# APPENDIX A: BUREAU OF METEOROLOGY REPORT

File: 70/13/24, 70/150

Australian Government

Bureau of Meteorology

## Air Safety Incident Report

## Sydney Airport

## 15 April 2007
## 0923 UTC

1 August 2007

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# Executive Summary

At approximately 0923 UTC, on 15 April 2007, a Boeing 747 encountered low-altitude wind shear when attempting to land on runway 16R at Sydney Airport. The wind shear was (in all likelihood) associated with a thunderstorm microburst, which briefly occurred over the airfield as the aircraft attempted to land. This report examines the meteorological setting and the weather forecasts associated with the event. A separate report (Appendix 3) examines, in detail, the microburst and wind shear encounter. Wind shear events of this nature (associated with the downdrafts of individual thunderstorm cells) are considered to be an inherent risk with all thunderstorms.

Meteorological data shows that a thunderstorm, which produced the microburst, formed in an environment that suited high-based convective activity, but did not favour frequent or long-lasting thunderstorms. Initially, because the environment was not particularly favourable for thunderstorms, the meteorologists at Sydney Airport assessed that the probability of thunderstorms occurring the Airport would be low, so thunderstorms were not included in initial forecasts for Sydney Airport. As the situation evolved, the forecasts were revised during the afternoon and thunderstorms were then forecast at the Airport for the late afternoon to evening period. When thunderstorms eventually did occur at the Airport (in the evening), a post-analysis of high-resolution meteorological data showed that a microburst briefly resulted over the northern end of the airfield – at the time of the reported wind shear encounter. The microburst, which in all likelihood caused the wind shear, was present for just a few minutes and then dissipated. A detailed account of the wind shear and microburst event – analysing both the data in the vicinity of the Airport and the Flight Data Recorder – is attached separately in Appendix 3.

Forecasts (TAF and TTF), Aerodrome Warnings and Thunderstorm Alerts were issued by the Sydney Airport Meteorological Unit to indicate the potential for thunderstorms at the Airport, up to 3 ½ hours before the wind shear encounter.

Post-analysis of Airservices anemometer data revealed the classic signature of a microburst at the time of the incident. The Bureau is currently looking at ways to improve the integrity of the Wind Shear Warning product on a national basis through improved training resources, better use of available data and improved communication with Air Traffic Control. In addition to this, the Bureau conducted a low level wind shear alert system (LLWAS) trial at Darwin in 1997 and, since 2002, has archived high-resolution wind data from the Airservices anemometer network at Sydney Airport. Following further analysis of these data, the Bureau will present a paper on the frequency of wind shear events at Sydney Airport and will hold discussions with industry, the Civil Aviation Safety Authority, Airservices Australia and Sydney Airport Corporation Limited on the findings.

# CONTENTS

# 1. Synoptic Situation

On 15 April 2007, a trough of low-pressure was approaching Sydney from the west (see Figure 1.1). The trough lay in a southeast to northwest orientation, across NSW, and extended beyond its southern and northern borders, and marked the convergent region in-between two high-pressure systems: one centred over the Tasman Sea, and the other, to the west, near Adelaide. The trough's motion was from west towards east – not uncommon for broad-scale weather patterns.

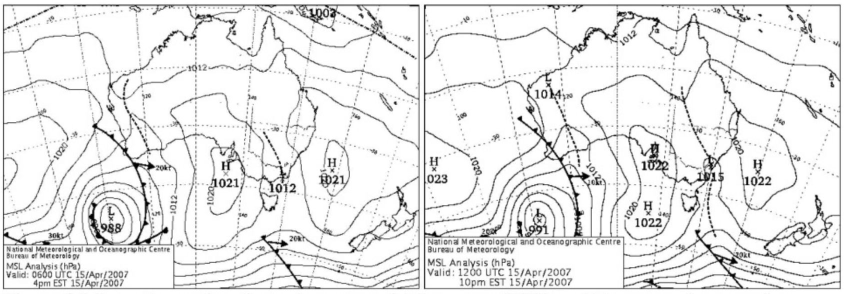


**Figure 1.1** Synoptic weather charts show a trough lying across NSW, and it's eastward progression between 06Z and 12Z on 15 April 2007.

