorded radar data indicated that the aircraft entered radar coverage about 50 km north of Condobolin at 1346:34. The last valid radar data from the secondary surveillance radar[2] located on Mount Bobbara was at 1349:53. During that 3 minute 19 second period, the recorded aircraft track was approximately 56 km left of the Coonamble to Hillston track and showed a change in direction from southerly to south-westerly. The aircraft's groundspeed was in the range between 200 and 220 kts. The aircraft's altitude remained steady at 10,000 ft. The last recorded radar position of the aircraft was approaching the limit of predicted radar coverage and was within 10 km of the location of the main aircraft wreckage (Figure 1).

Earlier that day, the aircraft had departed Bendigo, Vic, at 0602 and arrived at Archerfield at 1034. The pilot and the observer-pilot were on board. The aircraft was refuelled to full tanks with 314 litres of aviation gasoline at Archerfield. The refuelling agent reported that the main and auxiliary tanks were full at the completion of refuelling. He also reported that the pilots had commented that the forecast for their return flight indicated that weather conditions would be 'patchy'.

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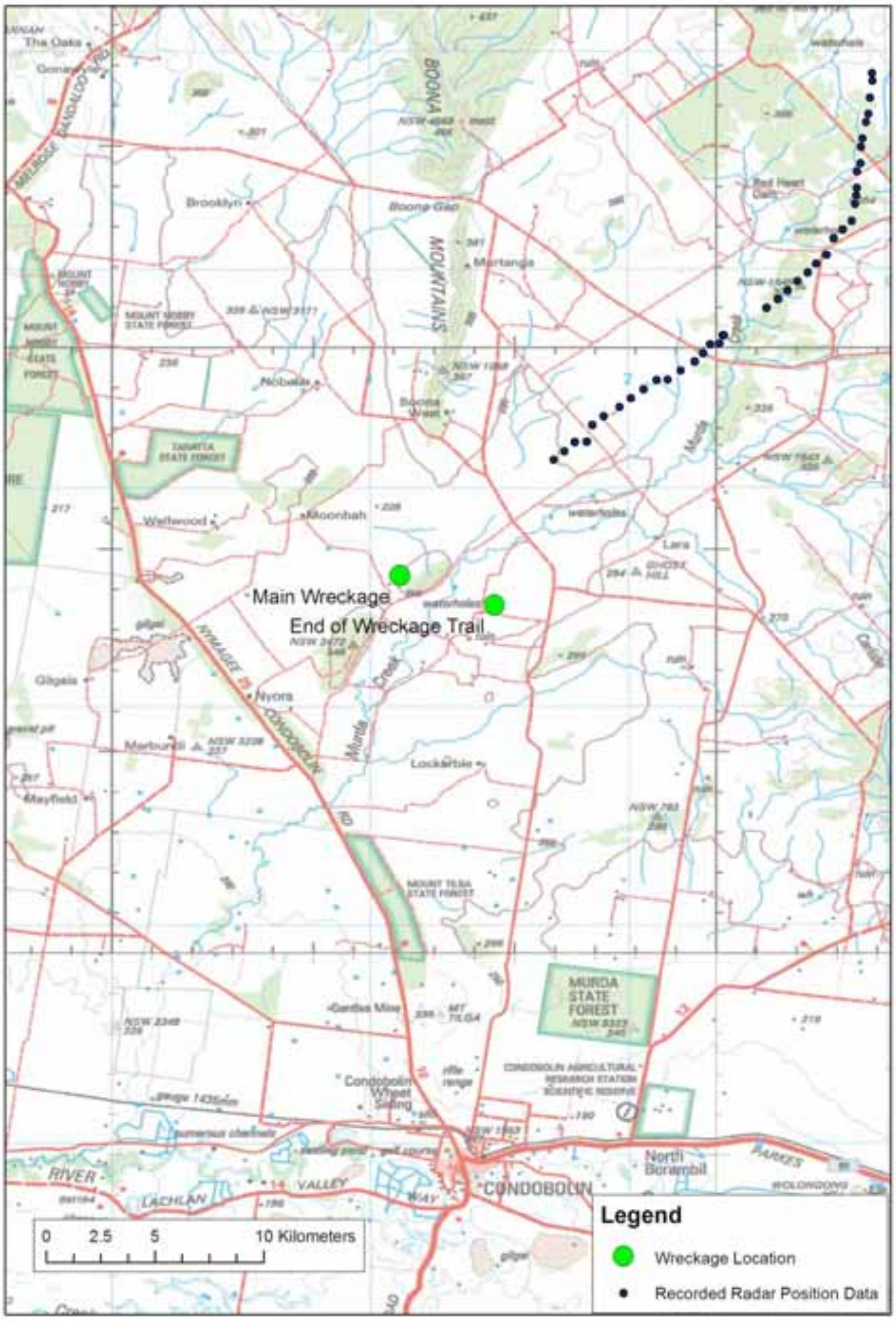
1 The 24 hour clock is used in this report to describe the time of day, Eastern Daylight-saving Time (ESuT), as particular events occurred. Eastern Daylight-Saving Time was Coordinated Universal Time (UTC) plus 11 hours.

2 The radar had a range of 250 NM (463 km) and was 116 NM (215 km) southeast of Condobolin Airport.

Figure 1: Wreckage location and radar data



1.2 Injuries to persons

Injuries	Crew	Passengers	Others	Total
Fatal	1	2	1	4
Serious				
Minor				
None				4

1.3 Damage to aircraft

Sections of the aircraft's extremities and control surfaces, along with the right engine, had separated during flight. The fuselage and remaining wing sections, with the left engine still attached, impacted the ground inverted and were destroyed by a post-impact fuel-fed fire (Figure 2).

Figure 2: Burnt, inverted fuselage and inner wing sections

1.4 Other damage

Nil.

1.5 Personnel information

The pilot in command was appropriately qualified and licensed to undertake the flight. He held a commercial pilot's licence, a command multi-engine instrument flight rating and a Grade 1 flight instructor rating. The pilot's total flying experience was approximately 4,600 hours. He had more than 1,000 hours experience in PA31 type aircraft, extending over 13 years. He had undergone the majority of his flying training with, and was employed by, the company that operated PYN. Flying PYN had been practically his full-time occupation for the previous 20 months.

The other pilot on board the aircraft was also employed by the company that operated PYN. He had recently been endorsed on the PA31 and had about 6 hours experience on type. He held a commercial pilot's licence and a command multi-engine instrument flight rating. His total flying experience was about 1,560 hours. He enjoyed a close working and social relationship with the pilot in command, who he had known since mid-2001.

The aircraft owner was also a pilot and had flown PYN for many years. It was the owner's policy that the aircraft, while capable and operated under the IFR, should be flown in visual flight conditions only. He was reported to have been a 'fussy flyer' who was averse to taking risks to save time or money, particularly regarding weather (see also reference to aircraft weather radar in Section 2.6).

The pilot in command was aware of the owner's requirement regarding visual flight and enjoyed a close working relationship with the owner. It was reported that there were many examples where the owner and/or pilot had cancelled or postponed flights because of actual or forecast unfavourable weather. It was reported that the pilot had intended to fly to Archerfield the day before the occurrence, but postponed the flight to the following day because afternoon thunderstorms were forecast at the destination.

Both the pilot in command and the other pilot on board had experience in unusual aircraft attitude recognition and recovery. They had undertaken training for low-level power line patrol operations that included level, climbing and descending turns at up to 60 degrees angle of bank, and stall symptoms and recovery through that range of aircraft attitudes. The pilot in command had conducted basic aerobatic flight manoeuvres some years previously, while the other pilot had completed an aerobatic endorsement in 2001.

1.6 Aircraft information

The aircraft's records indicated that it was manufactured in 1982 and had a total time in service of about 2,900 hours. It had recently been fitted with new engines, propellers, and fuel tanks. A review of the maintenance records confirmed that the aircraft was operating on a valid maintenance release at the time of the accident. The records did not indicate whether Airworthiness Directive (AD) 41, Amendment 1, Propeller Hub Eddy Current Inspection had been completed on the right propeller. However, that omission was not considered to have played any part in the development of the accident.

The aircraft was not fitted with a weather radar or lightning detection system[3]. There was no regulatory requirement for either system to be fitted to the aircraft. The aircraft was equipped with a King KFC 200 auto-pilot and a Garmin GNS530 Global Positioning System (GPS) unit that was coupled to the auto-pilot.

The aircraft was fitted with dual flight controls and could be flown from the left or right cockpit seat.

The aircraft fuel system included an inboard and outboard fuel tank in each wing. The tanks were of a bladder type and made of black rubberised material. During normal operations, the inboard tanks were selected for takeoff and the outboard tanks selected once the aircraft reached cruise altitude. When the outboard tanks neared empty, the inboard tanks were again selected. At the stage of the flight where the aircraft broke up, and assuming normal fuel system operation by the pilot, fuel in the outboard tanks would have been exhausted and the engines would have been receiving fuel from the inboard tanks.

1.7 Meteorological information

1.7.1 Weather forecasts

The pilot had obtained the appropriate weather forecast prior to the flight from Bendigo to Archerfield. The Area 22 forecast, issued by the Bureau of Meteorology (BoM) at 0220 (Appendix A), indicated thunderstorms ‘tending occasional’[4] east of a line from Bourke to Griffith after 1000. The storms were associated with a surface trough moving through central NSW. The Aeronautical Information Publication (AIP) ENROUTE (ENR) section 1.10 paragraph 1.2.8 stated:

> When [a] preflight briefing is obtained more than one hour prior to ETD[5], pilots should obtain an update before departure to ensure that the latest information available can be used for the flight. The update should be obtained by NAIPS[6] pilot access, telephone, or when this is impracticable, by radio.

At 0933, a new Area 22 forecast was issued. That forecast contained no significant changes to the 0220 forecast. It was not established whether the pilot received that forecast.

At 1130, the Area 22 forecast was amended to indicate that the thunderstorm activity had increased from ‘tending occasional’ to ‘frequently observed’[7] east of a

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3 Lightning detection systems detect lightning strike activity within a 200 NM (370 km) radius of the aircraft. The information is presented graphically in the cockpit and can be used to circumnavigate areas of electrical activity associated with thunderstorms.

4 Aeronautical Information Publication (AIP) Australia Part 1 General (GEN) 3.6.3 stated that in the case of cloud associated with thunderstorms, well-separated thunderstorm cells would be described as ‘occasional’.

5 Estimated time of departure.

6 The National Aeronautical Information Processing System is a multi-function, computerised, aeronautical information system.

7 AIP GEN 3.6.3, in the case of thunderstorm clouds, defined ‘frequent’ to mean thunderstorms with little or no separation.

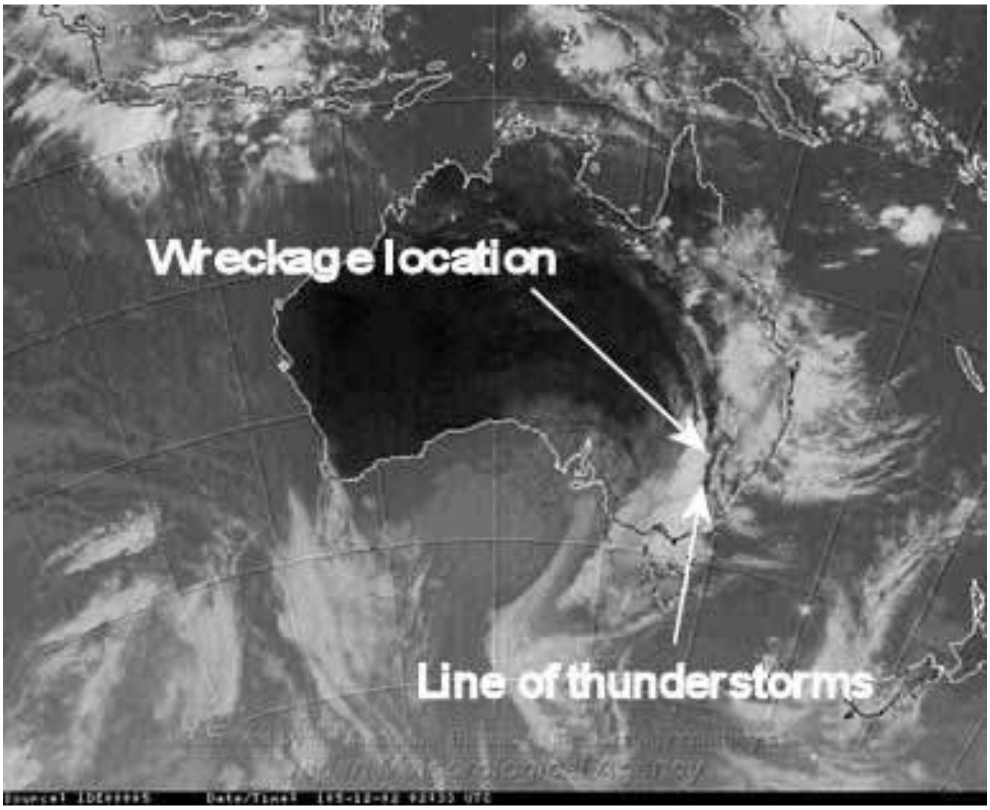
line from Bourke to Griffith. The area forecast included reference to a SIGMET[8]. SIGMET SY01 reported observed frequent thunderstorms within 60 NM (111 km) of a line from Cobar to Wagga (SIGMET SY01 – see Appendix B).

SIGMET SY01 was received by Airservices Australia from the BoM at 1127, 5 minutes after the aircraft departed Archerfield.

1.7.2 Analysis of actual weather conditions

The BoM advised in a report on the meteorological situation produced after the accident that an active frontal system was moving east at 15 to 25 kts through New South Wales. Satellite images showed a line of thunderstorms extending from south-central Queensland, through New South Wales, and into Victoria (Figure 3). A line of active thunderstorms visibly marked the front.

Figure 3: Infrared satellite image at 1330, 2 December 2005



The BoM reported that weather radar information showed a line of precipitation passing through Condobolin around 1350 on 2 December 2005. The radar images indicated an almost continuous line of storms extending south-south-west to north-north-east, from just north-west of Wagga Wagga. The line formed a ‘Y’ configuration just north of Condobolin near the accident location (Figures 4 and 5). Beyond that, to the north, the forks of the storm complex were beyond radar detection from Wagga Wagga, before emerging within range of the Moree weather radar further to the north. Later, when the storms were in better range of radars, the

8 Weather advisory service to warn of potentially hazardous (significant) extreme meteorological conditions dangerous to most aircraft, eg extreme turbulence, severe icing, squall lines, dense fog.

two forks of the storm complex appeared to extend more-or-less unbroken for some distance to the north.

Figures 4 and 5 are weather radar images provided by the BoM. The captions accompanying each figure are analysis and interpretation provided by the BoM.

Figure 4: BoM composite weather radar image at 1350, 2 December 2005 showing the line of thunderstorms in 'Y' configuration.

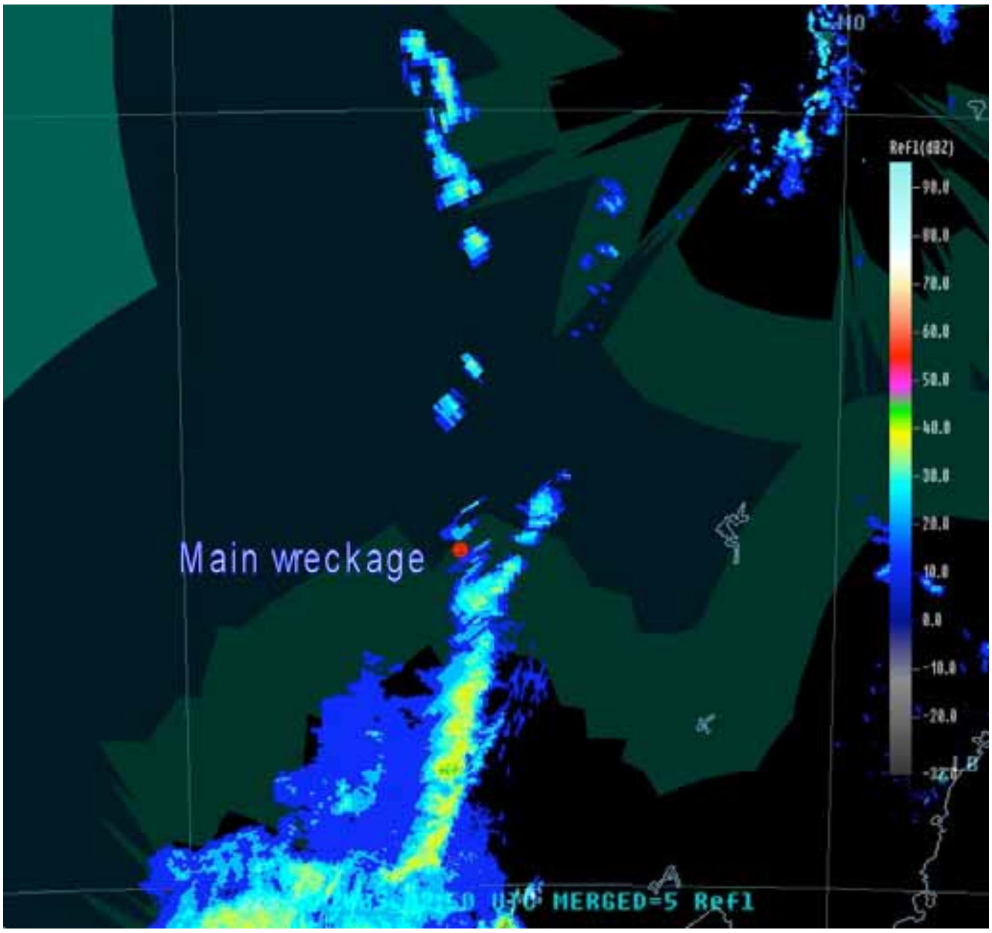


Figure 4 shows merged data recorded at 1350 from Wagga Wagga, Captains Flat and Moree weather radars. The red circle (just below and left of centre) indicates the wreckage location. From that position, Wagga Wagga radar was located approximately 261 km to the south-south-east (bottom centre of image) and Moree radar approximately 454 km to the north-east (near top right corner of image).

Figure 5: BoM enlarged image from Wagga Wagga weather radar at 1350, 2 December 2005

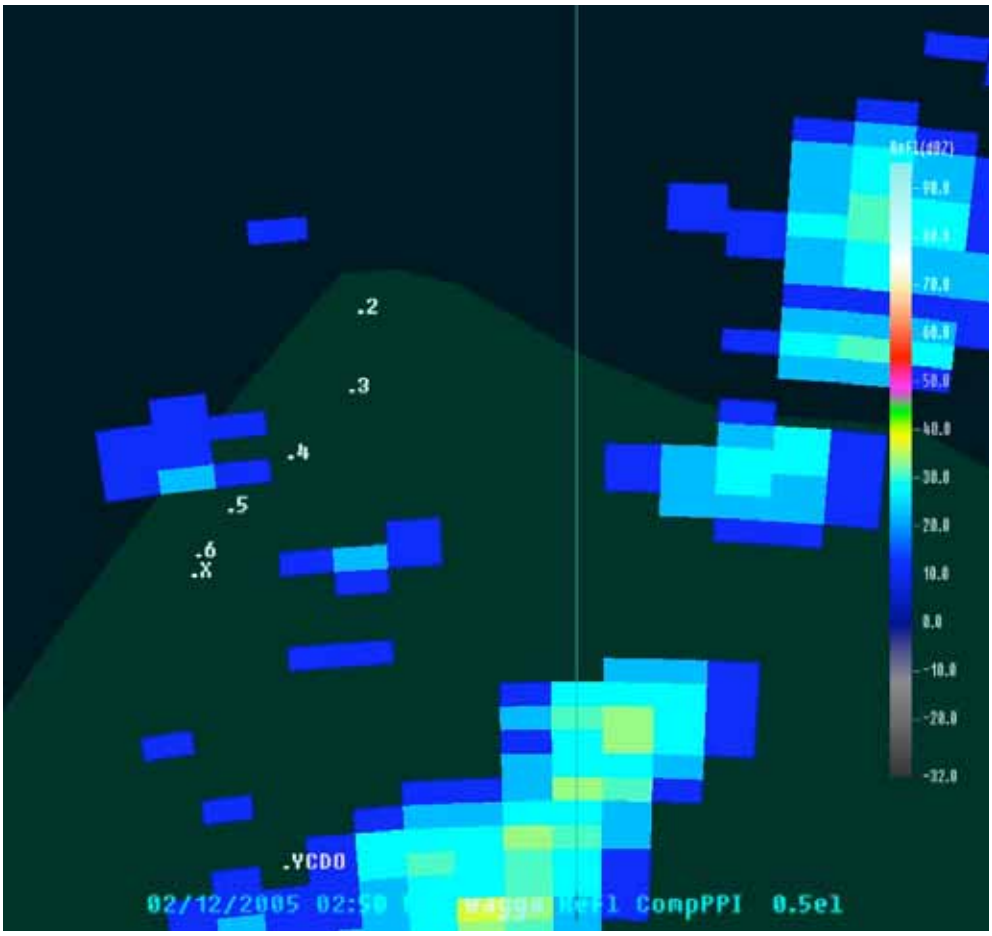


Figure 5 shows data from Wagga Wagga radar at 1350 enlarged to show detail in the vicinity of the accident site. ‘X’ marks the approximate position of the aircraft wreckage. The points labelled "2" through to "6" mark approximately the recorded radar positions of the aircraft. ‘YCDO’ indicates the location of Condobolin Airport. The centre of the radar's beam was 3,050 to 4,260 m (10,000 ft to 14,000 ft) above the ground level where it intersected storms in the vicinity of the accident location.