When the trough eventually passed through Sydney, early the next morning, it brought a southerly wind change. During the period before the change, when the high in the Tasman Sea generated northeast winds and the trough was still west of Sydney (on the afternoon and early evening on 15 April), a scattered field of clouds developed across NSW in the zone ahead of the approaching trough (see Figure 1.2).

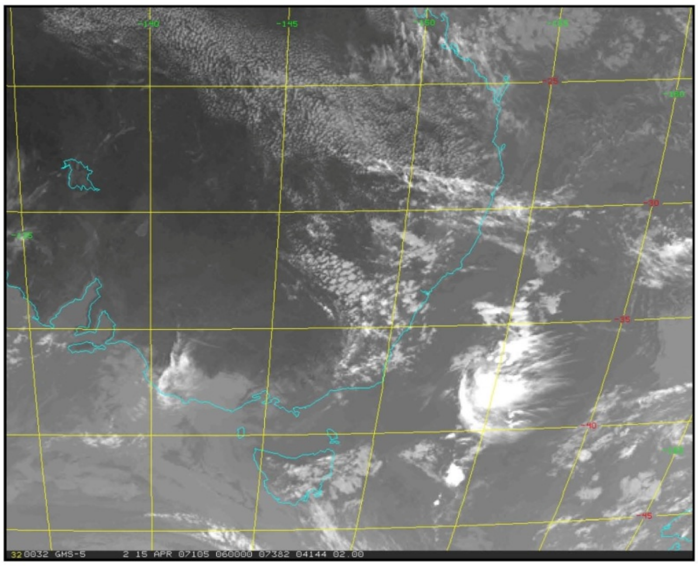

**Figure 1.2** Satellite image shows convective clouds (speckled grey and white) east of the trough position, at 06Z on 15 April 2007 (Satellite image originally processed by the Bureau of Meteorology from the geostationary satellite MTSAT-1R operated by the Japan Meteorological Agency).

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## 2. The Weather

A detailed analysis and discussion of the microburst that caused the wind shear encounter is attached in Appendix 3. The discussion below is a broader summary of the weather events leading up to, and around the incident.

In the afternoon, before the incident occurred, the weather in Sydney started out fine with northeast winds around 15 knots and little, if any, significant cloud (see Aerodrome Weather Reports in Appendix 1). The vertical profile of the atmosphere (Figure 2.1) shows that it was potentially unstable at the time, with conditions suitable for high-based convective clouds to develop (if the necessary atmospheric forcing was present). The steep lapse rate in air temperature, especially in the lowest several thousand feet, shows an environment suitable for convective clouds to grow to a significant height. The moisture profile also shows that the air was relatively dry in the layers below about 8000 feet (apart from the relatively shallow and moist layer at the surface). Overall, the atmospheric profile shows conditions favourable for the development of moderately high-based convective clouds, with relatively dry air below the cloud base: i.e. conditions not unfavourable for the formation of a microburst.

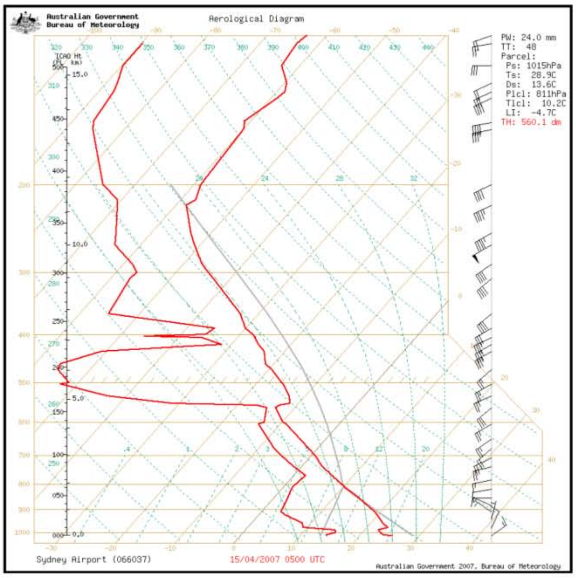


**Figure 2.1** Vertical profile of air temperature (right) and moisture (left) at Sydney Airport (05Z, 15 April 2007) shows a steep temperature lapse rate (between 1000ft-15000ft) and dry air (between 1000ft-8000ft). The vertical wind profile is shown on the far right.

A temperature inversion, in the lowest thousand feet near the surface, would have trapped the upward motion of air from the surface and inhibited the formation of convective clouds around the Airport. This explains how, despite the potentially unstable situation aloft, the weather remained fine at the Airport for much the afternoon.

The wind data show that the low-level temperature inversion was caused by northeast winds blowing in off the sea, underneath the (relatively warmer) northwest winds a thousand feet, or more, above.

While the sky above the Airport remained mostly free from cloud during the afternoon, cumulus clouds built up in the regions surrounding the Sydney Basin – to the north, west and south – where the low-level inversion was weaker, or non-existent, and failed to trap convection. High-based showers, and isolated thunderstorms, were generated inland and were driven towards the coast at a rate of about 20 knots by the winds above 10000 feet in the atmosphere, which were blowing from the west or southwest. At first, the showers and thunderstorms that approached the coast dissipated over the Sydney Basin as the convective cells were inhibited by the low-level inversion near the coast (see Figure 2.2).

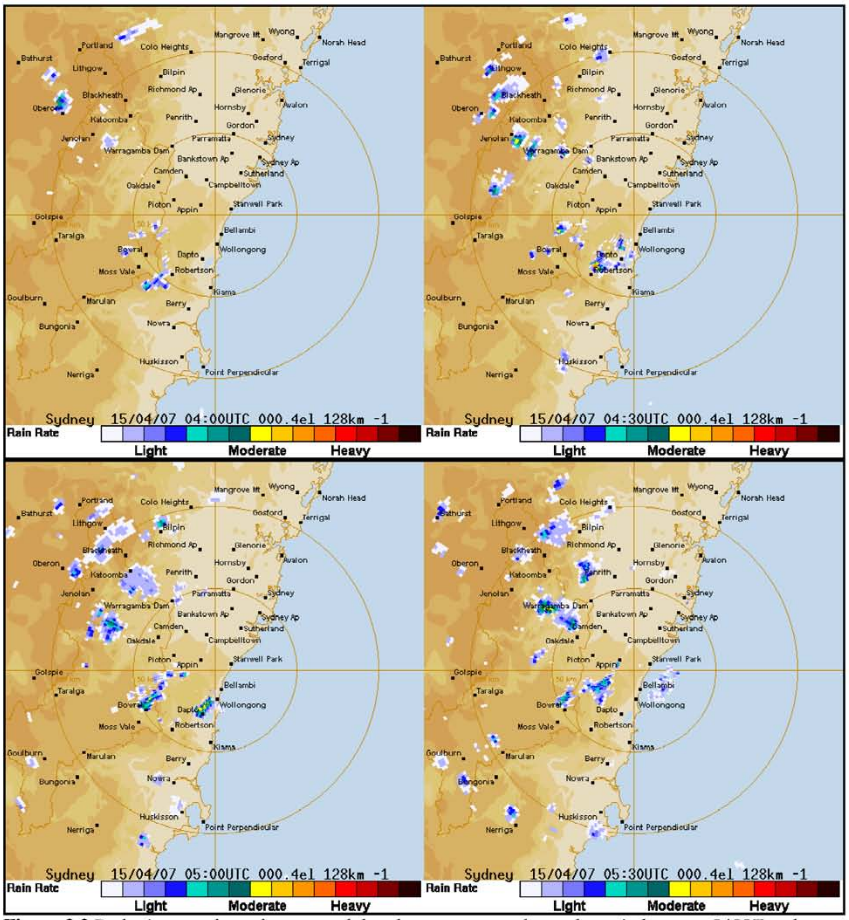


**Figure 2.2** Radar images show showers and thunderstorms over elevated terrain between 0400Z and 0530Z, with little or no development over the Sydney Basin.