The BoM advised that, notwithstanding the limited ability of the weather radars to detect storms at distances in the order of 370 km[9], there were indications in the detail of the images that individual storm cells were located very close to the recorded aircraft location around 1350. Furthermore, it appeared that immediately prior to the accident, the aircraft was likely to have been surrounded on the west, south and east sides (that is, inside the ‘Y’ depicted in Figure 4) by a large complex of storms.

The BoM estimated that, in the vicinity of the accident location, the individual storm cells were moving towards the south-east at between 35 and 45 kts, while the

9 The nominal maximum range of BoM weather radar equipment was 350 km.

larger complex of storms, as a whole, made progress towards the east at about 30 kts.

A weather summary report produced by the BoM is included at Appendix C to this report.

1.7.3 Provision of weather information

SIGMET

International Civil Aviation Organization (ICAO) *Annex 3 — Meteorological Services for International Air Navigation* defined SIGMET information as:

> Information issued by a meteorological watch office concerning the occurrence or expected occurrence of specified en-route weather phenomena which may affect the safety of aircraft operation.

The Manual of Meteorology, Part 2, Aviation Meteorology[10], stated in part:

> SIGMET information relates to the occurrence of one or more of the following phenomena:
>
> (a) *At subsonic cruising levels*
>
> - active thunderstorm area;
> - tropical revolving storm;
> - severe line squall;
> - heavy hail;
> - severe turbulence;
> - severe icing;
> - marked mountain waves;
> - widespread sandstorms or dust storm.

Aeronautical Information Publication (AIP) Australia, General (GEN) 5.1.1 stated:

> SIGMET for thunderstorms is only issued when they are:
>
> (1) obscured (OBCS) by haze or smoke and cannot be readily seen;
>
> (2) embedded (EMBD) within cloud layers and cannot be readily recognised; or
>
> (3) frequent (FRQ) with little or no separation between adjacent storms and covering more than 75% of the area affected.

The AIP information was not included in the *Manual of Air Traffic Services* (MATS) (see also Section 1.17.9).

10 *Manual of Meteorology, Part 2, Aviation Meteorology*, Department of Science and Technology, 1981.

Pre-flight weather information services for pilots

A pre-flight briefing service for pilots was available through a self-help electronic system or through a briefing office. If required, a comprehensive telephone briefing could be requested from either Airservices Australia or the BoM. Normally a pre-flight briefing was not provided on air traffic control radio frequencies.

The pre-flight briefing was supported by an in-flight briefing service available through automated broadcast services, on pilot request, and hazard alert services. The automated broadcast services consisted of automatic terminal information service (ATIS), automatic enroute information services (AERIS), aerodrome weather information service (AWIS) and meteorological information for aircraft in flight (VOLMET). The ATIS and ERIS provided continuous terminal information and routine meteorological reports via very high frequency (VHF) transmitters located at airports and other locations around Australia. The AWIS provided actual weather conditions, via telephone or radio broadcast, from BoM automatic weather stations (AWS). At some locations, an enhanced AWIS, known as weather and terminal information reciter (WATIR) was available. The service consisted of AWS information and terminal information from the aerodrome operator. Broadcasts on VOLMET provide meteorological information for major international aerodromes and Townsville.

There was no means of establishing if the pilot accessed any of the automated weather information services by radio during the flight.

In-flight weather information services for pilots

An on request briefing service from FLIGHTWATCH[11] via VHF or high frequency (HF) radio was available to pilots operating in all classes of airspace. A service may also be requested through air traffic control when a pilot operating in controlled airspace is in an area not serviced by a FLIGHTWATCH VHF outlet. Subject to controller workload, a controller may require a pilot to contact FLIGHTWATCH on HF radio.

During the flight, between Archerfield and Coonamble, while the aircraft was maintaining 10,000 ft, FLIGHTWATCH VHF outlets at Springbrook and Mount Dowe were available for the pilot to request updated weather information. After Coonamble, the FLIGHTWATCH VHF outlet at Mount Canobolas was available for the pilot.

A review of automatic recorded voice transmission data did not reveal any indication that the pilot had requested a weather update from air traffic services (ATS) staff during the flight. It was possible that the pilot overheard weather information transmissions to other aircraft on FLIGHTWATCH.

1.7.4 Display of weather radar information

Weather radar data from BoM radar sites was displayed at various ATC operating positions by means of a computer based system (METRAD). METRAD images were not real time, but were subject to a 10-minute update cycle. The effective

11 FLIGHTWATCH is an on-request service provided by Airservices Australia to respond to requests for operational information from pilots operating in Australian airspace.

range of the radars was 75 NM (139 km). Weather radar formation was available to pilots on request, subject to controller workload.

The only BoM weather radar site located near the aircraft's route was at Moree. That radar had a shared weather watch/wind measurement role. On the day of the accident the Moree radar was being used for wind measurement between 1510 and 1620.

The weather radar sites at Wagga Wagga and Yarrawonga were more than 75 NM from the aircraft's planned route. They had a shared weather watch/wind measurement role.

The weather radar images included at Section 1.7.2 (Figures 4 and 5) were provided by the BoM following detailed analysis after the accident. Those images were not available to ATS staff.

1.7.5 Hazard alerting - guidance material

The Procedures for Air Traffic Services - Air Traffic Management (PANS-ATM) (Doc 4444) contained the International Civil Aviation Organization (ICAO) Procedures for Air Navigation Services. The publication was the result of the progressive evolution of the *Procedures for Air Navigation Services — Air Traffic Control (PANS-ATC)* prepared by the Air Traffic Control Committee of the International Conference on North Atlantic Route Service Organization (Dublin, March 1946). Originally applicable on a regional basis, the PANS-ATC became applicable on a worldwide basis through international agreement on 1 February 1950.

The PANS-ATM, was complementary to the ICAO Standards and Recommended Practices contained in Annex 2— *Rules of the Air* and in Annex 11 — *Air Traffic Services*. The PANS-ATM specified procedures to be applied by air traffic services units in providing the various air traffic services.

The PANS-ATM section *Transmission of Special Air Reports* provided guidance on when SIGMET and AIRMET information should be advised to pilots and stated:

> Special air-reports shall be disseminated to aircraft for a period of 60 minutes [1 hour] after their issuance…
>
> The special air-report, SIGMET and AIRMET information to be passed to aircraft on ground initiative should cover a portion of the route up to one hour's flying time ahead of the aircraft except when another period has been determined on the basis of regional air navigation agreements.

The ICAO *Doc 9673 — Asia Pacific Regions, Air Navigation Plan, Volume 1, Basic ANP* stated in relation to SIGMET information that:

> They should be disseminated to be available at ATS units for transmission to aircraft in flight for the route ahead up to a distance corresponding to two hours' flying time.

The ICAO *Doc 7030 — Regional Supplementary Procedures*, in the section relating to MID/ASIA, which included Australia, stated:

> SIGMET information passed to aircraft shall cover a portion of the route up to two hours' flying time ahead of the aircraft.

Civil Aviation Safety Authority (CASA) *Civil Aviation Safety Regulations 1998 (CASR) Part 172 – Air Traffic Service Providers*, stated:

> An ATS [Air Traffic Service] provider must ensure that any traffic service that it provides is provided in accordance with the procedures and rules set out in ICAO Doc. 4444, as varied by Gen 1.7 of Part 1 of the AIP.

and:

> If a regional supplementary procedure set out in ICAO Doc 7030 relates to an air traffic service that the provider provides, the provider must also ensure that the service is provided in accordance with that procedure.

Part 172 also stated in relation to priority of inconsistent procedures that:

> If, apart from this regulation, an ATS provider would be required by this Division to ensure that any air traffic service that it provides is provided in accordance with 2 or more procedures that are inconsistent, the provider is only required to ensure that the service is provided in accordance with whichever of the procedures has the highest priority.

The order of priority of a procedure was listed in Part 172 as follows (starting with those of highest priority):

> (a) procedures in Parts 1 and 2 of the AIP;
>
> (b) procedures for aeronautical telecommunications in Volume II of Annex 10, as varied by Gen 1.7 of Part 1 of the AIP;
>
> (c) Procedures in ICAO Doc. 7030;
>
> (d) Procedures in ICAO Doc, 4444, as varied by Gen 1.7 of Part 1 of the AIP;
>
> (e) Any procedure in the provider's operations manual.

Gen 1.7 of Part 1 of the AIP did not refer to SIGMET information dissemination.

1.7.6 Hazard alerting - Australian practice

The Aeronautical Information Package published by Airservices Australia included in Part 1, GEN 3.5, Meteorological Services, a section on hazardous weather. Pertinent extracts included:

> 6.1.1 Cooperative and concerted action is required by pilots, meteorologists and ATS to ensure the most accurate information is promulgated to assist pilots in the avoidance of hazardous weather, particularly…phenomena associated with thunderstorms – icing, hail and turbulence.
>
> 6.1.3 ATS is responsible for distributing reports of hazardous meteorological conditions to pilots as part of the Flight Information Service.
>
> 6.1.4 Whilst manoeuvring in hazardous weather situations, pilots are responsible for the safety of their own aircraft using advices and clearances passed by ATS and from their own visual or airborne radar observations. They are also responsible for passing visual and airborne radar observations of hazardous weather to ATS.
>
> 6.2 Pilot Action

> 6.2.1 Outside controlled airspace all hazardous weather avoidance action is the sole responsibility of the pilot in command. However, in order to preserve the safety of the aircraft and other traffic, the pilot in command is requested to advise ATS of intended actions.
>
> 6.2.2 The pilot in command, both inside and outside controlled airspace, must advise ATS promptly of any hazardous weather encountered, or observed either visually or by radar. Whenever practicable, those observations should include as much detail as possible, including locations and severity. Hazardous weather includes, in particular, thunderstorms, severe turbulence, hail, icing, line squalls, and volcanic ash cloud.

The *Manual of Air Traffic Services* (MATS) stated that a pilot was responsible for requesting the information upon which to base in-flight operational decisions. It also stated that:

> Flight Information Services shall be provided to all aircraft which are likely to be affected by the information and which are:
>
> - provided with air traffic control service; or
>
> - otherwise known to the relevant air traffic services units.

Where air traffic service units provided both flight information service and air traffic control service, the provision of air traffic control service had precedence over the provision of flight information service. Requests for operational information were to be dealt with on a first come / first served basis and were to be issued by FLIGHTWATCH where established; or workload permitting, air traffic control. The flight information service included the provision of pertinent meteorological conditions.

In relation to a hazard alert service, the MATS stated:

> Surveillance of the following reports shall form the basis of the Hazard Alert service. Information from other sources should also be assessed and included in the Hazard Alert as appropriate:
>
> a. weather forecasts:
>
> 1.SIGMET: to aircraft operating or about to operate on a route or in an area affected or likely to be affected;
>
> 2.AIRMET: to aircraft operating or about to operate at or below 10,000 FT;
>
> b. amended forecasts;
>
> c. observations and reports indicating weather conditions at the destination have deteriorated below the IFR or VFR alternate minima;
>
> d. navigation and communication facilities including destination GPS RAIM Prediction;
>
> e. known aerodrome facilities and hazards.

> A Hazard Alert service shall contain information assessed by air traffic services (ATS) to be of an unexpected and critical nature and shall be broadcast on the appropriate ATS frequencies on receipt and in the first hour following the observed, or notified onset of the conditions at H15 and H45 as necessary; or directed to those aircraft maintaining continuous communications with ATS at the time the hazard is assessed that are within one hours flight time of the hazardous conditions; and directed to all aircraft engaged in SAR action.

The MATS did not define the meaning of 'unexpected and critical'.

MATS required the ATC unit in whose airspace the hazard was either forecast or existed to ensure that the hazard alert information was notified as soon as practicable to pilots of aircraft which were likely to be affected by the hazard condition. That may entail the hazard alert information being addressed to or passed to pilots via another ATC unit.

Airservices Australia issued local instructions applicable to the Melbourne Air Traffic Services Centre. With respect to hazard alerts, those instructions stated:

> Responsibility for assessment and ensuring that Hazard Alerts are distributed to affected aircraft rests with the ENR [En route] Sector or TCU [Terminal Control Unit] position within whose area the destination aerodrome is situated.

The implication of the 1 hour dissemination criterion detailed in the AIP, which had priority over procedures detailed in ICAO Doc. 4444 and ICAO Doc. 7030, was that a pilot in command was responsible for accessing information that was outside that 1 hour 'look ahead' window.

1.7.7 Interaction between the pilot and air traffic services (ATS)

During the flight, the aircraft transited a number of airspace sectors within the Brisbane and Melbourne Flight Information Regions[12] (FIRs). Pilots of aircraft operating in each sector communicated with ATS on a radio frequency specific to that sector. Normally, one air traffic controller (the sector controller) dealt with the air traffic in a sector. The sector controller instructed pilots to change radio frequency as the aircraft entered the next sector.

After departing Archerfield, the pilot initially communicated on the radio frequency for Brisbane Approach, before transferring at 1126 to the Downs Sector frequency. At 1200, the pilot was instructed to transfer to the Newell Sector frequency. The level of traffic in the Newell Sector at the time was light and there were no requests for weather diversions by other pilots during the period that PYN was in that sector. Both the Downs and Newell Sectors were within the Brisbane FIR.

At 1317, shortly after the pilot had reported at the Coonamble position, the controller instructed the pilot to change frequency to the next sector – Bogan Sector – that was located in the Melbourne FIR.

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12 Each FIR was composed of a number of sectors. Each sector had a specific title, e.g. 'Downs Sector'.

The area encompassed by SIGMET SY01 also fell within the Melbourne FIR. Consequently, Melbourne FIR sector controllers were responsible for determining to which aircraft any hazard alert should apply.

Information about PYN was displayed on the Bogan Sector controller's TAAATS[13] computer generated air situation display. The displayed information was based on the aircraft's flight plan, its departure time from Archerfield, and position report information from the pilot en route. TAAATS was programmed not to display the aircraft's position on the sector controller's air situation display until it was within 30 minutes' flight time of the FIR boundary. TAAATS would have automatically transferred responsibility for PYN to the Bogan Sector when the aircraft was 10 minutes from the FIR boundary.

During interview following the occurrence, the controller responsible for the Bogan Sector reported that he assessed that SIGMET SY01 did not meet the 'unexpected and critical' requirement for the issuance of hazard alert with regard to PYN. The controller based that assessment on the following:

- the hazard was not unexpected because thunderstorms had been included in the Area 22 forecasts issued at 0220 and 0933
- the hazard was not critical because at that time the aircraft was in excess of 1 hour's flying time from the hazard area.

As there was no requirement to provide the information to the pilot of PYN the controller did not initiate any further action.

At 1159, the Bogan Sector controller issued an all stations hazard alert broadcast for an amended Nyngan Terminal Area Forecast that included a TEMPO[14] period. That broadcast was repeated at 1215 and 1248. Around that time, there were requests from pilots of aircraft tracking to Bourke and Parkes for diversions due to weather. The controller approved those requests. The 1248 broadcast included additional changes to forecasts for Condobolin and Cobar. The controller advised pilots to contact FLIGHTWATCH for more information. At 1301, the controller checked whether the pilot of a Piper Chieftain, which had departed Bourke for Cobar, had received the information about an amended terminal area forecast for Cobar. That pilot confirmed that he had received the information.

At 1317[15], when the pilot of PYN transferred to the Bogan Sector frequency, he reported that the flight was maintaining 10,000 ft and was manoeuvring up to 5 NM (9.3 km) left of track due to weather. Between 1320 and 1325, the controller received requests (on the sector frequency) for diversions due to weather from the pilots of the following aircraft:

- a Saab 340, that was 11 NM (20 km) south-east Griffith passing 10,200 ft, to divert up to 30 NM (55km) right of track

13 TAAATS is The Australian Advanced Air Traffic System.

14 Used to indicate change in prevailing conditions expected to last for a period of less than 1 hour in each instance.

15 SIGMET SY01 had been issued more than 1 hour previously (1 hour 47 minutes had elapsed since issue).

- a Piper Chieftain, that had departed Bourke at 1313 on climb to 9,000 ft and tracking to the south-east of Bourke, to divert 15 NM (28 km) right of track
- a Boeing 737, that was at the FIR boundary and tracking south at flight level 370, to divert 15 NM east of track
- an Airbus Industrie 320, on a similar track to the 737 to divert 15 NM east of track.

At 1325, the sector workload was split between two controllers because of increasing traffic levels and complexity due to the weather situation. Between, 1325 and 1335, there were two further requests from pilots for diversions due to weather.

There was no indication that the ability of the controllers to fulfil the requirements of their positions was affected by the workload level.

1.8 Aids to navigation

Not relevant.

1.9 Communications

A review of air traffic services (ATS) recorded audio data confirmed the following:

- communications between the pilot and air traffic control services were normal
- no distress or other urgency transmission was received from the pilot
- no transmission was received from the pilot that hazardous weather had been observed or encountered.

1.10 Aerodrome information

Not applicable.

1.11 Flight recorders

The aircraft was not fitted with a flight data or cockpit voice recorder; nor was it required to be by aviation regulations.

1.12 Wreckage information

Post-impact fire damage limited the extent to which some of the aircraft's systems, including the fuel and electrical systems, could be examined. Examination of the cockpit controls and instruments, including the autopilot and GPS systems, also was not possible.

1.12.1 Engines and propellers

The engines and propellers were removed from the accident site and examined. Damage was consistent with the effects of the in-flight break up, the ground impact, and the post-impact fire. Pertinent observations included:

- The position of the engine controls at impact could not be determined.
- The left engine remained attached to the aircraft and had received significant fire damage (Figure 6).
- The left propeller had no indications of rotation at ground impact. One left propeller blade had broken off approximately 10 cm from the blade root. The separated blade section was not found. That blade had failed in overload, possibly when struck by a part of the aircraft during the break-up sequence.
- The right engine showed no evidence of fire damage (Figure 7).
- The right propeller blades were in the feathered position at impact.
- There was evidence on the propeller flange that the propeller was rotating at the time the engine was torn from the wing.

There was no indication that the engines were not capable of normal operation prior to the breakup.

Figure 6: Left engine showing broken propeller blade

Figure 7: Separated right engine

1.12.2 Fuselage and inner wing sections

The fuselage impacted the ground inverted, with low forward speed. Both wings had failed outboard of the engine nacelles (Figure 8). The right engine had separated from the aircraft and was found about 300 m from the fuselage. The left engine remained attached to the wing.

Figure 8: Failed left wing main spar (inverted) outboard of engine nacelle

The rear fuselage and empennage showed evidence of severe torsional twisting to the right, typically incurred by an extreme rate of roll in the opposite direction (Figure 9).