But later, after 06Z, some showers and thunderstorms, which developed to the west of Sydney, continued moving east over the Sydney Basin without dissipating as they moved closer to the coast (see Figure 2.3).

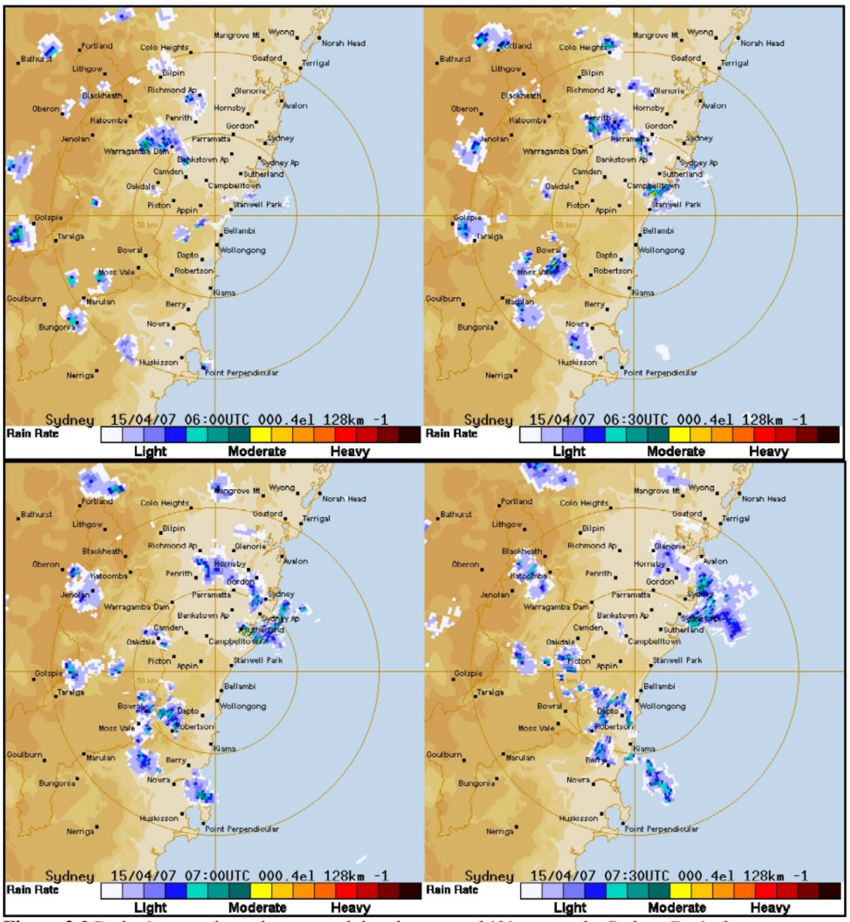


**Figure 2.3** Radar images show showers and thunderstorms drifting over the Sydney Basin from west to east between 0600Z and 0730Z.

The cluster of showers and thunderstorms, which caused the thunderstorm and microburst at the Airport, first appeared on radar to the southwest of Sydney (before 0830Z), then moved over the Airport between 0920Z – 0930Z and cleared to the east by 1000Z (see Figure 2.4).