Figure 9: Torsional twisting to rear fuselage and empennage

The landing gear was retracted and the flaps were up at the time of impact.

The top and bottom engine cowlings for the right engine, and the bottom cowling for the left engine were attached and in the closed position at ground impact. The left engine top cowling was attached to the engine but was incomplete. The missing cowling structure was likely to have been destroyed by the post-impact fire.

The extent of the fire damage to the cockpit meant that no useful information could be obtained regarding the cockpit instruments and controls.

The condition of the main wreckage precluded examination for evidence of lightning strike or hail damage on that section of the aircraft.

1.12.3 Components recovered from wreckage trail

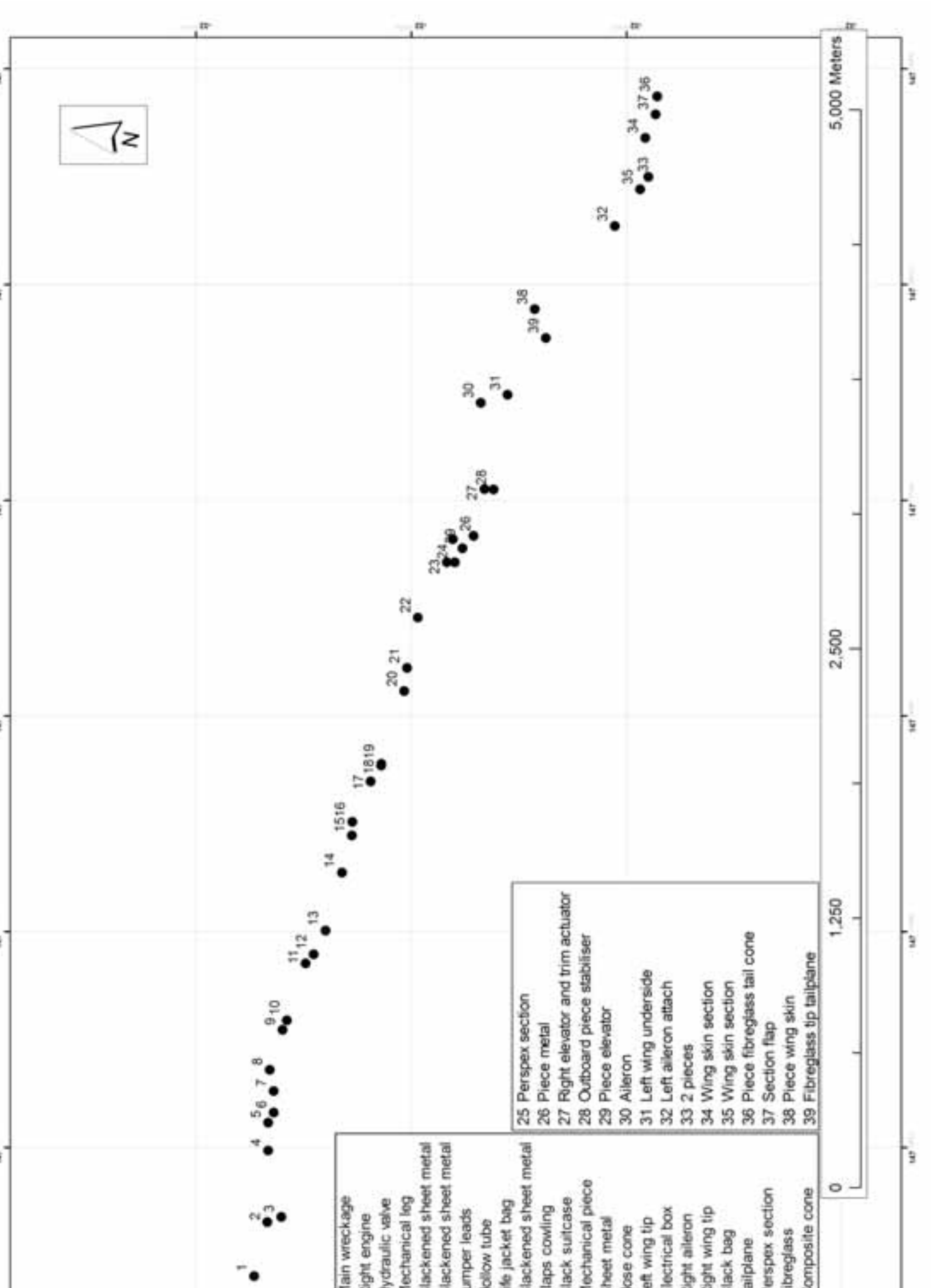
Numerous segments of the outer wings, tailplane and nose section were found along the wreckage trail, including parts from the four extremities of the aircraft structure. They were removed from the accident site for detailed examination. The following parts of those sections were not found:

- most of the upper skin of the outer left wing
- the left wing leading inboard and outboard sections
- the upper section of the rudder (containing the mass balance weight)
- the outboard section of the right elevator (containing the mass balance weight)
- the section of the right elevator outboard of the outboard elevator hinge

- the outboard half of the elevator trim tab.

Figure 10 shows a large scale diagram of the location and identity of the items found along the wreckage trail.

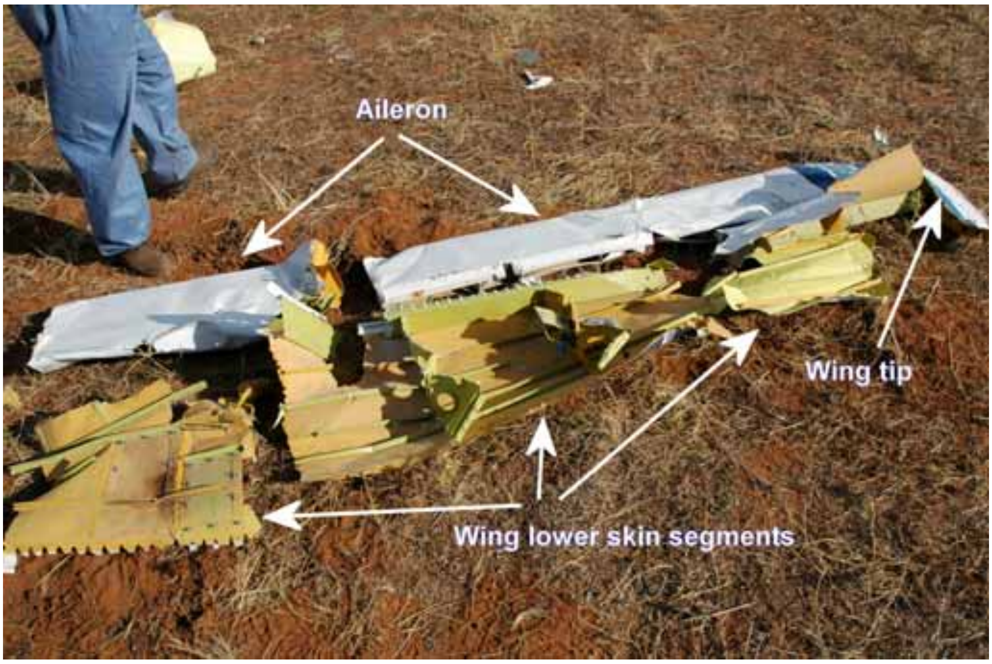
Figure 10: Location and identity of recovered wreckage



There was no evidence of heat, smoke, or fire damage to items 11 to 39 inclusive (Figure 10, see also 1.14 Fire). No evidence was found of hail or lightning strike damage to any section of the aircraft found along the wreckage trail.

An example of the nature of the disruption that occurred to the outer wing structures is demonstrated by the recovered left wing pieces shown in Figure 11, roughly reassembled. The outer right wing sustained similar damage.

Figure 11: Recovered outer left wing pieces showing extent of destruction



Examination of the wing and tailplane portions recovered from the wreckage trail enabled the following observations:

- The shape and edge profile of a section of the right wing leading edge indicated that the section was torn off towards the leading edge of the wing. That damage implied that the wing was not moving in the conventional forward flight direction when the section separated (Figure 12).

Figure 12: Section of right wing leading edge

- The right aileron, at about its mid-span position, had been bent upwards at least 60 degrees at some point during the breakup sequence. The condition of the hinges and their surrounds suggested that the aileron was forced in a span-wise direction during the break-up.
- The right aileron trim tab remained attached, and the trim tab control rod was firmly attached to the trim and its control mechanism screw jack. Both trim cables were attached to the drum but had failed in overload. The aileron stops and the aileron bell crank travel stops were in place and showed no discernable deformation (Figure 13). There was no evidence of repetitive, hard contacts on any of the stops (Figure 14).

Figure 13: Showing right aileron stops (shaded)

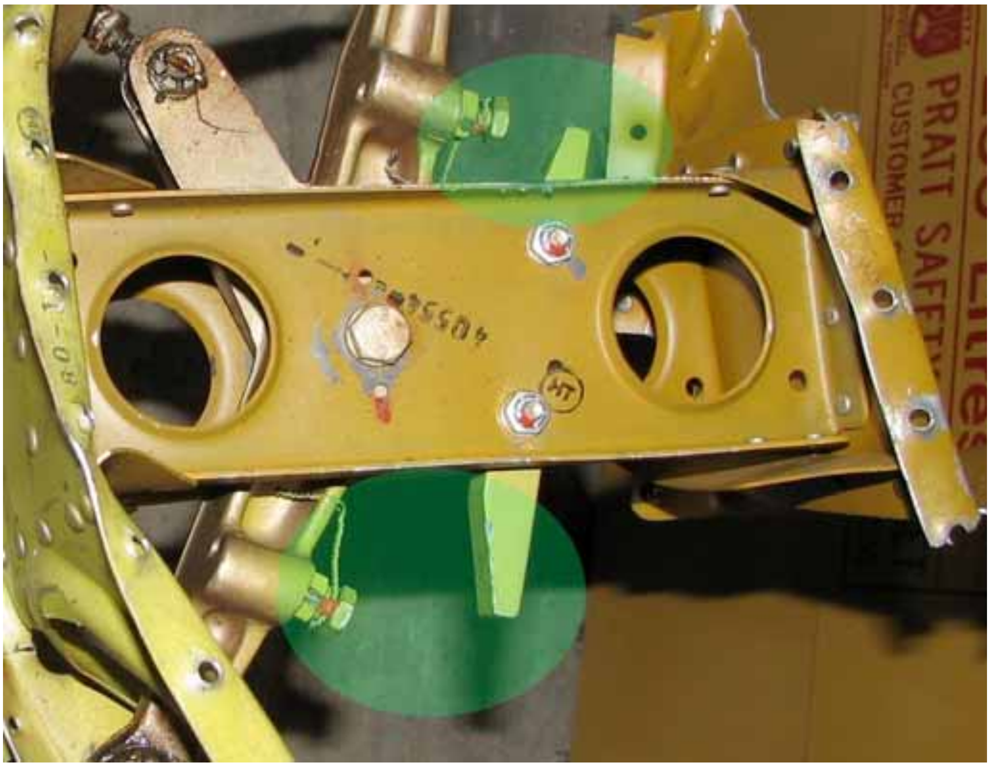
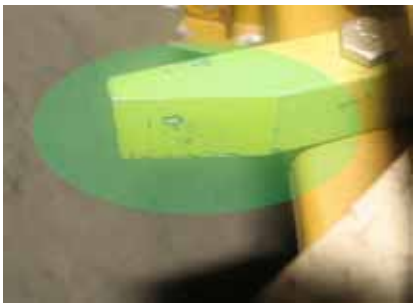
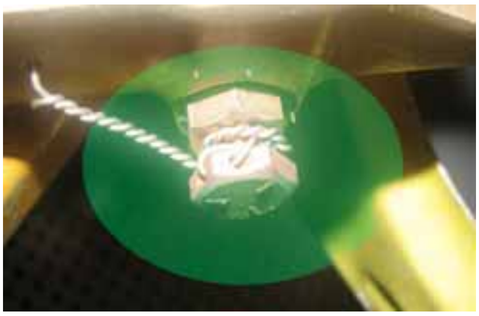


Figure 14: Right aileron stops showing absence of repetitive contact





- The right aileron balance weight had separated in the plane of the aileron.
- Compression creases on the left elevator suggested that the balance weight separated due to impact on its leading edge, rather than due to inertia loads only. The right elevator balance weight was missing and the surrounding structure offered no indication as to the mode of its separation.
- Neither the elevator, nor the elevator trim tab, showed abnormal deformation to suggest the presence of flutter (see also Section 1.16.3).
- The nature of the deformation to the recovered left wing skin segments suggested that the skin peeled off in a rearwards direction over the wing trailing edge.
- A tear at about the mid-span position of the left aileron indicated that it had folded upwards through at least 90 degrees at that location during the break-up sequence.

- Damage to the horizontal stabiliser suggested that it was struck by a solid object (such as part of a wing or the right engine), which penetrated through to the elevator leading edge.
- The elevator trim tab control rod remained securely attached to the trim tab. The trim tab cable drum and screw jack were securely attached to the stabiliser spar. Both control cables had failed in overload. The threaded shaft of the screw jack mechanism had failed in overload in the area of the cotter pin hole. Although the hole reduced the strength of the shaft, the residual strength was well in excess of any conceivable normal operating loads. Failure of the shaft could have been a result of the airframe breakup, or ground impact. It is also possible that the failure was induced when the screw jack was over-ridden to beyond the stop as the cables were stripped during the breakup.
- The left elevator remained attached to the stabiliser. Damage to the inboard leading edge of the elevator indicated that it may have been struck by a solid object. Both the stabiliser and the elevator were bent upwards along a line running diagonally from the location of the leading edge damage.
- There was no evidence of sooting on any of the separated wing pieces, as might have been expected from a fuel tank explosion.
- There was no evidence of scuff marks from fuel tank bladder material on the inner surfaces of the separated wing pieces, as might have been expected from a fuel tank explosion.

1.13 Medical information

Post-mortem examination results provided confirmation that the pilot in command occupied the right cockpit seat at the time of the accident. The other pilot was in the left cockpit seat. There was no evidence to suggest that either pilot suffered from any condition that might have affected their ability to operate the aircraft.

1.14 Fire

There was no evidence of pre-break-up fire damage on any of the pieces of the aircraft that were recovered from the wreckage trail, including the right engine.

Three small pieces of aircraft skin (items 5, 6, and 10) that were located between approximately 700 and 1200 m from the main wreckage were blackened, charred and showed signs of paint blistering. The following features were apparent on those pieces:

- there was no evidence of burning or melting of the metal
- blackening was present on both surfaces
- the clean appearance of surface scratches indicated that the scratching occurred after the blackening
- there was no evidence of streaking or pooling of molten metal
- the pieces had separated from the aircraft solely as the result of mechanical overload.

The United States Air Force has published a document titled *Safety Investigation*[16] which includes a chapter on aircraft fire investigation. That chapter included the following information:

- aircraft epoxy paint blisters at 454 – 510 degrees C
- aluminium sheeting melts at about 635 degrees C
- in-flight fire temperatures typically exceed 1370 degrees C due to the slipstream effect.

1.15 Survival aspects

The accident was not survivable.

1.16 Additional information

1.16.1 Weather related decision making

Weather-related general aviation accidents remain one of the most significant causes for concern in aviation safety. Many studies have highlighted the dangers associated with continued flight into adverse weather. For example, a 2005 Australian Transport Safety Bureau (ATSB) study [17] compared pilots who continued flying into adverse weather with those who took some form of weather avoidance action. The results emphasised that no group of pilots was immune to the dangers associated with adverse weather. Those who continued flying into adverse weather included pilots across wide levels of experience, conducting a broad range of flight operations, and in environments Australia-wide. The study was based on a set of 491 aviation accident and incident reports drawn from the ATSB occurrence database. The results highlighted that a safe pilot was a proactive pilot and that dealing with adverse weather did not involve a one-off decision, but was a continually evolving process.

The ATSB study indicated that how far a pilot was into a flight (that is, the proportion of the flight completed) was an important factor in influencing the decision making process. The most salient result was that pilots in the weather avoidance group took action in a timely manner, early in a flight. That is, they were proactive in their decision making by taking control of the situation before the situation took control of them. Conversely, pilots who continued flying into adverse weather apparently did not focus on, or react to, the prevailing weather conditions until relatively late in a flight. The flight of PYN was approximately three-quarters completed at the time of the accident.

The research also emphasised the dynamic nature of aeronautical decision making, in that a pilot may make a series of good decisions, but that is no automatic protection against a subsequent poor decision that might place the safety of a flight at risk. In such a situation, when the weather deteriorated further into a flight, the

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16 AF PAMPHLET 127 – 1, Volume II, 31 July 1987, Chapter 15, FIRE INVESTIGATION

17 http://www.atsb.gov.au/publications/2005/pilot_behaviours_adverse_weather.aspx.

options may have changed and the pilot may then be faced with a more difficult dilemma.

1.16.2 Recorded radar data

An examination of the radio line of sight coverage information for Mt Bobbara Route Surveillance Radar indicated that the position of the aircraft when radar contact was lost was close to the theoretical vertical and horizontal limit of radar coverage in the area. There was insufficient information to determine whether the aircraft maintained track and/or altitude for a period after radar contact was lost or whether the loss of contact occurred because the aircraft descended below radar coverage.

1.16.3 Trajectory analysis

Trajectory analysis involves relating the disposition, weight, and size of wreckage components to the atmospheric wind at various altitudes, to calculate the altitude and position at which the breakup occurred. The track of the aircraft at breakup can be established from the position of the aircraft at the time of the breakup and the location of an item of wreckage (such as an engine) that, by virtue of its momentum, would have continued in the direction of the aircraft’s track at the time of breakup.

There was no observed or actual wind data available for the Condobolin area. Recorded wind observations at Wagga Wagga, Cobar, and Forbes indicated that a representative wind speed in the Condobolin area at the time of the accident was likely to have been in the range of 40 to 60 kts.

On that basis, calculations were completed for wind speeds of 40, 50, and 60 kts. The calculations produced break-up altitudes of 5,510 ft (wind 40 kts), 4,560 ft (wind 50 kts), and 3,920 ft (wind 60 kts). These calculations are an estimate only because of the variability of the speed and direction of winds within or in the proximity, of thunderstorms. Also, winds associated with thunderstorm activity may include variable updrafts and downdrafts. The geographical location of the breakup was calculated (based on a wind speed of 50 kts) to have been approximately 1,100 m north-west of the position of the main wreckage.

Based on the last recorded radar position of the aircraft, the track of the aircraft at the time of breakup was 226 degrees T. That compared with 235 degrees T, the last recorded aircraft track.

1.16.4 Lightning activity

Analysis of lightning activity data confirmed that between 1349 (when radar contact was lost) and 1352.30 (sufficient time for the aircraft to have travelled about 20 km), lightning activity was concentrated predominantly in two areas; one was more than 8 km west and the other more than 17 km south of a line between the last recorded radar position and the location of the main wreckage. Those areas approximated the areas of precipitation evident on the weather radar images provided by the BoM and which are apparent to the left and right of the aircraft’s track in Figure 5. The nearest recorded strike was about 3.5 km from that line.

1.16.5 Aerodynamic flutter

Aerodynamic flutter is a phenomenon involving the high frequency oscillation of a structure under the interaction of aerodynamic and aero-elastic forces. Flutter can involve aircraft wings, primary flight control surfaces, or trim control tabs. When flutter occurs, it is often characterised by increasing amplitude, leading to structural failure. Flutter is prevented through a combination of structural design strength, the incorporation of control surface mass balance weights, and the application of aircraft performance limitations. Flutter should not normally occur within an aircraft's approved flight operating envelope. However, factors such as incorrectly rigged flight controls and loose control cables can lead to flutter at speeds within the flight envelope.

Typical post-accident evidence of wing flutter would include signs of excessive torsional and bending deformation to the upper and lower wing skin panels. Flutter in a control surface would cause it to move rapidly between the limits of travel set by the mechanical control stops, and for the balance weight to be stressed within its housing. Such movements would leave signatory damage to the surrounding structure, including the control stops.

1.16.6 Thunderstorm hazards

The BoM has published a *Manual of Meteorology* Part 2, *Aviation Meteorology* that devotes a chapter to thunderstorms. Pertinent extracts from that chapter include:

> Basically there are two groups – frontal and air mass thunderstorms. The former group includes squall line storms and the latter includes orographic and nocturnal thunderstorms. The main distinction between the two groups is that frontal type thunderstorms tend to be organised in lines, while air mass thunderstorms tend to be more scattered or isolated. The most severe frontal type storm will give worse flying conditions than the most severe air mass type.
>
> All thunderstorms are turbulent, although some a lot more than others, and some are potentially destructive to aircraft. In the last case, current knowledge leaves unresolved the question of whether or not the turbulence itself can be severe enough to cause an aircraft to break up in mid-air. Some cases in which this seems to have happened may have been caused by attempted recovery manoeuvres loading the aircraft beyond structural limitations when in severe turbulence.
>
> Vertical gusts produce the main turbulence hazards in thunderstorms. These are short period fluctuations imposed on the larger scale up and downdraughts.
>
> Strong vertical gusts occur anywhere in the storm but are most frequent and severe near adjacent up and down draughts in the mature storm. The danger in gusts is twofold:
>
> (a) severe loadings may be imposed on the aircraft structure;
>
> (b) violent changes in aircraft attitude may induce stall or other conditions in which an attempted recovery may exceed the design limitations of the aircraft.
>
> Radar will assist in avoiding the cells. But remember that radar identifies rain areas only. Severe turbulence can occur well away from the rain echo and the body of the cloud, so keep a good distance from all cells if possible.

In 1983, the US Federal Aviation Administration (FAA) published Advisory Circular 00-24B which described the hazards of thunderstorms and offered guidance to pilots. It included the following statements:

> Potentially hazardous turbulence is present in all thunderstorms, and severe thunderstorms can destroy an aircraft.
>
> Outside the cloud, shear turbulence has been encountered several thousand feet above and 20 miles laterally from a severe storm.

Advisory Circular AC 00-24B is reproduced in full at Appendix C.

1.16.7 Recent safety alert to United States pilots

In October 2006, the US National Transportation Safety Board issued a Safety Alert brochure - *Thunderstorm Encounters*[18], following a number of recent investigations that identified accidents that had been wholly or partly attributable to [aircraft] encounters with severe weather.

The brochure reminded pilots that ‘severe weather avoidance is primarily your responsibility’ but that controllers can assist, when workload permits, in providing either additional services and/or information. It added that ‘the proper use of ATC weather advisory services may be critical to your safety when operating near areas of convective activity’.

18 A copy of the safety alert is available at http://www.ntsb.gov/alerts/SA_011.pdf.

2 ANALYSIS

It was apparent from the wide wreckage dispersion that the aircraft structure broke up during flight. There was no indication, either by way of emergency radio transmission from the pilot, or in changes in the altitude, track, and speed of the aircraft as recorded by radar, that the flight was not proceeding normally before radar contact was lost.

The wreckage examination did not reveal any pre-existing fault or condition that could have weakened the aircraft structure and caused it to break up at a load that was below the design load limit.

2.1 The in-flight breakup

No information was available regarding the aircraft's flight profile between the time radar contact was lost and the breakup. The wreckage pattern and the trajectory analysis implied that the aircraft completed a manoeuvre, or a series of manoeuvres that resulted in it descending more than 4,000 ft before being subjected to loads that exceeded its structural limits. However, that analysis was based on assumptions regarding the local wind and the aircraft's track. At best, therefore, the analysis results may be indicative only of the aircraft's altitude and track when the breakup occurred.

The absence of any radio transmission from the pilot after radar contact was lost could indicate that the aircraft was influenced by a sudden, major event that arose with little or no warning, denying the pilots any chance of transmitting a distress message. Similarly, the workload involved in coping with such an event could have precluded the transmission of a distress message.

None of the recovered wing panel sections exhibited evidence of excessive torsion/bending deformation as would be expected if wing flutter had occurred. The possibility of aileron flutter was nullified by the undamaged condition of the right aileron control stops. Neither the elevator, nor the elevator trim tab exhibited deformation consistent with flutter. Based on that evidence, it is unlikely that aerodynamic flutter contributed to the breakup.

The nature of the damage to the outer wing sections indicated that the loads were not sufficient to cause the wings to separate as complete sections, but were great enough to cause structural deformation of the outer wings that resulted in partial lifting or loss of a wing skin panel. Damage of that nature could lead to a progressive shedding of pieces of wing due to aerodynamic loads. Loss of structural integrity would have resulted, leading to rapid and dramatic changes in the aerodynamic load conditions on the aircraft. Consequently, the aircraft would have been destabilised in yaw, pitch, and roll.

It is possible for the aircraft to have been destabilised to the extent that it was momentarily subjected to aerodynamic loads from the left or right side, or from the rear. For example, the profile and edge features of the recovered right wing leading edge panel (Figure 12) suggested that it was torn from the wing structure by aerodynamic loads from a rearwards direction relative to the wing structure. The situation may have been aggravated by additional stresses and spar deformation due to associated engine vibrations as the airflow through the propellers fluctuated. The twisting evidence presented by the remains of the empennage that were attached to the main wreckage indicated that the aircraft was subject to extreme rolling forces at some stage during the breakup.

There was no evidence that the aircraft had been struck by lightning or that there had been an in-flight explosion such as a fuel tank explosion. Although the condition of the main wreckage precluded a complete examination, the absence of recorded lightning strike activity in the immediate vicinity of the aircraft around the time radar contact was lost indicated that the aircraft was less, rather than more, likely to have been struck by lightning.

The location along the wreckage trail of the blackened aircraft pieces indicated that they had separated later in the break-up sequence than the items that showed no heat or fire effects. The extent and nature of the damage to the blackened pieces indicated that the event that caused the blackening was not intense or sustained. Rather, the evidence pointed to the presence of a fire of low intensity. The nature of the scratching damage to the blackened pieces indicated that the blackening occurred before the pieces separated from the aircraft. A likely explanation for those features is that late in the break-up sequence, fuel from a ruptured tank ignited, leading to the blackening observed on the wreckage pieces.

The nature of damage to the main wreckage indicated that the fire was fuel-fed. It may have been a continuation of the fire that caused the blackening to the pieces found along the wreckage trail. Alternately, there may have been a short duration 'fire ball' type event before the main wreckage impact, followed by another fire that began after impact, when spilled residual fuel from an intact tank ignited.

Because the extent of damage prevented the auto-pilot system being examined, the status of that system could not be confirmed. A malfunction of the auto-pilot system, either as a lone event, or in conjunction with a turbulence encounter, could have played a part in the circumstances that led to the breakup. However, there was insufficient evidence upon which to form any assessment as to the level of such a possibility.

Overall, in considering the breakup, there was sufficient evidence from the examination of the wreckage, and its disposition, to include exceedance of the aircraft's structural limits as a contributing factor to the accident. There was insufficient evidence to conclude that an in-flight fire or explosion contributed to the breakup.

2.2 The prevailing weather

The weather radar images, coupled with the recorded air traffic control radar information, suggested that the aircraft may have been funnelled between two lines of cells, possibly leaving the pilot no alternative but to attempt to fly through a gap between cells if they wanted to comply with the owner's wishes to fly visually.

There was no means of establishing whether the aircraft was in cloud at that time, or how far the aircraft was from cloud. However, against the background of the aircraft owner's practice regarding non-visual flight, the experience level of the pilot and his relationship with the owner, it seems highly unlikely that they would have penetrated cloud deliberately, particularly any cloud associated with thunderstorms. Given the aircraft's intended track in relation to the line of thunderstorms and the direction of their progress, from west to east, the potential for the aircraft to enter cloud unintentionally, was probably increased. This would be particularly so if it had been subjected to an in-flight upset.

The aircraft was certainly operating in the vicinity of thunderstorm cells at the time of the accident. Those conditions brought with them the possibility of an encounter with turbulence, even at a distance of several kilometres from cloud formations. Turbulence of sufficient strength had the potential to cause structural damage to the aircraft and/or disturb it from controlled straight and level flight into an extreme or unusual attitude. If the latter occurred, causing the aircraft to stall or placing it in a nose-low attitude with increasing speed, it is possible for the structural limits to have been exceeded during an attempt to return the aircraft to normal straight and level flight conditions, particularly in the presence of vertical gusts embedded in updraughts and downdraughts. If the conditions were sufficiently extreme, it is possible for the aircraft to have been disturbed from controlled flight repeatedly. Such conditions would have placed the pilot under extreme workload and stress levels, irrespective of whether the aircraft was in clear air or in cloud.

The proximity of the aircraft to the storm cells and the severe weather associated with those cells was considered sufficient justification to include the prevailing weather conditions as a contributing factor to the occurrence.

2.3 Weather-related pilot decisions

The evidence allowed some conclusions to be drawn regarding the pilot's knowledge of the weather conditions likely to be encountered during the flight:

- The Area 22 weather forecast that the pilot obtained before the flight included thunderstorms east of a line from Bourke to Griffith. He should have been aware, therefore, that there may have been storms en route, and of their location. His comment to the refueller at Archerfield that conditions for the return flight were 'patchy' could be interpreted as confirmation of that knowledge.
- The recorded air traffic control information included radio transmissions related to pilots of other aircraft diverting off track due to weather. It was likely that the pilot of PYN overhead some or all of those transmissions.
- There was no evidence from the recorded radio transmissions of any request from the pilot for an update on the weather situation after the aircraft departed Archerfield.
- The track diversions made by the aircraft after passing Coonamble, confirmed by the recorded radar data, indicated that the pilot was aware of weather ahead of the aircraft and had made a series of decisions to remain clear of that weather.

There was no means of determining the visual weather picture, and its rate of change, that was evident from the cockpit of PYN. Without that information, it was difficult to form any positive conclusions regarding the pilot's decision making and any associated level of risk. The risk averse practice followed by the pilot and the aircraft owner regarding flight in weather suggested that the cruise and weather diversion segments of the flight would not have continued had either party been concerned about the weather ahead. That argument adds weight to the possibility that the conditions that precipitated the breakup occurred in cloud-free, clear conditions.

Nevertheless, the assessment by the Bureau of Meteorology (BoM) that ‘immediately prior to the accident, the aircraft was likely to have been surrounded on the west, south and east sides (that is, inside the ‘Y’) by a large complex of storms’ may reflect the research summarised at Section 1.16.1. That is, early decisions regarding weather conditions may have led to more difficult dilemmas in the face of (possibly rapidly) deteriorating conditions as the flight progressed.

2.4 Aircraft weather radar and/or lightning detection systems

Aircraft weather radar and/or lightning strike information would have provided the pilot with additional information regarding the weather ahead of the aircraft. In that context, there was potential for it to have assisted the pilot in making decisions regarding weather avoidance. However, there was insufficient information available from which to assess the level of that contribution, or its significance. Therefore, the absence of those systems could not be included as a contributory factor to the accident.

2.5 Airservices Australia assessment of SIGMET information

SIGMET SY01, received by Airservices Australia from the BoM at 1127, notified conditions that had been assessed by the BoM as being potentially hazardous to aviation. The Airservices Australia hazard alert procedures involved examining SIGMET (amongst other) information to determine if it was ‘critical and unexpected’. At face value, that process involved Airservices Australia re-assessing information that had already been assessed as potentially hazardous to aviation by the BoM, the pre-eminent national weather forecasting organisation. Put more simply, it involved expert meteorologist opinion being re-evaluated by individuals who were not expert meteorologists and the terms ‘critical’ and ‘unexpected’ were undefined. Such a situation could result in inappropriate and inconsistent assessments of SIGMET (and possibly other meteorological) information being made by Airservices Australia personnel.

The preceding observations raise the question as to whether Airservices Australia should have assessed the SIGMET information as ‘unexpected and critical’. It could reasonably be argued that storms, per se, were not ‘unexpected’ because they had been included in the Area 22 forecast issued at 0220. The criticality of the SIGMET information could be viewed in a similar manner. On the other hand, the increased frequency of the storms that the SIGMET highlighted could be interpreted as ‘unexpected’ because it was not forecast. It could also be argued that the increase in thunderstorm activity from ‘occasional’ to ‘continuous observed’ was critical information.

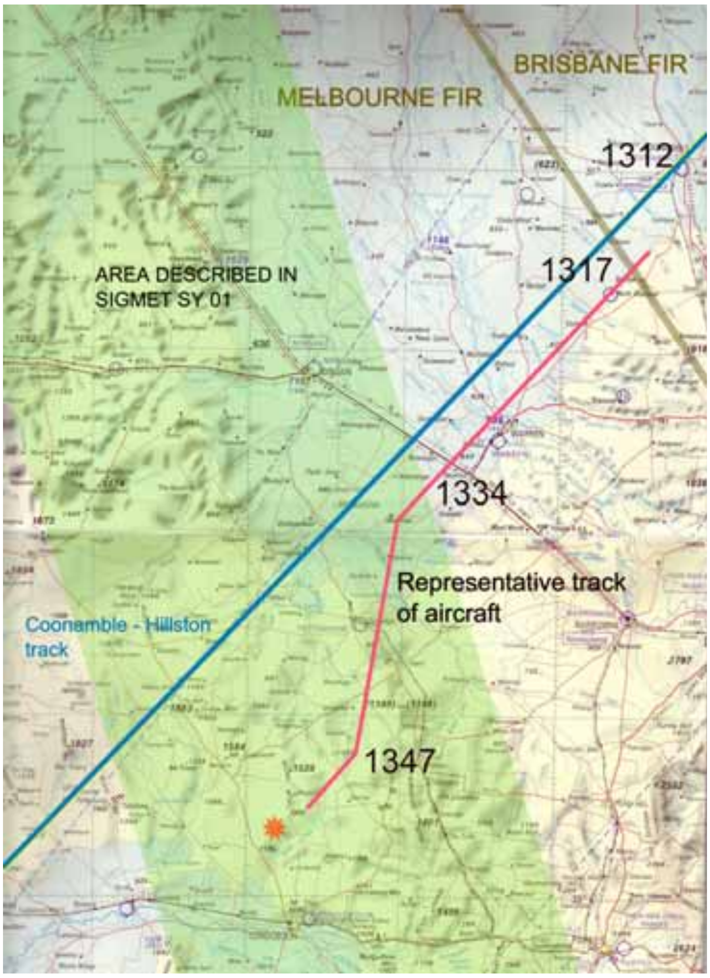
From a safety perspective, the process of assessing whether information represents an aviation hazard should be determined by the information that has the highest level of reliability assurance, in terms of both factual content and expert judgement – in the case of SIGMETs, that is the BoM. Further, in the case of thunderstorms, the criteria listed in the Aeronautical Information Publication (Australia) and by which the BoM issued SIGMETs for thunderstorms (obscured, embedded, or frequent) imply a strong argument for such information to automatically be classified as meeting the 'unexpected and critical' criteria. The use of Airservices Australia personnel to assess SIGMET information against undefined assessment criteria appears to lack safety and quality assurance (see also Section 3, Safety Action).

There was insufficient evidence to classify the assessment of SIGMET information by Airservices Australia personnel as a contributory factor to the occurrence. However, there was sufficient evidence to classify the assessment of such information by Airservices Australia personnel as another safety factor.

2.6 Provision of SIGMET information to PYN

Figure 15 depicts key information regarding the flight after the aircraft passed overhead Coonamble. It shows the planned track from Coonamble to Hillston (blue line), and a representation of the actual track taken by the aircraft based on recorded radio and radar data (red line). The local times that the aircraft was at specific locations appear in black. The diagram also shows the Brisbane/Melbourne Flight Information Region (FIR) boundary (brown) and the area described in SIGMET SY01 (shaded green).

Figure 15: Key flight information after Coonamble



Because the area described in SIGMET SY01 fell within the Melbourne FIR, there was no responsibility on the part of air traffic service agencies covering the

Brisbane FIR regarding any hazard alert associated with the SIGMET. Therefore, air traffic control sectors within the Melbourne FIR had the task of assessing the SIGMET and determining any follow-up action. However, because the aircraft was outside 1 hour of flight time[19] of the hazard when the SIGMET was issued, and in accordance with air traffic control procedures, at that time there was no requirement for the information to be passed to the pilot.

The question then arises as to whether the conduct of the flight would have been different if the pilot had received SIGMET SY01. The significant feature of the SIGMET information was that the level of storm activity had increased. The absence of any report from the pilot regarding the nature of the in-flight weather, or of any request by the pilot to FLIGHTWATCH or to the sector controller for weather information, could indicate that the pilot held no concern about the weather and/or was happy to rely on a visual assessment. A decision in such circumstances might not normally need to be made until the aircraft was within a few minutes flight time of cloud. In any case, the availability of numerous suitable diversion airfields en route for the aircraft to land until the weather passed may have encouraged the pilot to continue the flight while assessing the weather visually.

In a context similar to that relating to aircraft weather radar, the passing of SIGMET SY01 information to the pilot would have added to the pool of weather information available to the pilot. However, it was not possible to gauge whether the pilot would have assessed the SIGMET information as a reason to conduct the flight any differently. On that basis, the fact that SIGMET SY01 was not passed to the aircraft could not be included as a contributing factor in the occurrence.

2.7 Cockpit seating positions

Both pilots were endorsed to fly the aircraft type. The flight instructor qualification held by the pilot in command allowed him to occupy the right cockpit seating position for the flight. The observer-pilot had been endorsed on the aircraft and was qualified to occupy a control seat. The investigation drew no significance from the seating positions of the pilots as determined by wreckage and forensic examination.

19 The aircraft was also outside the 2-hour flight time specified in ICAO Doc. 9673 and ICAO Doc. 7030.

3 FINDINGS

3.1 Contributing factors

- A line of thunderstorms crossed the aircraft's intended track.
- The aircraft was operating in the vicinity of thunderstorm cells.
- In circumstances that could not be determined, the aircraft's load limits were exceeded, causing structural failure of the airframe.

3.2 Other safety factors

- Air traffic control procedures, did not require the SIGMET information to be passed to the aircraft.
- There were shortcomings in the Airservices Australia Hazard Alert procedures and guidelines for assessing SIGMET information.
- Air traffic control procedures for the dissemination of SIGMET information contained in the Aeronautical Information Publication were inconsistent with procedures contained in International Civil Aviation Organization (ICAO) Doc. 4444 and ICAO Doc. 7030.

3.3 Other key findings

- The aircraft was not equipped with weather radar or lightning strike detection systems.
- The pilot did not make any request for additional information regarding the weather to air traffic services.
- The pilot in command was occupying the right cockpit seat and the observer- pilot the left cockpit seat at the time of the breakup, but that arrangement was not considered to have influenced the development of the accident.

4 SAFETY ACTION

4.1 Civil Aviation Safety Authority

The Civil Aviation Safety Authority (CASA) has recently provided information to pilots in relation to aviation meteorology generally and more specifically in relation to operating in and around thunderstorms, particularly in the following Flight Safety Australia articles:

- *Observing the weather – an overview from the Bureau of Meteorology* - Flight Safety Australia, March – April 2007
- *Into the abyss – Southern Cloud accident reviewed* - Flight Safety Australia, July – August 2006
- *No way out – a meteorological maze* - Flight Safety Australia, May – June 2006.

In February 2006, following the investigation (200402797) of a fatal accident involving a Piper Cheyenne near Benalla, Vic. that impacted terrain and burnt and the consequent lack of information from such accident sites, the ATSB issued the following recommendation to CASA:

> R20060004
>
> The Australian Transport Safety Bureau recommends that the Civil Aviation Safety Authority (CASA), review the requirements for the carriage of on-board recording devices in Australian registered aircraft as a consequence of technological developments.

On 11 May 2006, CASA advised that:

> The Civil Aviation Safety Authority will analyse the cost benefit of the recommendation regarding the carriage of on-board recording devices to this type of operation.

On 17 July 2007, CASA advised that:

> On the issue of on-board recording devices, this is a cost and maintenance burden with existing equipment. Low cost/new technology units are not currently available. CASA will continue to monitor this.