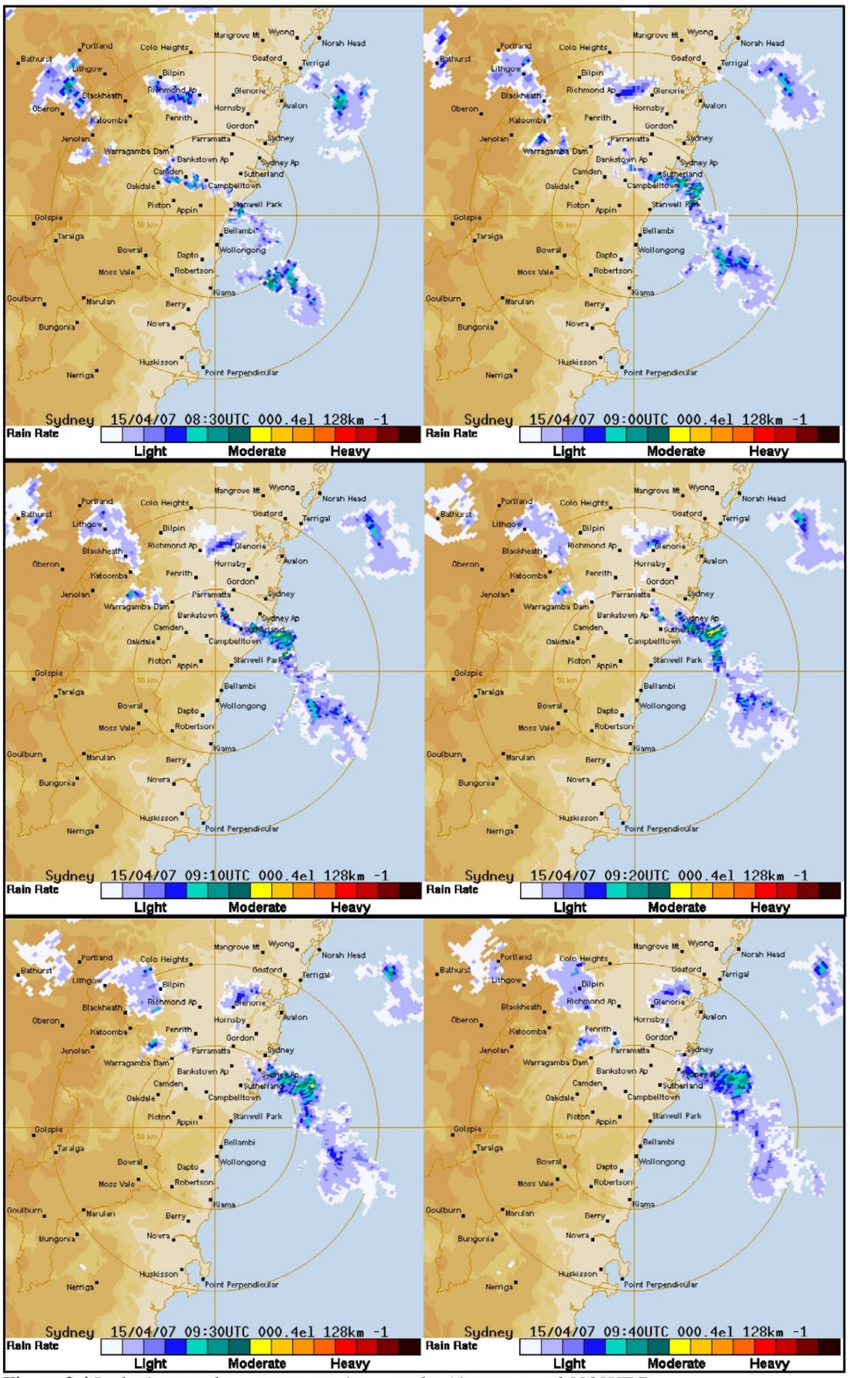


**Figure 2.4** Radar images show storms moving over the Airport around 0920UTC.

These storms generated a gust-front of southwest winds, which spread out ahead of the advancing line of storms. At the Airport, the gust-front was first recorded with a southwest wind-change of 15 to 20 knots between 0910Z and 0920Z (see Appendix 1 and Appendix 3 for wind recordings).

Then, at 0920Z, the leading cells from the approaching storm complex were detected overhead (at the Airport), by radar. Visual observations (see Aerodrome Weather Reports in Appendix 1) confirm that the clouds were predominantly high-based (12 000 feet), as expected from the weather balloon sounding. Relatively weak radar reflectivity indicated low to moderate precipitation rates. The post analysis of wind data shows that, from this time, winds measured at the thresholds of runways 16R and 07 began to spread out in a divergent pattern – indicating that the outflow descending from a high-based storm cell was spreading out and developing into a microburst over the airfield (see Appendix 3).