On 7 September 2007, CASA advised that:

> As you are aware, on 11 May 2006 CASA advised of an intention to conduct a cost/benefit analysis of the recommendation regarding the carriage of on-board recording devices to this type of operation.
>
> I understand that CASA has previously investigated this matter and, based on the equipment available at the time, could not justify mandating carriage of recording devices on low capacity aircraft. However, given other priorities, this has not yet been confirmed by way of a cost/benefit analysis.
>
> I have now directed that a cost/benefit analysis be undertaken. I expect to have a result before the end of the year and will forward the results to you.

4.2 Airservices Australia

In February 2006, Airservices Australia issued a Focus of the Month newsletter titled *What's the news on 'Hazard Alert Services'.* The newsletter explained that hazard alert information included 'any information that constitutes a physical danger to the safe flight or increases fuel carriage requirements'.

On 11 May 2007, Airservices Australia issued National Information Circular No: NIC 08/2007. The circular was the result of an extensive review of the Flight Information Service, including hazard alerting that was initiated in November 2004. That circular included a section titled *Background Information*, part of which stated:

> The Review of the Hazard Alert Service by DSEA [Directorate of Safety and Environmental Assurance] in Nov 2004 identified inconsistencies and ambiguities in the provision of Flight Information Service (FIS) and the expectations of both ATC and the industry. These ambiguities had evolved through disparate interpretations of the requirements leading to the creation of detailed instructions, at different levels, of documentation, which are not clearly aligned to international guidelines.
>
> The subsequent study undertaken to action the recommendations of the DSEA report identified a greater deficiency in the total and consistent application of FIS as part of our Air Traffic Services requirements as described by ICAO Annex 11.
>
> Hazard alerting is a component of FIS that has evolved as a separate function (Hazard Alert Service). This is not the design intent of hazard alerting and is to the detriment of the total FIS requirement. The MATS [Manual of Air Traffic Services] & AIP [Aeronautical Information Publications] sections describing FIS and Hazard Alerts have been rewritten (AL12/AL51 Effective 07 June 2007) to emphasise that the ATC responsibility is primarily to notify pilots of the availability of elements of FIS.

Pertinent rewritten sections of AIP GEN 3.3 AIR TRAFFIC SERVICES included the following:

> 1. **GENERAL**
>
> 1.1 The objectives of the air traffic services are to:
>
> a. prevent collisions between aircraft;
>
> b. prevent collisions between aircraft on the manoeuvring area and obstructions on that area;
>
> c. expedite and maintain an orderly flow of traffic;
>
> d. provide advice and information useful for the safe and efficient conduct of flights; and
>
> e. notify appropriate organisations regarding aircraft in need of search and rescue aid, and assist such organisations as required.
>
> 2. **FLIGHT INFORMATION SERVICE**
>
> 2.1 **Pilot Responsibility**

2.1.1 Pilots are responsible for requesting information necessary to make operational decisions.

2.2 Operational Information

2.2.1 Information about the operational aspects of the following subjects is normally available from ATS:

a. meteorological conditions;

b. air routes and aerodromes, other than ALAs [authorised landing areas]

c. navigation aids;

d. communications facilities;

e. ATS Procedures;

f. airspace status;

g. hazard alerts;

h. search and rescue services;

i. maps and charts; and

j. regulations concerning entry, transit and departure for international flights.

2.3 Preflight Information (CAR 239)

2.3.1 Before beginning a flight, the pilot in command must study all available information appropriate to the intended operation. This requirement includes all Head office and FIR NOTAM [Notices to Airmen] applicable to the en route phase of flight and location specific NOTAM for aerodromes.

2.3.2 The Pre-flight Briefing Service is primarily an automated service. Pilots are encouraged to obtain pre-flight briefing, either via the self-help electronic systems or through the briefing offices. These services are listed in ERSA GEN [En route Supplement Australia – General].

2.3.3 For pilots who require an elaborate briefing, contact numbers for ATS and Bureau of Meteorology (BoM) staff are available from the briefing offices.

2.3.4 Pilots must obtain an appropriate pre-flight briefing before departure from those places where suitable facilities exist. Where suitable facilities are not available, briefing may be obtained from FLIGHTWATCH as soon as practicable after the flight commences. The information requested should be confined to data considered essential for the safe conduct of the flight to the first point of intended landing where additional information can be obtained.

2.3.5 Preflight briefing will not normally be provided on ATC communications channels.

2.4 In-flight Information

2.4.1 The in-flight information services are structures to support the responsibility of pilots to obtain information in-flight on which to base operational decisions relating to the continuation or diversion of a flight. The service consists of three elements:

a. ATC initiated FIS

b. Automatic Broadcast Services; and

c. an On-Request Service.

2.5 **ATC Initiated FIS**

2.5.1 ATC initiated FIS will include the provision of pertinent operational information such as:

a. meteorological conditions and the existence of non-routine MET products;

b. changes to air routes;

c. changes to serviceability of navigation facilities, eg. RAIM[20];

d. change to serviceability of communications facilities;

e. changes to conditions of aerodromes and associated facilities;

f. changes to ATS procedures;

g. changes to airspace status; and

h. information on unmanned free balloon (including “Operation Hibal” activities).

2.5.2 ATC initiated advice is generally limited to aircraft within one hour flight time of the condition or destination at time of receipt of the information by ATC. Pilots must consider this when complying with para 2.1.1 so that accurate information is received in adequate time.

2.5.3 A sudden (not forecast NOTAMed) change to a component of FIS having an immediate and detrimental effect on the safety of an aircraft will be communicated by ATC using the prefix “Hazard Alert”.

2.5.4 ATC broadcasts prefixed by “Hazard Alert” will be made at H+15 and H+45 in the hour following the initial transmission while awaiting updated or amended MET Products or NOTAM.

20 RAIM means Receiver Autonomous Integrity Monitoring as it relates to predicting the availability of Global Positioning System (GPS) signals for air navigation at particular locations.

4.3 Recommendations

While not contributory to the accident, the investigation identified a safety issue relating to inconsistency in air traffic control procedures for SIGMET information dissemination contained in the Aeronautical Information Publication compared with those contained in International Civil Aviation Organization (ICAO) Doc. 4444 and ICAO Doc. 7030.

The ATSB does not have the resources to carry out a full cost-benefit analysis of every recommendation. The cost of any recommendation must always be balanced against its benefits to safety, and aviation safety involves the whole community. Such analysis is a matter for the body to which the recommendation is addressed. As such, the ATSB issues the following safety recommendations.

ATSB safety recommendation R20070025

The Australian Transport Safety Bureau recommends that the Civil Aviation Safety Authority, in consultation with Airservices Australia, review the requirements for the dissemination of SIGMET information with a view to minimising differences between air traffic control procedures contained in the Aeronautical Information Publication and those contained in ICAO Doc.4444 and ICAO Doc.7030.

ATSB safety recommendation R20070026

The Australian Transport Safety Bureau recommends that Airservices Australia, in consultation with the Civil Aviation Safety Authority, review the requirements for the dissemination of SIGMET information with a view to minimising differences between air traffic control procedures contained in the Aeronautical Information Publication and those contained in ICAO Doc.4444 and ICAO Doc.7030.

5 APPENDIX A: WEATHER FORECAST AREA 22

011520 YSRFYMYX*

AMENDED AREA FORECAST 011520 TO 020500 AREA 22

OVERVIEW:

A SURFACE TROUGH NEAR APOMA/YIVO/YBRN, EXPECTED NEAR BRR/YGTH BY 23Z, THEN YCBR/YCOM BY 05Z. ISOLATED SHOWERS, TENDING SCATTERED E OF YBKE/YGTH AFTER 23Z. ISOLATED THUNDERSTORMS E OF TROUGH AND WITHIN 120NM W OF TROUGH, TENDING OCCASIONAL E OF YBKE/YGTH AFTER 23Z.

SUBDIVISIONS:

A: E OF TROUGH

B: W OF TROUGH

WIND:

	2000	5000	7000	10000	14000	18500
A:	010/30	350/30	340/25	330/30 PS06	330/40 MS03	330/45 MS11
B:	270/25	300/25	310/25	320/30 ZERO	330/50 MS08	330/60 MS17

CLOUD:

ISOL/OCNL CB 5000/40000 AS PER OVERVIEW.

LOCALLY BKN ST 2000/5000 NEAR SHRA/TSRA, CHIEFLY E OF YBKE/YGTH.

LOCALLY BKN CU 5000/10000, OCNL TOPS 20000.

AREAS BKN ACAS ABOVE 10000 E OF TROUGH AND WITHIN 120NM W OF TROUGH.

WEATHER:

TSRA, SHRA

VISIBILITY:

3000M TSRA, 5000M SHRA

FREEZING LEVEL:

10500 SW / 13000 NE, LOWERING TO 6000 IN SW BY 05Z.

ICING:

MOD IN CLD ABV FZL.

AMD TURBULENCE:

MOD IN CU AND AC.

OCNL MOD BLW 5000FT.

*Amended area forecast Area 22 valid from 0220 EDT on 2 Dec until 1600 EDT on 2 Dec issued at 0220 EDT on 2 Dec by the Bureau of Meteorology.

Overview: A surface trough is near a line from APOMA, Ivanhoe to Balranald, expected near a line Barringun Griffith by 1000 EDT, then near a line Collarenebri Cooma by 1600 EDT. Isolated showers, tending scattered east of Bourke Griffith after 0800 EDT. Isolated thunderstorms east of the trough and with 120 nautical miles (222 km) west of the trough, tending occasional east of Bourke Griffith after 1000 EDT.

Wind: East of the trough at 10,000 ft 330 degrees at 30 knots, temperature plus 7 degrees centigrade and west of the trough at 10,000 ft 320 degrees at 30 knots, temperature zero centigrade.

Cloud: Isolated/occasional cumulonimbus cloud, base 5,000 ft and tops 40,000 ft, as per overview. Locally broken stratus cloud, base 2,000 ft tops 5,000 feet near the showers of rain/thunderstorms with rain after 1000 EDT, chiefly east of Bourke Griffith. Locally broken cumulus cloud, base 5,000 ft tops 10,000 ft with occasional tops to 20,000. Areas of broken altocumulus/altostratus cloud, above 10,000 ft, east of the trough and within 120 nautical miles west of trough.

Weather: Thunderstorms with rain and showers of rain.

Visibility: Reducing to 3,000 metres associated with thunderstorms with rain and 5,000 metres associated with showers of rain.

Freezing level: 10,500 ft in the southwest and 13,000 ft in the northeast, lowering to 6,000 ft in the southwest by 1600 EDT.

Icing: Moderate in cloud above the freezing level.

Amended turbulence: Moderate in cumulus and altocumulus cloud and occasionally moderate below 5,000 ft.

6 APPENDIX B: SIGMET SYDNEY 01

020027 YSRFYMYX*

WSAU21 ASRF 020030

YMMM SIGMET SY01 VALID 020030/020330 YSRF – MELBOURNE FIR

FRQ TS OBS WITHIN 60NM OF LINE S3100E14600 TO S3500E14730 MOVING SLOWLY E. INTST NC.

STS: NEW=

*SIGMET (significant weather) number Sydney 1 valid 1130 EDT until 1430 EDT for the Melbourne flight information region.

Frequent thunderstorms (cumulonimbus clouds with little or no separation between them) observed within 60 nautical miles (111 km) of a line from latitude S31 00 longitude E146 00 to latitude S35 00 longitude E147 30 and moving slowly east. Intensity no change.

7 APPENDIX C: BUREAU OF METEOROLOGY REPORT

Australian Government
Bureau of Meteorology

Air Safety Incident Report
Weather Summary

Condobolin

2nd December 2005
0250 UTC

Prepared by: Andrea Henderson*
Date: 20th December 2005

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Executive Summary

An active frontal system moved through central New South Wales on 2 December 2005. The front was accompanied by a line of frequent thunderstorms stretching from southern Queensland through New South Wales and into Victoria. Satellite, radar and ground observations all show that the frontal system and associated thunderstorms passed through Condobolin at approximately 0240 UTC. As the front moved through, a 110-degree change in the wind direction was observed with a sharp fall in the temperature, an increase in the surface pressure and a short period of intense rainfall. Forecasts valid for the time of the incident adequately depicted the deteriorating conditions, and a SIGMET warning for the line of thunderstorms had also been issued approximately 2 hours prior to the incident.

Aviation Forecasts Issued

Condobolin lies in Area 22, under the Aviation Area Forecast System. From 1520 UTC on 1 December 2005 the Area 22 forecast indicated thunderstorms were present near and east of the trough line, and would become occasional east of Griffith to Bourke after 23Z (see Appendix 6: Area Forecasts). This was an amended forecast, though still provided sufficient lead-time for thunderstorm development. The 2300 UTC issue of the Area 22 forecast was consistent, with no change to the thunderstorm area or intensity. At 0030 UTC, the Area 22 forecast was amended to increase the thunderstorms to frequent east of Bourke to Griffith, and a SIGMET was issued for this line. The sequence of SIGMETs issued on the day appear below. The SIGMET was reviewed at 0300 UTC and 0600 UTC to update the coordinates of the line of frequent thunderstorms.

```
YMMM SIGMET SY01 VALID 020030/020330 YSRF- MELBOURNE FIR
FRQ TS OBS WITHIN 60NM OF LINE S3100E14600 TO S3500E14730
MOVING SLOWLY E.INTST NC.
STS: NEW=

YMMM SIGMET SY02 VALID 020300/020600 YSRF- MELBOURNE FIR
FRQ TS OBS WITHIN 60NM OF LINE S2900E14630 TO S3445E14700
MOVING SLOWLY E. INTST NC.
STS: REV SY01 VALID 020030/020330=

YMMM SIGMET SY03 VALID 020600/020900 YSRF- MELBOURNE FIR
FRQ TS OBS WITHIN 60NM OF LINE S2900E14830 TO S3130E14900 TO
S3300E14930 TO S3600E14830 MOVING SLOWLY E. INTST NC.
STS: REV SY02 VALID 020300/0206000=
```

The timing of the change remained the same throughout the area forecasts, with the front expected to extend from Goodooga to Parkes by 0500 UTC. Observations show that the front went through Parkes at 0408 UTC. Therefore the area forecast provided an accurate expectation of actual weather conditions.

In addition to the Area Forecasts, the Terminal Aerodrome Forecasts (TAFs) valid for Condobolin, Dubbo and Parkes also had thunderstorms forecast (see Appendix 7: Terminal Aerodrome Forecasts). All three locations, had INTER periods of thunderstorms with variable winds gusting up to 45 knots, visibility reducing to 3000m and broken cloud at 1000 feet. Moreover, all three TAFs had moderate turbulence below 5000 feet forecast.

In summary, the forecasts valid at the time of the incident were consistent with the observed conditions, and provided adequate warning of deteriorating conditions.