Over the next few minutes, the wind measurements indicate that the microburst intensified over the northern end of the airfield (with a horizontal shear equivalent to 43 knots recorded across a distance of 1.7 km at 0921Z). During this period, the observer at the Airport reported a thunderstorm with light rain.

By 0925Z, the storm cell's core had moved to the east of the Airport, and the microburst had weakened. A few minutes later, another storm's outflow moved across the Airport, but this time with weaker winds.

By 1000Z, the entire storm complex had cleared to the east of the Airport and winds had returned to the prevailing, northeast, direction.

## 3. Aviation Forecasts Issued

On 15 April 2007, the Terminal Forecasts for Sydney (TAF and TTF), which were issued before 0545Z, indicated northeast winds at 15 knots and no significant weather. The forecaster's assessment was that the probability of thunderstorms, or showers (which were expected to develop over the tablelands to the west and southwest of Sydney), was less than 30% (mainly because of the low-level inversion that was inhibiting convection near the coast). The Airport Weather Briefing issued in the morning indicated only a 10% chance of showers affecting the Airport, and a 20% chance of thunderstorms occurring seaward of the Airport.

By late afternoon, when showers and thunderstorms had developed within 50 nautical miles to the west of Sydney and were moving closer, the forecast was reassessed: it had become less certain that the convection would be inhibited as it approached Sydney; the TAF was amended at 0548Z and indicated showers plus a 30% probability of thunderstorms (for periods less than 30 minutes) at the Airport between 06Z and 10Z.

When showers and thunderstorms developed within approximately 30 nm to the west of the Airport, the TTF (issued at 0600Z) indicated thunderstorms at the Airport from 0630Z. Subsequent issues of the TTF continued to forecast thunderstorms at the Airport up until 1000Z (after which the probability of further storms was assessed to be below 30%).

An Aerodrome Warning (of thunderstorms) and a Thunderstorm Alert were issued at 0650Z, when a thunderstorm was detected within 10 nm of the Airport. The Aerodrome Warning, which was valid up until 1000Z, warned Aerodrome users of the high likelihood of thunderstorms. The Thunderstorm Alert advised ground staff that thunderstorms had been detected within 10 nm of the Airport. The Thunderstorm Alert was cancelled an hour later, when thunderstorms were no longer detected within 10 nm of the Airport.

A subsequent Thunderstorm Alert was issued at 0857Z, when thunderstorms were again detected within 10 nm of the Airport. Again, it was cancelled about an hour later, when storms were no longer within 10 nm.

Wind Shear Warnings were not issued for the Airport because the risk of wind shear, which is a potential hazard associated with all thunderstorms, is implied when a forecast or warning of thunderstorms is issued. On this occasion, there were no real-time reports or observations of wind shear. And, apart from thunderstorms, there were no expectations of wind shear associated with any other phenomena.

The Terminal Forecasts (TAF and TTF) issued after 0545Z indicated the potential for thunderstorms at Sydney Airport between 06Z and 10Z. However, because the thunderstorms were not anticipated to bring a significant increase in wind speed, the forecasts didn't indicate any significant wind variation with the thunderstorm change groups in the TAF or TTF. The weather observations, however, indicated that at times the thunderstorms did cause temporary fluctuations in the wind direction of up to 180° in variance with the forecast wind (see Appendix 1 and Appendix 3, between 09Z and 10Z). Although no significant increase (above the forecast) in wind speed was recorded, a forecast including a variable wind direction with the thunderstorms would have better represented the actual conditions that occurred at the Airport.

Copies of relevant forecasts and warnings issued before, and around, the time of the incident are contained in Appendix 2. TTFs are in Appendix 1.