Appendix 1: Surface Charts

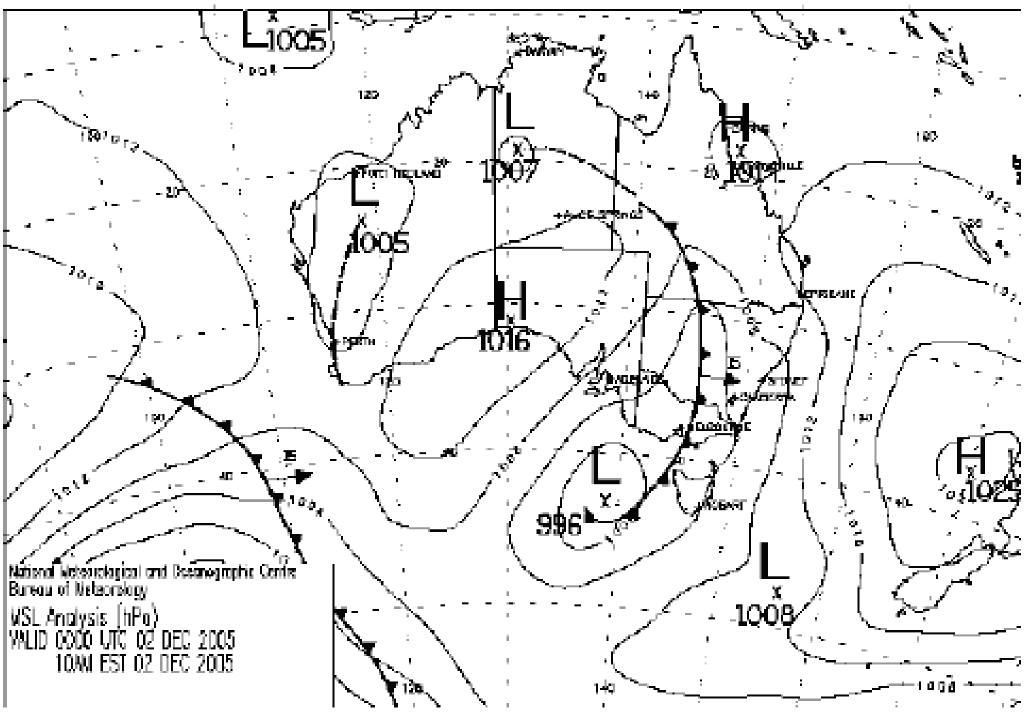

Figure 1: Mean Sea Level Pressure Analysis, 0000 UTC 2 December 2005

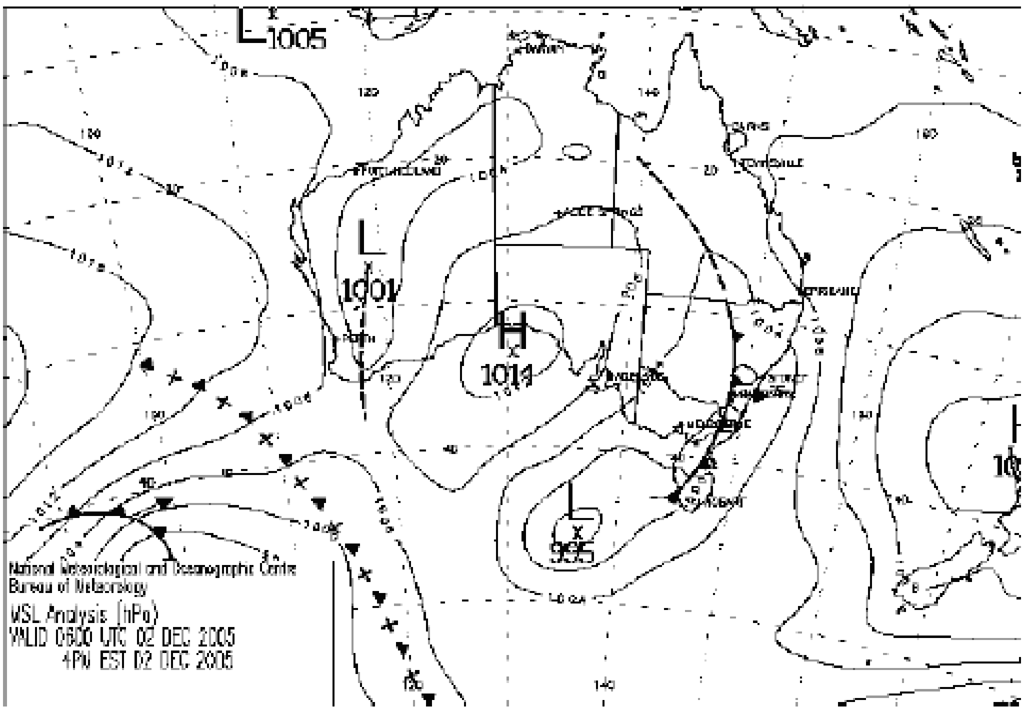

Figure 2: Mean Sea Level Pressure Analysis, 0600 UTC 2 December 2005

Appendix 2: Satellite Images

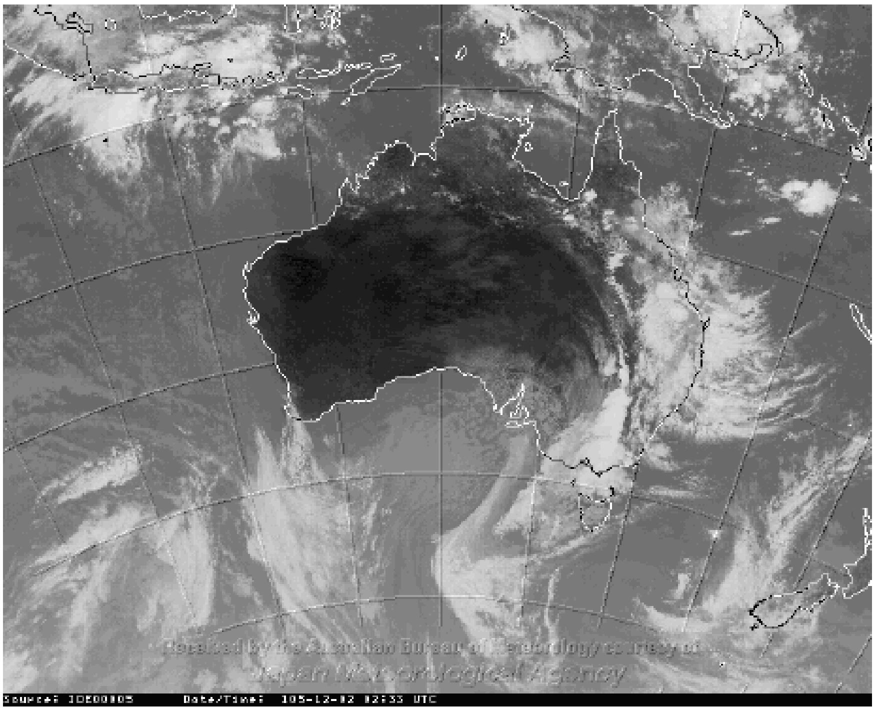

Figure 3: Infrared Satellite Image, 0230 UTC 2 December 2005

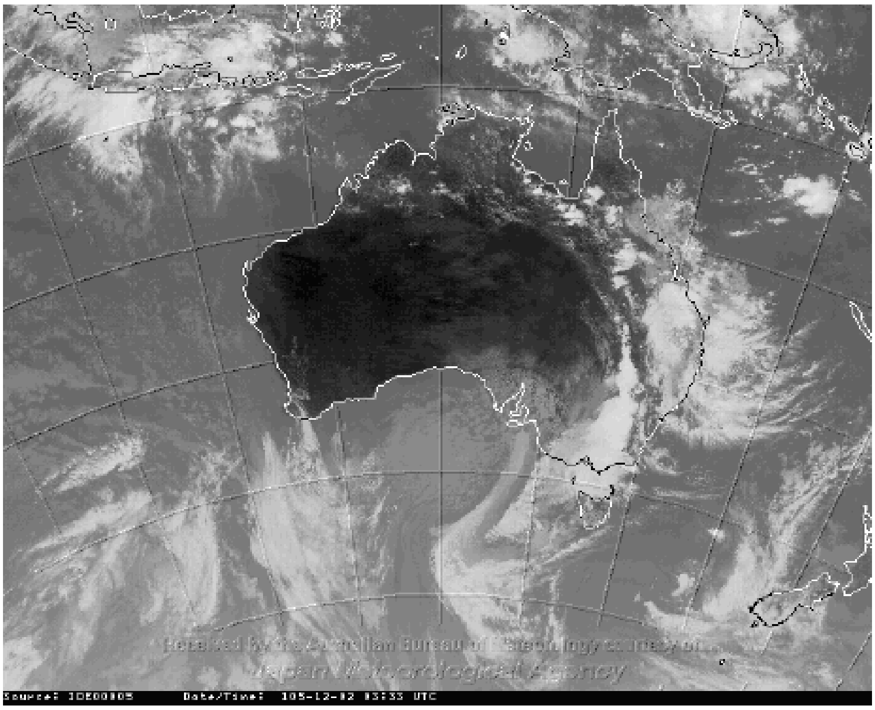

Figure 4: Infrared Satellite Image, 0330 UTC 2 December 2005

Appendix 3: Radar Images

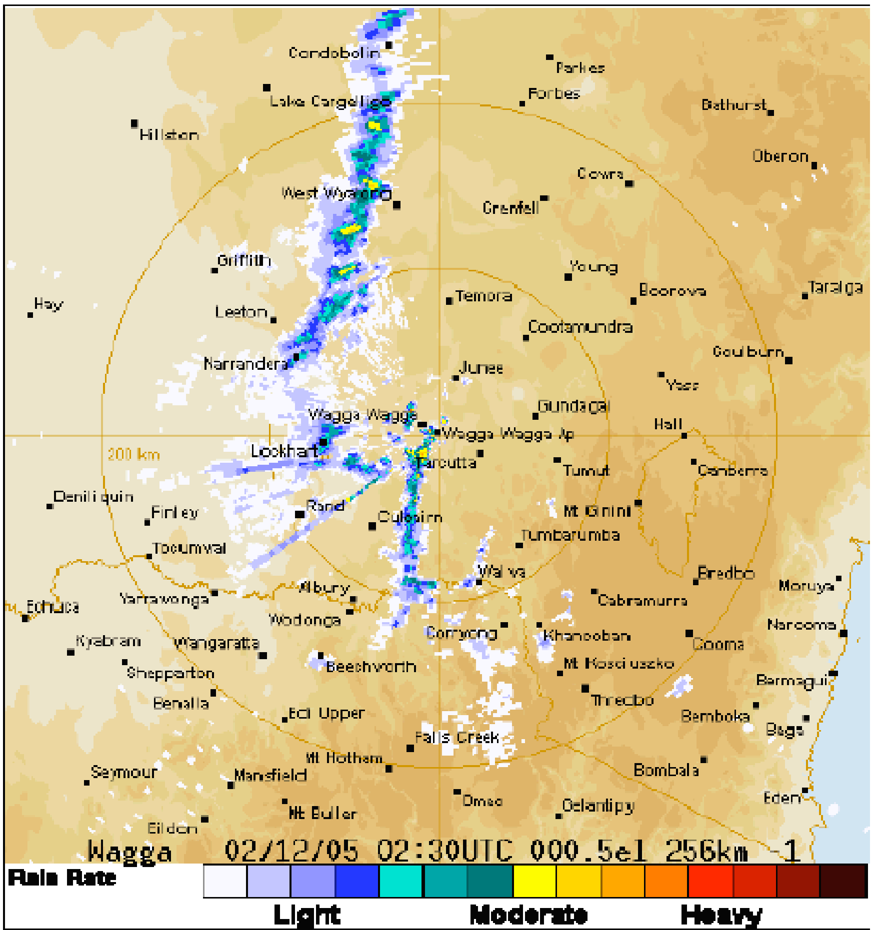

Figure 5: Image from Wagga Wagga Radar at 0230 UTC 2 December 2005 [1]

[1] NOTE: Condobolin is located more than 200km north of the radar; hence the radar beam is lookin an elevated echo, as such the radar return is not indicative of surface conditions.

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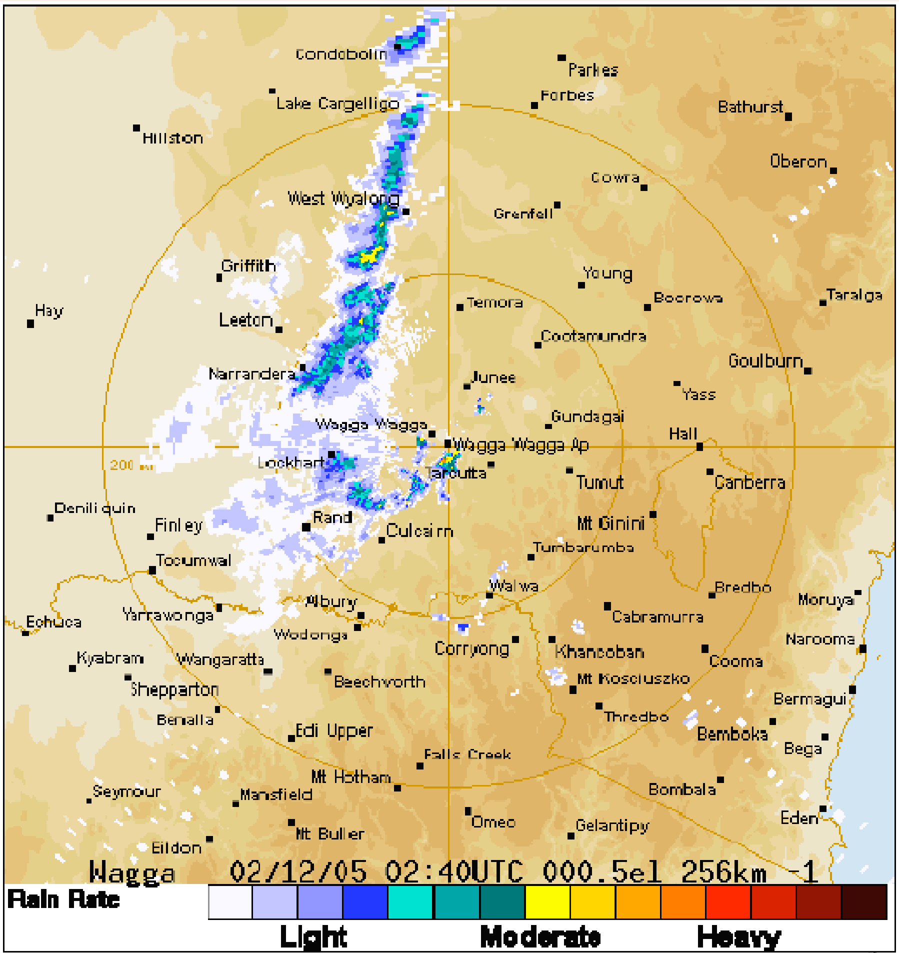

Figure 6: Image from Wagga Wagga Radar at 0240 UTC 2 December 2005 [2]

[2] NOTE: Condobolin is located more than 200km north of the radar; hence the radar beam is looking at an elevated echo, as such the radar return is not indicative of surface conditions.

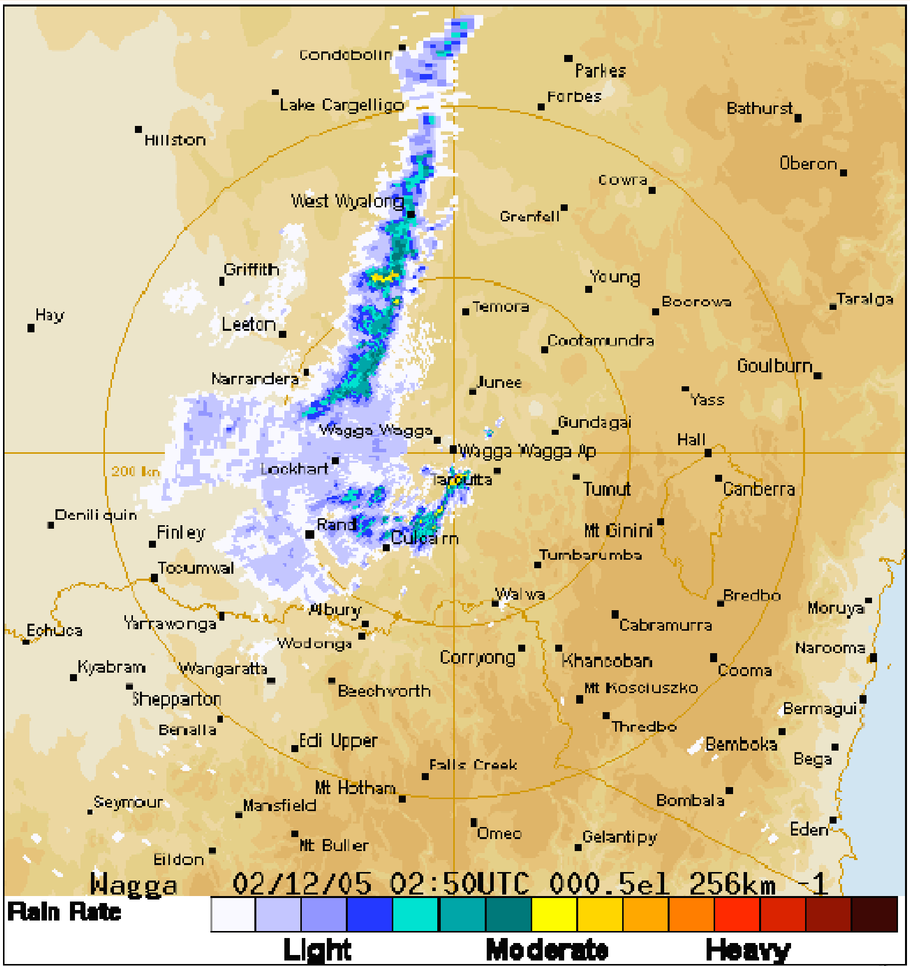

Figure 7: Image from Wagga Wagga Radar at 0250 UTC 2 December 2005 [3]

[3] NOTE: Condobolin is located more than 200km north of the radar; hence the radar beam is looking at an elevated echo, as such the radar return is not indicative of surface conditions.

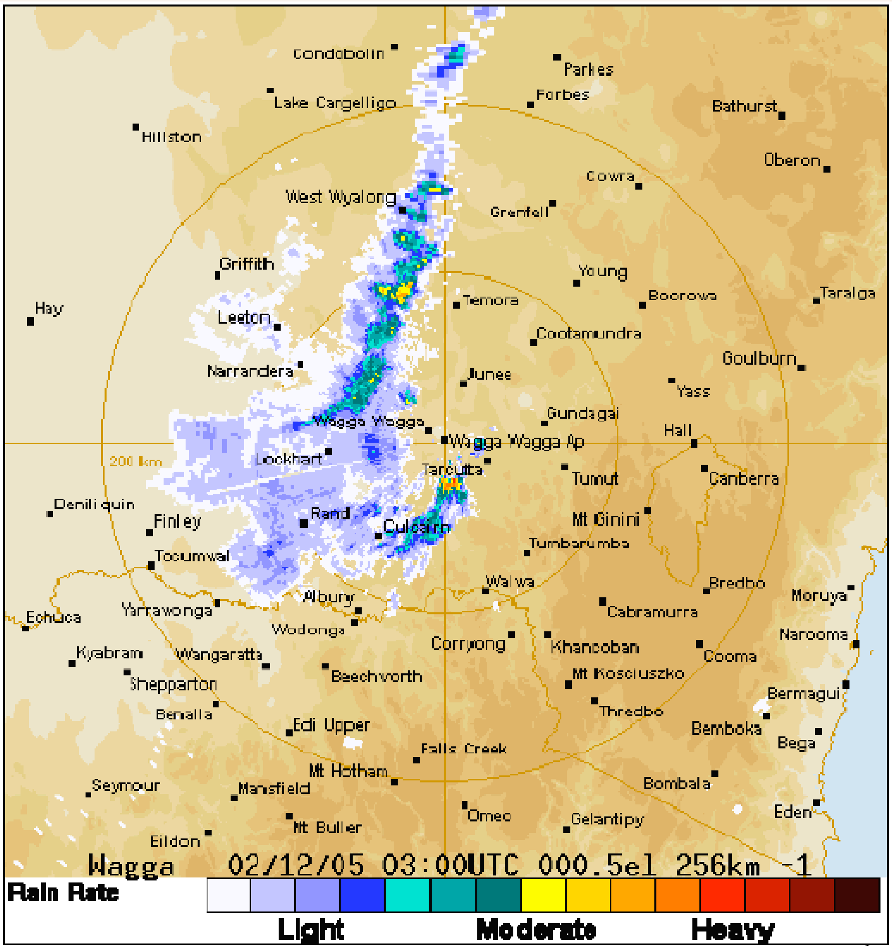

Figure 8: Image from Wagga Wagga Radar at 0300 UTC 2 December 2005 [4]

[4] NOTE: Condobolin is located more than 200km north of the radar; hence the radar beam is looking at an elevated echo, as such the radar return is not indicative of surface conditions.

Appendix 4: Upper Air Charts*

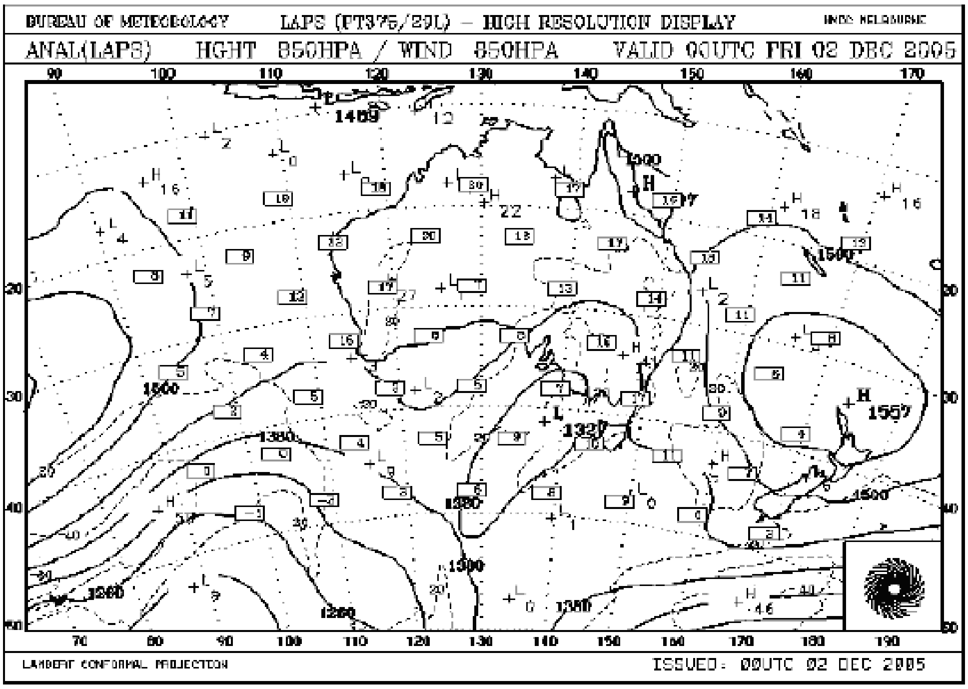

Figure 9: 850hPa analysis, 0000 UTC 2 December 2005

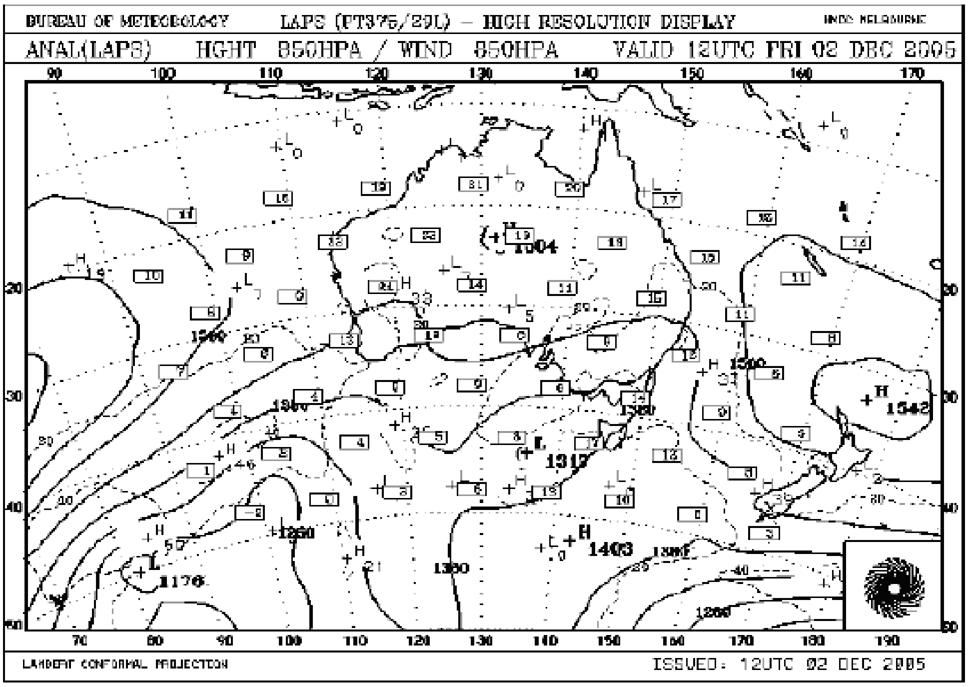

Figure 10: 850hPa analysis, 1200 UTC 2 December 2005

* geopotential height (m) in bold contours, temperature (°C) in boxes, and wind (kn) in dashed contours.

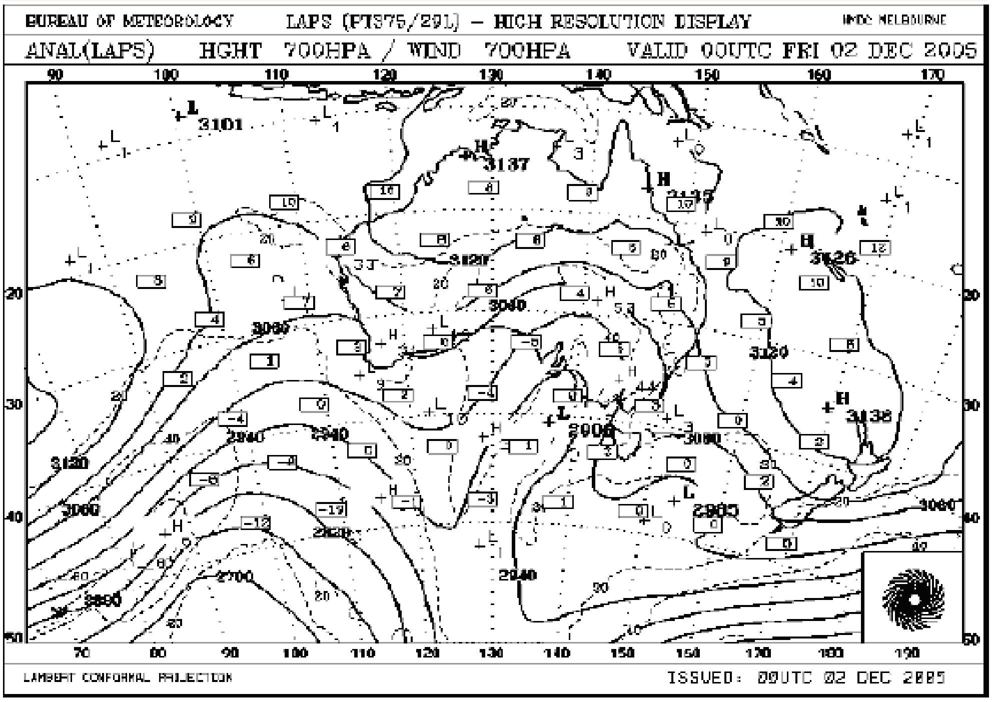

Figure 11: 700hPa analysis, 0000 UTC 2 December 2005

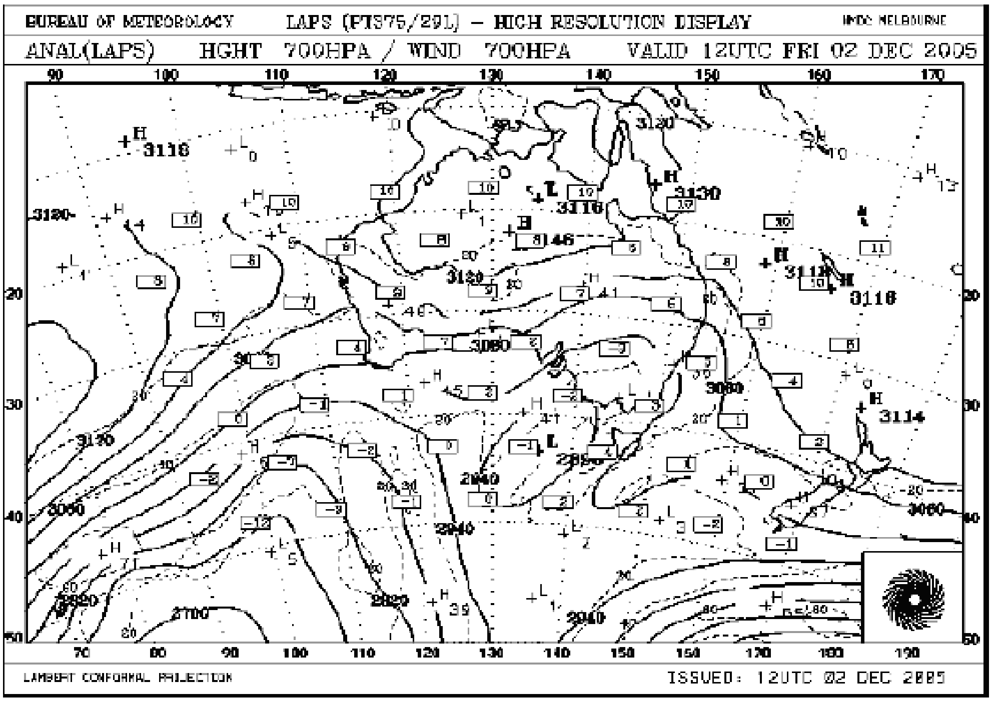

Figure 12: 700hPa analysis, 1200 UTC 2 December 2005

Appendix 5: Surface Observations

Date (UTC)	Time (UTC)	Wind Direction	Wind Speed (kn)	Wind Gust (kn)	Temp (°C)	Dewpoint (°C)	QNH (hPa)	Rain last 10 min (mm)	Rain since 9 am (mm)
01/12/05	1900	030	19	33	23.6	13.2	1004.9	0.0	0.0
01/12/05	**2000**	**030**	**24**	**34**	**23.3**	**15.1**	**1005.0**	**0.0**	**0.0**
01/12/05	**2100**	**030**	**22**	**32**	**23.2**	**16.0**	**1005.0**	**0.0**	**0.0**
01/12/05	2200	030	21	29	24.4	15.9	1004.3	0.0	0.0
01/12/05	**2214**	**030**	**22**	**34**	**24.8**	**15.5**	**1004.4**	**0.0**	**0.0**
01/12/05	**2300**	**020**	**20**	**28**	**25.4**	**15.4**	**1004.0**	**0.0**	**0.0**
02/12/05	0000	020	18	27	27.0	14.8	1002.6	0.0	0.0
02/12/05	**0041**	**020**	**21**	**31**	**28.5**	**14.3**	**1001.3**	**0.0**	**0.0**
02/12/05	**0100**	**020**	**22**	**28**	**28.9**	**14.4**	**1000.5**	**0.0**	**0.0**
02/12/05	**0130**	**030**	**22**	**31**	**31.0**	**13.8**	**998.5**	**0.0**	**0.0**
02/12/05	**0200**	**020**	**25**	**35**	**29.5**	**13.3**	**997.9**	**0.0**	**0.0**
02/12/05	**0233**	**330**	**17**	**26**	**28.6**	**14.1**	**999.1**	**0.0**	**0.0**
02/12/05	**0235**	**280**	**22**	**28**	**24.3**	**13.8**	**999.3**	**0.0**	**0.0**
02/12/05	**0243**	**280**	**21**	**31**	**19.2**	**15.9**	**1000.5**	**3.4**	**3.4**
02/12/05	**0300**	**270**	**26**	**36**	**17.6**	**16.1**	**1001.2**	**2.6**	**13.8**
02/12/05	**0310**	**280**	**19**	**26**	**17.3**	**16.0**	**1001.9**	**3.0**	**16.8**
02/12/05	0400	250	18	25	15.1	13.3	1001.6	0.0	19.6
02/12/05	0500	250	15	19	16.4	13.9	1003.4	0.0	19.6
02/12/05	0600	260	15	20	16.0	13.1	1004.5	0.0	19.6

Table 1: Observations taken from Condobolin Automatic Weather Station (AWS). Items in bold represent Special Meteorological Reports (SPECI).

Date (UTC)	Time (UTC)	Wind Direction	Wind Speed (kn)	Wind Gust (kn)	Temp (°C)	Dewpoint (°C)	QNH (hPa)	Rain last 10 min (mm)	Rain since 9 am (mm)
01/12/05	2000	080	10	14	20.8	17.4	1009.0	0.0	7.8
01/12/05	2100	070	10	16	21.2	17.6	1008.8	0.0	7.8
01/12/05	2200	020	11	15	23.1	17.4	1008.3	0.0	7.8
01/12/05	2300	360	17	25	25.6	17.8	1007.0	0.0	0.0
02/12/05	0000	020	18	23	25.0	17.5	1006.3	0.0	0.0
02/12/05	0200	010	23	31	28.6	17.5	1003.2	0.0	0.0
02/12/05	**0213**	**010**	**24**	**34**	**27.7**	**17.6**	**1002.5**	**0.0**	**0.0**
02/12/05	**0300**	**010**	**26**	**37**	**28.4**	**18.2**	**1001.9**	**0.0**	**0.0**
02/12/05	**0331**	**010**	**21**	**27**	**28.7**	**19.4**	**1001.2**	**0.0**	**0.0**
02/12/05	**0400**	**360**	**20**	**29**	**25.1**	**19.7**	**1000.5**	**0.0**	**0.0**
02/12/05	0500	010	19	25	25.1	19.9	999.8	0.0	1.2
02/12/05	**0510**	**290**	**26**	**35**	**24.2**	**14.8**	**1000.9**	**0.0**	**1.2**
02/12/05	**0518**	**280**	**28**	**38**	**19.7**	**14.7**	**1001.2**	**0.0**	**1.2**
02/12/05	**0535**	**270**	**17**	**26**	**17.4**	**15.9**	**1002.2**	**0.2**	**3.2**
02/12/05	**0553**	**280**	**21**	**39**	**17.5**	**15.9**	**1003.5**	**0.0**	**3.2**
02/12/05	**0601**	**260**	**26**	**39**	**16.7**	**15.4**	**1003.3**	**0.2**	**3.4**
02/12/05	**0608**	**250**	**21**	**28**	**16.4**	**15.1**	**1003.2**	**0.8**	**4.2**
02/12/05	**0659**	**200**	**07**	**12**	**15.8**	**14.4**	**1003.8**	**0.4**	**7.0**
02/12/05	**0746**	**230**	**13**	**18**	**15.6**	**14.0**	**1005.8**	**0.0**	**7.2**
02/12/05	0800	230	13	18	15.5	14.1	1005.7	0.0	7.2

Table 2: Observations taken from Dubbo Automatic Weather Station (AWS) Items in bold represent Special Meteorological Reports (SPECI). Data at 0100 UTC is missing.

Date (UTC)	Time (UTC)	Wind Direction	Wind Speed (kn)	Wind Gust (kn)	Temp (°C)	Dewpoint (°C)	QNH (hPa)	Rain last 10 min (mm)	Rain since 9 ar (mm)
01/12/05	2000	010	15	23	20.8	17.3	1007.9	0.0	0.0
01/12/05	**2015**	**020**	**16**	**26**	**21.0**	**17.4**	**1007.9**	**0.0**	**0.0**
01/12/05	2100	030	18	23	22.9	17.4	1007.4	0.0	0.0
01/12/05	**2145**	**030**	**21**	**31**	**23.3**	**16.9**	**1007.1**	**0.0**	**0.0**
01/12/05	**2200**	**020**	**24**	**33**	**23.8**	**16.6**	**1006.7**	**0.0**	**0.0**
01/12/05	2300	020	23	30	25.2	16.7	1006.1	0.0	0.0
01/12/05	**2318**	**010**	**23**	**33**	**24.7**	**16.2**	**1005.9**	**0.0**	**0.0**
02/12/05	**0000**	**020**	**21**	**31**	**26.1**	**17.2**	**1004.8**	**0.0**	**0.0**
02/12/05	0100	010	21	27	27.7	17.3	1003.5	0.0	0.0
02/12/05	**0119**	**020**	**21**	**33**	**27.3**	**16.3**	**1002.8**	**0.0**	**0.0**
02/12/05	**0200**	**020**	**20**	**30**	**29.0**	**16.6**	**1001.2**	**0.0**	**0.0**
02/12/05	**0253**	**020**	**23**	**30**	**30.5**	**16.9**	**999.2**	**0.0**	**0.0**
02/12/05	**0301**	**020**	**24**	**36**	**29.6**	**16.1**	**999.5**	**0.0**	**0.0**
02/12/05	**0338**	**360**	**22**	**38**	**23.3**	**14.6**	**1000.1**	**0.0**	**0.0**
02/12/05	**0400**	**350**	**17**	**24**	**23.7**	**20.5**	**1000.3**	**0.0**	**0.8**
02/12/05	**0408**	**280**	**25**	**35**	**21.4**	**15.9**	**1001.2**	**0.0**	**0.8**
02/12/05	**0544**	**250**	**24**	**28**	**15.4**	**15.3**	**1002.7**	**2.2**	**14.6**
02/12/05	0600	250	21	29	14.3	14.2	1004.1	1.2	17.0
02/12/05	**0609**	**250**	**19**	**29**	**4.1**	**14.0**	**1004.3**	**2.8**	**19.6**
02/12/05	0700	220	12	16	14.4	14.3	1005.5	0.0	22.6
02/12/05	0800	200	09	11	13.9	13.8	1005.9	0.2	23.6

Table 3: Observations taken from Parkes Automatic Weather Station (AWS). Items in bold represent Special Meteorological Reports (SPECI).

Appendix 6: Area Forecasts

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AMEND AREA FORECAST 011520 TO 020500 AREA 22

OVERVIEW:
A SURFACE TROUGH NEAR APOMA/YIVO/YBRN, EXPECTED NEAR BRR/YGTH BY 23Z,
THEN YGDA/YPKS BY 05Z. ISOLATED SHOWERS, TENDING SCATTERED E OF
YBKE/YGTH AFTER 23Z. ISOLATED THUNDERSTORMS E OF TROUGH AND WITHIN
120NM W OF TROUGH, TENDING OCCASIONAL E OF YBKE/YGTH AFTER 23Z.

SUBDIVISIONS:
A: E OF TROUGH
B: W OF TROUGH

WIND:
    2000    5000    7000     10000        14000        18500
A: 010/30  350/30  340/25  330/30 PS06  330/40 MS03  330/45 MS11
B: 250/25  300/25  310/25  320/30 ZERO  330/50 MS08  330/60 MS17

CLOUD:
ISOL/OCNL CB 5000/40000 AS PER OVERVIEW.
LOCALLY BKN ST 2000/5000 NEAR SHRA/TSRA AFTER 23Z, CHIEFLY E OF
YBKE/YGTH.
LOCALLY BKN CU 5000/10000, OCNL TOPS 20000.
AREAS BKN ACAS ABOVE 10000 E OF TROUGH AND WITHIN 120NM W OF TROUGH.

WEATHER:
TSRA, SHRA.

VISIBILITY:
3000M TSRA, 5000M SHRA.

FREEZING LEVEL:
10500 SW / 13000 NE, LOWERING TO 6000 IN SW BY 05Z.

ICING:
MOD IN CLD ABV FZL.

AMD TURBULENCE:
MOD IN CU AND AC.
OCNL MOD BLW BELOW 5000FT.
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AREA FORECAST 012300 TO 021100 AREA 22

OVERVIEW:
A SURFACE TROUGH NEAR BRR/YGTH BY 23Z, THEN NEAR YGDA/YPKS BY 05Z,
AND YMGI/YGIL BY 11Z. ISOLATED SHOWERS, TENDING SCATTERED E OF
YBKE/YGTH. ISOLATED THUNDERSTORMS E OF TROUGH AND WITHIN 120NM W OF
TROUGH, TENDING OCCASIONAL E OF YBKE/YGTH. SCATTERED
SHOWERS/THUNDERSTORMS CONTRACTING FURTHER E WITH PASSAGE OF TROUGH.

SUBDIVISIONS:
A: E OF TROUGH
B: W OF TROUGH

WIND:
    2000    5000    7000     10000        14000        18500
A: 010/30  350/30  340/30  340/35 PS07  340/40 MS02  330/45 MS15
B: 270/30  290/30  300/35  320/40 MS02  330/50 MS11  330/55 MS13

CLOUD:
ISOL/OCNL CB 5000/40000 AS PER OVERVIEW.
LOCALLY BKN ST 2000/5000 NEAR SHRA/TSRA, CHIEFLY E OF YBKE/YGTH.
LOCALLY BKN CU 5000/10000, OCNL TOPS 20000, MOSTLY E OF YBKE/YGTH.
AREAS BKN ACAS ABOVE 10000 E OF TROUGH AND WITHIN 120NM W OF TROUGH.

WEATHER:
TSRA, SHRA.

VISIBILITY:
3000M TSRA, 5000M SHRA.

FREEZING LEVEL:
7500 S / 13000 N.

ICING:
MOD IN CLD ABV FZL.

TURBULENCE:
MOD IN CU AND AC.
OCNL MOD BLW BELOW 5000FT.
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AMEND AREA FORECAST 020030 TO 021100 AREA 22

AMD OVERVIEW:
A SURFACE TROUGH NEAR BRR/YGTH BY 23Z, THEN NEAR YGDA/YPKS BY 05Z,
AND YMGI/YGIL BY 11Z. ISOLATED SHOWERS, TENDING SCATTERED E OF
YBKE/YGTH. ISOLATED THUNDERSTORMS E OF TROUGH AND WITHIN 120NM W
OF TROUGH, TENDING FREQUENT/OCCASIONAL E OF YBKE/YGTH. SCATTERED
SHOWERS/THUNDERSTORMS CONTRACTING FURTHER E WITH PASSAGE OF
TROUGH. SIGMENT CURRENT FOR LINE OF FREQUENT THUNDERSTORMS[REFER
SIGMET SY01].

SUBDIVISIONS:
A: E OF TROUGH
B: W OF TROUGH

WIND:
    2000    5000    7000     10000         14000         18500
A: 010/30  350/30  340/30  340/35 PS07  340/40 MS02  330/45 MS15
B: 270/30  290/30  300/35  320/40 MS02  330/50 MS11  330/55 MS13

AMD CLOUD:
ISOL/OCNL/FRQ CB 5000/40000 AS PER OVERVIEW.
LOCALLY BKN ST 2000/5000 NEAR SHRA/TSRA, CHIEFLY E OF YBKE/YGTH.
LOCALLY BKN CU 5000/10000, OCNL TOPS 20000, MOSTLY E OF YBKE/YGTH.
AREAS BKN ACAS ABOVE 10000 E OF TROUGH AND WITHIN 120NM W OF
TROUGH.

WEATHER:
TSRA, SHRA.

VISIBILITY:
3000M TSRA, 5000M SHRA.

FREEZING LEVEL:
7500 S / 13000 N.

ICING:
MOD IN CLD ABV FZL.

TURBULENCE:
MOD IN CU AND AC.
OCNL MOD BLW BELOW 5000FT.
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AMEND AREA FORECAST 020400 TO 021700 AREA 22

AMD OVERVIEW:
SURFACE TROUGH NEAR YBRR/YNAR, EXPECTED NEAR YCBR/YGIL BY 11Z AND OUT
OF AREA BY 17Z.ISOLATED SHOWERS, SCATTERED NEAR TROUGH AND W OF TROUGH
S OF 32S.OCCASIONAL THUNDERSTORMS E OF TROUGH BECOMING
FREQUENT WITHIN 60NM OF TROUGH.SIGMENT CURRENT FOR LINE OF FREQUENT
THUNDERSTORMS [REFER SIGMET]. BROKEN STRATUS IN PRECIPITATION.

SUBDIVISIONS:
A: E OF TROUGH
B: W OF TROUGH

WIND:
    2000    5000    7000     10000        14000        18500
A: 340/30  350/35  340/35  340/35 PS02  330/45 MS03  330/50 MS11
B: 240/30  250/25  250/30  260/30 MS02  270/40 MS09  270/55 MS15

AMD CLOUD:
OCNL/FRQ CB 4000/40000 AS PER OVERVIEW.
BKN ST 1500/4000 IN SHRA/TSRA.
SCT CU 4000/10000, BKN WITHIN 120NM OF TROUGH WITH OCNL TOPS TO 20000.
SCT CU 2500/10000, W OF TROUGH, BKN S OF 32S.
SCT ACAS ABOVE 10000, BKN WITHIN 120NM OF TROUGH.

WEATHER:
TSRA, SHRA.

VISIBILITY:
3000M TSRA, 4000M SHRA.