## Appendix 1: OBSERVATIONS

## Aerodrome Weather Reports and Trend Type Forecasts

Sydney Airport, 0400Z – 1100Z on 15/04/2007

```
TTF METAR YSSY 150400 07013/15KT CAVOK 27.0/13.9 1015.8
RMK RF00.0/000.0
NOSIG

TTF METAR YSSY 150430 08014/16KT CAVOK 26.4/15.0 1015.5
RMK RF00.0/000.0
NOSIG

TTF METAR YSSY 150500 05013/15KT CAVOK 25.6/14.8 1015.2
RMK RF00.0/000.0
TS 33NM TO SW MOVING NE AT 18KT
NOSIG

TTF METAR YSSY 150530 06012/15KT CAVOK 25.7/14.5 1015.0
RMK RF00.0/000.0 TS 38NM TO SW AND 45NM TO W MOVING ESE AT 20KT
NOSIG

TTF METAR YSSY 150600 04014/16KT 9999 VCSH 1CU050 3AC100 25.6/14.3 1015.1
RMK RF00.0/000.0 TS 32NM TO SW AND WNW MOVING NE AT 22KT
INTER 0630/0900 4000 TSRA SCT030 SCT060CB

TTF METAR YSSY 150630 05012/15KT 9999 VCSH 1CU050 4AC100 24.2/14.6 1015.2
RMK RF00.0/000.0 TS 11NM TO SW AND 23NM TO WNW MOVING ENE AT 15KT LIGHTNINGS TO SW
INTER 0700/0930 4000 TSRA SCT030 SCT060CB

TTF SPECI YSSY 150652 08011/13KT 9999 VCTS 1ST025 6AC100 1CB050 23.4/15.8 1015.5
RMK RF00.0/000.0 TS 8NM TO NW AND SSW MOVING NE AT 12KT
INTER 0700/0952 4000 TSRA SCT030 SCT060CB

TTF SPECI YSSY 150700 07009/12KT 9999 VCTS 1CU040 6AC100 1CB060 23.2/15.2 1015.7
RMK RF00.0/000.0 TS 5NM TO S MOVING NE AT 12KT
INTER 0700/1000 4000 TSRA SCT030 SCT060CB

TTF SPECI YSSY 150730 07008/12KT 9999 VCSH 1CU050 4AC090 22.9/16.3 1016.0
RMK RF00.0/000.0 TS 5NM TO SSE AND 8NM TO NNE MOVING ESE AT 15KT TCU TO EAST
INTER 0730/1000 4000 TSRA SCT030 SCT060CB

TTF SPECI YSSY 150754 03018/22KT CAVOK 23.4/16.2 1015.2
RMK RF00.0/000.0 LIGHTNING NE
INTER 0754/1000 4000 TSRA SCT030 SCT060CB

TTF METAR YSSY 150800 04018/22KT CAVOK 23.1/16.3 1015.3
RMK RF00.0/000.0 LIGHTNING NE/S
INTER 0800/1000 4000 TSRA SCT030 SCT060CB

TTF METAR YSSY 150830 03017/19KT 9999 1CU045 3CI250 23.1/12.4 1015.4
RMK RF00.0/000.0 TS 18NM TO SW MOVING ENE AT 15KT
INTER 0830/1000 4000 TSRA SCT030 SCT060CB

TTF METAR YSSY 150900 03015/18KT 9999 1CU045 3AC120 23.1/11.6 1015.6
RMK RF00.0/000.0 TS 7NM TO SSW MOVING ENE AT 15KT
FM0910 18015KT 9999 -SHRA FEW040 SCT100
FM1000 02015KT 9999 -SHRA FEW040 SCT080
INTER 0900/1000 4000 TSRA SCT030 SCT060CB

TTF SPECI YSSY 150919 20015/21KT 9999 VCSH 1CU025 6AC120 22.3/13.6 1017.6
RMK RF00.0/000.0 LIGHTNING SE
FM1000 02015KT 9999 -SHRA FEW040 SCT080
INTER 0919/1000 4000 TSRA SCT030 SCT060CB

TTF SPECI YSSY 150924 13007/09KT 9999 -TSRA 1ST018 6AC120 1CB050 23.5/12.2 1017.0
RMK RF00.0/000.0 TS 3NM TO S MOVING ENE AT 15KT
FM1000 02015KT 9999 -SHRA FEW040 SCT080
INTER 0924/1000 4000 TSRA SCT030 SCT060CB

TTF METAR YSSY 150930 15007/10KT 9999 -SHRA 1ST020 7AC120 23.2/13.4 1017.7
RMK RF00.0/000.0
FM1000 02015KT 9999 -SHRA FEW040 SCT080
INTER 0930/1000 4000 TSRA SCT030 SCT060CB

TTF SPECI YSSY 150950 03020/23KT 9999 VCSH 1ST020 5AC100 21.7/14.6 1016.1
```