FREEZING LEVEL:
12000 N/8000 S.

ICING:
MOD IN CLD ABV FZL.

TURBULENCE:
MOD IN CU AND AC.
OCNL MOD BLW BELOW 5000FT.
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Appendix 7: Terminal Aerodrome Forecasts (TAFs)

TAF YCDO 011806Z 1908 03015G25KT 9999 -SHRA SCT100
FM23 01015G25KT 9999 -SHRA SCT050
FM01 28015G25KT 9999 -SHRA SCT040
FM06 26015G25KT 9999 -SHRA SCT035
FM19 MOD TURB BLW 5000FT
INTER 2306 VRB20G45KT 3000 TSRA BKN010 SCT040CB
T 23 24 27 26 Q 1003 1004 1002 1000

TAF YSDU 011754Z 1812 07010KT 9999 -SHRA SCT100
FM22 02015G25KT 9999 -SHRA FEW050 SCT100
FM00 36015G25KT 9999 -SHRA SCT050 BKN100
FM03 28010G20KT 9999 -SHRA SCT040 BKN100
FM18 MOD TURB BLW 5000FT
INTER 0008 VRB20G45KT 3000 TSRA BKN015 SCT040CB
T 20 22 27 28 Q 1008 1008 1006 1003

TAF YSDU 012335Z 0012 36018G28KT 9999 -SHRA SCT040 BKN100
FM04 32018G28KT 9999 -SHRA SCT040 BKN100
FM00 MOD TURB BLW 5000FT
INTER 0005 VRB25G45KT 3000 TSRA BKN015 SCT040CB
TEMPO 0512 VRB25G45KT 3000 TSRA BKN010 SCT040CB
T 27 30 26 22 Q 1006 1003 1002 1003

TAF YPKS 011750Z 1908 05010KT 9999 -SHRA SCT100
FM00 01015G25KT 9999 -SHRA SCT050 BKN100
FM02 28015G25KT 9999 -SHRA SCT040 BKN100
FM19 MOD TURB BLW 5000FT
INTER 0008 VRB20G45KT 3000 TSRA BKN010 SCT040CB
T 21 23 26 26 Q 1006 1006 1004 1001

TAF YPKS 020124Z 0214 34020G30KT 9999 -SHRA SCT040 BKN100
FM08 26015G25KT 9999 -SHRA BKN030 BKN100
FM02 MOD TURB BLW 5000FT
INTER 0204 VRB20G45KT 3000 TSRA BKN015 SCT050CB
TEMPO 0411 VRB20G45KT 4000 +TSRA BKN010 SCT050CB
INTER 1114 4000 SHRA BKN010
T 30 27 24 20 Q 1002 1000 1000 1003

U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: THUNDERSTORMS

Date: 1/20/83
Initiated by: AFO-260

AC No: 00-24B
Change:

1. PURPOSE. This advisory circular describes the hazards of thunderstorms to aviation and offers guidance to help prevent accidents caused by thunderstorms.

2. CANCELLATION. Advisory Circular 00-24A, dated June 23, 1978, is canceled.

3. RELATED READING MATERIAL. Advisory Circulars 00-6A, Aviation Weather, 00-45B, Aviation Weather Services, 00-50A, Low Level Wind Shear.

4. GENERAL. We all know what a thunderstorm looks like. Much has been written about the mechanics and life cycles of thunderstorms. They have been studied for many years; and while much has been learned, the studies continue because much is not known. Knowledge and weather radar have modified our attitudes toward thunderstorms, but one rule continues to be true—any storm recognizable as a thunderstorm should be considered hazardous until measurements have shown it to be safe. That means safe for you and your aircraft. Almost any thunderstorm can spell disaster for the wrong combination of aircraft and pilot.

5. HAZARDS. A thunderstorm packs just about every weather hazard known to aviation into one vicious bundle. Although the hazards occur in numerous combinations, let us look at the most hazardous combination of thunderstorms, the squall line, then we will examine the hazards individually.

a. Squall Lines. A squall line is a narrow band of active thunderstorms. Often it develops on or ahead of a cold front in moist, unstable air, but it may develop in unstable air far removed from any front. The line may be too long to detour easily and too wide and severe to penetrate. It often contains steady-state thunderstorms and presents the single most intense weather hazard to aircraft. It usually forms rapidly, generally reaching maximum intensity during the late afternoon and the first few hours of darkness.

b. Tornadoes.

(1) The most violent thunderstorms draw air into their cloud bases with great vigor. If the incoming air has any initial rotating motion, it often forms an extremely concentrated vortex from the surface well into the cloud. Meteorologists have estimated that wind in such a vortex can exceed 200 knots; pressure inside the vortex is quite low. The strong winds gather dust and debris and the low pressure generates a funnel-shaped cloud extending downward from the cumulonimbus base. If the cloud does not reach the surface, it is a "funnel cloud"; if it touches a land surface, it is a "tornado."

(2) Tornadoes occur with both isolated and squall line thunderstorms. Reports for forecasts of tornadoes indicate that atmospheric conditions are favorable for violent turbulence. An aircraft entering a tornado vortex is almost certain to suffer structural damage. Since the vortex extends well into the cloud, any pilot inadvertently caught on instruments in a severe thunderstorm could encounter a hidden vortex.

(3) Families of tornadoes have been observed as appendages of the main cloud extending several miles outward from the area of lightning and precipitation. Thus, any cloud connected to a severe thunderstorm carries a threat of violence.

c. Turbulence.

(1) Potentially hazardous turbulence is present in all thunderstorms, and a severe thunderstorm can destroy an aircraft. Strongest turbulence within the cloud occurs with shear between updrafts and downdrafts. Outside the cloud, shear turbulence has been encountered several thousand feet above and 20 miles laterally from a severe storm. A low level turbulent area is the shear zone associated with the gust front. Often, a "roll cloud" on the leading edge of a storm marks the top of the eddies in this shear and it signifies an extremely turbulent zone. Gust fronts often move far ahead (up to 15 miles) of associated precipitation. The gust front causes a rapid and sometimes drastic change in surface wind ahead of an approaching storm. Advisory Circular 00-50A, "Low Level Wind Shear," explains in greater detail the hazards associated with gust fronts. Figure 1 shows a schematic cross section of a thunderstorm with areas outside the cloud where turbulence may be encountered.

(2) It is almost impossible to hold a constant altitude in a thunderstorm, and maneuvering in an attempt to do so produces greatly increased stress on the aircraft. It is understandable that the speed of the aircraft determines the rate of turbulence encounters. Stresses are least if the aircraft is held in a constant attitude and allowed to "ride the waves." To date, we have no sure way to pick "soft spots" in a thunderstorm.

d. Icing.

(1) Updrafts in a thunderstorm support abundant liquid water with relatively large droplet sizes; and when carried above the freezing level, the water becomes supercooled. When temperature in the upward current cools to about $-15^{o}C$, much of the remaining water vapor sublimates as ice crystals; and above this level, at lower temperatures, the amount of supercooled water decreases.

(2) Supercooled water freezes on impact with an aircraft. Clear icing can occur at any altitude above the freezing level; but at high levels, icing from smaller droplets may be rime or mixed rime and clear. The abundance of large, supercooled water droplets makes clear icing very rapid between 0°C and -15°C and encounters can be frequent in a cluster of cells. Thunderstorm icing can be extremely hazardous.

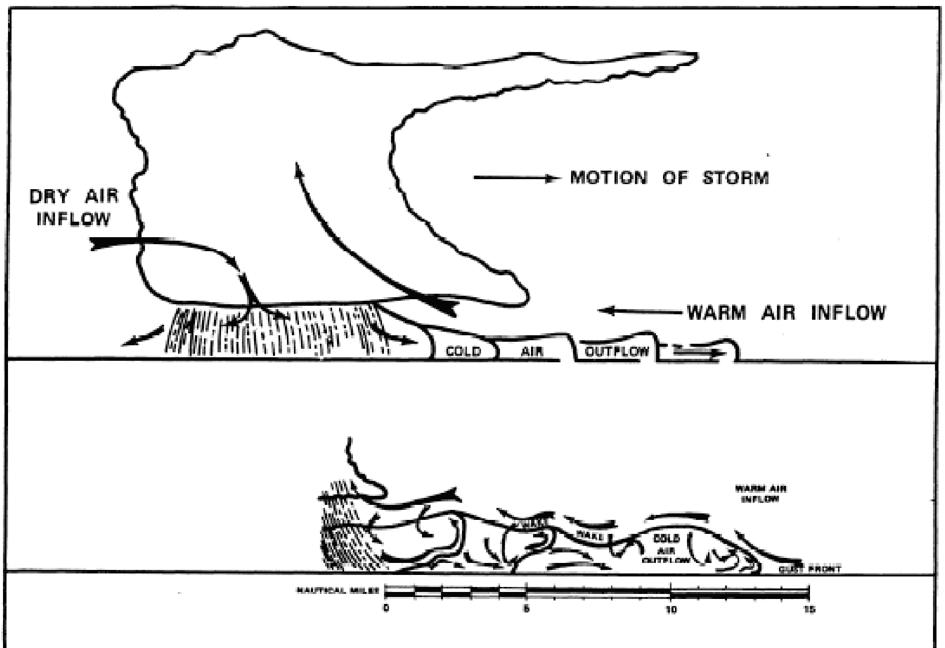

Fig. 1.

e. Hail.

(1) Hail competes with turbulence as the greatest thunderstorm hazard to aircraft. Supercooled drops above the freezing level begin to freeze. Once a drop has frozen, other drops latch on and freeze to it, so the hailstone grows--sometimes into a huge iceball. Large hail occurs with severe thunderstorms with strong updrafts that have built to great heights. Eventually, the hailstones fall, possibly some distance from the storm core. Hail may be encountered in clear air several miles from dark thunderstorm clouds.

(2) As hailstones fall through air whose temperature is above $0^{o}C$, they begin to melt and precipitation may reach the ground as either hail or rain. Rain at the surface does not mean the absence of hail aloft. You should anticipate possible hail with any thunderstorm, especially beneath the anvil of a large cumulonimbus. Hailstones larger than one-half inch in diameter can significantly damage an aircraft in a few seconds.

f. Low Ceiling and Visibility. Generally, visibility is near zero within a thunderstorm cloud. Ceiling and visibility also may be restricted in precipitation and dust between the cloud base and the ground. The restrictions create the same problem as all ceiling and visibility restrictions; but the hazards are increased many fold when associated with the other thunderstorm hazards of turbulence, hail, and lightning which make precision instrument flying virtually impossible.

g. Effect on Altimeters. Pressure usually falls rapidly with the approach of a thunderstorm, then rises sharply with the onset of the first gust and arrival of the cold downdraft and heavy rain showers, falling back to normal as the storm moves on. This cycle of pressure change may occur in 15 minutes. If the pilot does not receive a corrected altimeter setting, the altimeter may be more than 100 feet in error.

h. Lightning. A lightning strike can puncture the skin of an aircraft and can damage communications and electronic navigational equipment. Lightning has been suspected of igniting fuel vapors causing explosion; however, serious accidents due to lightning strikes are extremely rare. Nearby lightning can blind the pilot rendering him momentarily unable to navigate either by instrument or by visual reference. Nearby lightning can also induce permanent errors in the magnetic compass. Lightning discharges, even distant ones, can disrupt radio communications on low and medium frequencies. Though lightning intensity and frequency have no simple relationship to other storm parameters, severe storms, as a rule, have a high frequency of lightning.

i. Engine Water Ingestion.

(1) Turbine engines have a limit on the amount of water they can ingest. Updrafts are present in many thunderstorms, particularly those in the developing stages. If the updraft velocity in the thunderstorm approaches or exceeds the terminal velocity of the falling raindrops, very high concentrations of water may occur. It is possible that these concentrations can be in excess of the quantity of water turbine engines are designed to ingest. Therefore, severe thunderstorms may contain areas of high water concentration which could result in flameout and/or structural failure of one or more engines.

(2) At the present time, there is no known operational procedure that can completely eliminate the possibility of engine damage/flameout during massive water ingestion. Although the exact mechanism of these water-induced engine stalls has not been determined, it is felt that thrust changes may have an adverse effect on engine stall margins in the presence of massive water ingestion.

(3) Avoidance of severe storm systems is the only measure assured to be effective in preventing exposure to this type of multiple engine damage/flameout. During an unavoidable encounter with severe storms with extreme precipitation, the best known recommendation is to follow the severe turbulence penetration procedure contained in the approved airplane flight manual with special emphasis on avoiding thrust changes unless excessive airspeed variations occur.

6. WEATHER RADAR.

a. Weather radar detects droplets of precipitation size. Strength of the radar return (echo) depends on drop size and number. The greater the number of drops, the stronger is the echo; and the larger the drops, the stronger is the echo. Drop size determines echo intensity to a much greater extent than does drop number. Hailstones usually are covered with a film of water and, therefore, act as huge water droplets giving the strongest of all echoes.

b. Numerous methods have been used in an attempt to categorize the intensity of a thunderstorm. To standardize thunderstorm language between weather radar operators and pilots, the use of Video Integrator Processor (VIP) levels is being promoted.

c. The National Weather Service (NWS) radar observer is able to objectively determine storm intensity levels with VIP equipment. These radar echo intensity levels are on a scale of one to six. If the maximum VIP Levels are 1 "weak" and 2 "moderate," then light to moderate turbulence is possible with lightning. VIP Level 3 is "strong" and severe turbulence is possible with lightning. VIP Level 4 is "very strong" and severe turbulence is likely with lightning. VIP Level 5 is "intense" with severe turbulence, lightning, hail likely, and organized surface wind gusts. VIP Level 6 is "extreme" with severe turbulence, lightning, large hail, extensive surface wind gusts, and turbulence.

d. Thunderstorms build and dissipate rapidly. Therefore, do not attempt to plan a course between echoes. The best use of ground radar information is to isolate general areas and coverage of echoes. You must avoid individual storms from in-flight observations either by visual sighting or by airborne radar. It is better to avoid the whole thunderstorm area than to detour around individual storms unless they are scattered.

e. Airborne weather avoidance radar is, as its name implies, for avoiding severe weather--not for penetrating it. Whether to fly into an area of radar echoes depends on echo intensity, spacing between the echoes, and the capabilities of you and your aircraft. Remember that weather radar detects only precipitation drops; it does not detect turbulence. Therefore, the radar scope provides no assurance of avoiding turbulence. The radar scope also does not provide assurance of avoiding instrument weather from clouds and fog. Your scope may be clear between intense echoes; this clear area does not necessarily mean you can fly between the storms and maintain visual sighting of them.

f. Remember that while hail always gives a radar echo, it may fall several miles from the nearest visible cloud and hazardous turbulence may extend to as much as 20 miles from the echo edge. Avoid intense or extreme level echoes by at least 20 miles; that is, such echoes should be separated by at least 40 miles before you fly between them. With weaker echos you can reduce the distance by which you avoid them.

7. DO'S AND DON'TS OF THUNDERSTORM FLYING.

a. Above all, remember this: never regard any thunderstorm lightly. even when radar observers report the echoes are of light intensity. Avoiding thunderstorms is the best policy. Following are some do's and don'ts of thunderstorm avoidance:

(1) Don't land or takeoff in the face of an approaching thunderstorm. A sudden gust front of low level turbulence could cause loss of control.

(2) Don't attempt to fly under a thunderstorm even if you can see through to the other side. Turbulence and wind shear under the storm could be disastrous.

(3) Don't fly without airborne radar into a cloud mass containing scattered embedded thunderstorms. Scattered thunderstorms not embedded usually car be visually circumnavigated.

(4) Don't trust the visual appearance to be a reliable indicator of the turbulence inside a thunderstorm.

(5) Do avoid by at least 20 miles any thunderstorm identified as severe or giving an intense radar echo. This is especially true under the anvil of a large cumulonimbus.

(6) Do circumnavigate the entire area if the area has 6/10 thunderstorm coverage.

(7) Do remember that vivid and frequent lightning indicates the probability of a severe thunderstorm.

(8) Do regard as extremely hazardous any thunderstorm with tops 35,000 feet or higher whether the top is visually sighted or determined by radar.

b. If you cannot avoid penetrating a thunderstorm, following are some do's BEFORE entering the storm:

(1) Tighten your safety belt, put on your shoulder harness if you have one, and secure all loose objects.

(2) Plan and hold your course to take you through the storm in a minimum time.

(3) To avoid the most critical icing, establish a penetration altitude below the freezing level or above the level of $-15^{o}C$.

(4) Verify that pitot heat is on and turn on carburetor heat or jet engine anti-ice. Icing can be rapid at any altitude and cause almost instantaneous power failure and/or loss of airspeed indication.

(5) Establish power settings for turbulence penetration airspeed recommended in your aircraft manual.

(6) Turn up cockpit lights to highest intensity to lessen temporary blindness from lightning.

(7) If using automatic pilot, disengage altitude hold mode and speed hold mode. The automatic altitude and speed controls will increase maneuvers of the aircraft thus increasing structural stress.

(8) If using airborne radar, tilt the antenna up and down occasionally. This will permit you to detect other thunderstorm activity at altitudes other than the one being flown.

c. Following are some do's and don'ts <u>during</u> the thunderstorm penetration:

(1) Do keep your eyes on your instruments. Looking outside the cockpit can increase danger of temporary blindness from lightning.

(2) Don't change power settings; maintain settings for the recommended turbulence penetration airspeed.

(3) Do maintain constant attitude; let the aircraft "ride the waves." Maneuvers in trying to maintain constant altitude increase stress on the aircraft.

(4) Don't turn back once you are in the thunderstorm. A straight course through the storm most likely will get you out of the hazards most quickly. In addition, turning maneuvers increase stress on the aircraft.

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9 APPENDIX E: MEDIA RELEASE

Final ATSB investigation report on Condobolin in-flight breakup 4-fatality accident

The ATSB's final investigation report into a Piper Chieftain accident near Condobolin, NSW on 2 December 2005, resulting in four deceased persons, confirms that the aircraft broke up during flight when its structural limits were exceeded in the vicinity of thunderstorms.

The Australian Transport Safety Bureau report states that there was no indication, either by way of emergency radio transmission from the pilot, or in a change in the altitude, track and speed of the aircraft as recorded by radar, that the flight was not proceeding normally. Some minutes after the pilot reported diverting left of track to avoid weather, communications with the aircraft were lost.

The absence of an on-board recording device on the aircraft prevented a full analysis of the circumstances of the breakup. However, while post-impact fire damage limited the extent to which some of the aircraft's system's, including the fuel and electrical systems, could be examined, wreckage examination did not reveal any pre-existing fault or condition that could have weakened the aircraft structure and caused it to break up at a load within the design load limit.

A line of severe thunderstorms crossed the aircraft's planned track and were the subject of a SIGMET (significant weather advice) issued by the Bureau of Meteorology. As the SIGMET information did not meet the criteria for direct notification, it was not advised directly to the pilot of the aircraft. The investigation was unable to determine if the pilot had obtained the SIGMET from any of the range of pre and in-flight weather briefing services available to the pilot.

Analysis of the prevailing weather indicated that, immediately before the accident, the aircraft was likely to have been surrounded to the east, west, and south by a large complex of thunderstorms. That situation may have limited the options available to the pilot to avoid any possible hazardous phenomena associated with the storms.

Although, as a result of a review of Flight Information Service initiated in November 2004, Airservices Australia had identified inconsistencies and ambiguities in the provision of Flight Information Service, including Hazard Alert procedures, they were not assessed by the investigation to be contributing factors to the accident. As a result of its review, Airservices Australia initiated changes to the Flight Information Service and Hazard Alerts sections of the *Manual of Air Traffic Service*s and the *Aeronautical Information Publication* to improve future safety.

While not contributory to the accident, the report identifies a number of inconsistencies between Australian SIGMET dissemination procedures and those contained in International Civil Aviation Organization (ICAO) documentation. The report contains recommendations to Airservices Australia and the Civil Aviation Safety Authority to review Australian procedures with a view to minimising those inconsistencies.

The circumstances of the accident are a salient reminder to pilots of their responsibilities to request weather and other information necessary to make safe and timely operational decisions, and of the importance of avoiding thunderstorms by large margins.