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RMK RF00.0/000.0
FM1000 02015KT 9999 -SHRA FEW040 SCT080
INTER 0950/1000 4000 TSRA SCT030 SCT060CB

TTF METAR YSSY 151000 02019/22KT 9999 1CU035 3AC120 22.1/12.7 1016.2
RMK RF00.0/000.0
NOSIG

TTF METAR YSSY 151030 01011/15KT 9999 1CU035 22.5/12.9 1016.5
RMK RF00.0/000.0 TS 20NM TO NE, MOVING TO ENE AT 17 KNOTS
TTF:NOSIG

TTF METAR YSSY 151100 01011/14KT CAVOK 22.5/14.8 1016.6
RMK RF00.0/000.0
NOSIG
```

## Appendix 2: FORECASTS

### Terminal Aerodrome Forecasts

Sydney Airport, covering 0923Z on 15/05/2007

```
TAF YSSY 141042Z 141212
30007KT CAVOK
FM02 02015KT 9999 FEW040
RMK
T 20 18 16 16 Q 1022 1021 1020 1020

TAF YSSY 141648Z 141818
32007KT CAVOK
FM02 02015KT 9999 FEW040 SCT080
FM12 29008KT 9999 FEW040
RMK
T 17 17 24 26 Q 1020 1020 1019 1016

TAF YSSY 142218Z 150024
32007KT CAVOK
FM02 02015KT 9999 FEW040 SCT080
FM12 29008KT 9999 SCT080
FM18 22012KT 9999 SCT080
RMK
T 23 27 25 23 Q 1020 1017 1015 1015

TAF YSSY 150419Z 150606
02015KT 9999 FEW040 SCT080
FM13 29008KT 9999 SCT080
FM18 22012KT 9999 SCT080
FM02 17015KT 9999 -SHRA SCT035 SCT060
RMK
T 25 23 22 19 Q 1015 1015 1015 1015

TAF AMD YSSY 150548Z 150606
02015KT 9999 -SHRA FEW040 SCT080
FM13 29008KT 9999 SCT080
FM18 22012KT 9999 SCT080
FM02 17015KT 9999 -SHRA SCT035 SCT060
PROB30 INTER 0610 4000 TSRA SCT030 SCT060CB
RMK
T 25 23 22 19 Q 1015 1015 1015 1015

TAF YSSY 151045Z 151212
02012KT 9999 FEW035 SCT120
FM13 29008KT 9999 FEW030 SCT080
FM18 22012KT 9999 FEW030
FM02 17015KT 9999 -SHRA SCT035 SCT060
RMK
T 22 19 17 17 Q 1016 1015 1015 1016
```

## Airport Weather Briefings

Sydney Airport, covering 0923Z on 15/05/2007

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Sydney Airport Weather Briefing
Issued at 1202Z on 14/04/07

Sydney TAF
TAF YSSY 141042Z 14 1212
30007KT CAVOK
FM02 02015KT 9999 FEW040
RMK
T 20 18 16 16 Q 1022 1021 1020 1020

TAF Summary
A high in the west Tasman is directing a northerly over Sydney. Winds
at the airport will tend light northwest overnight, and then return
to the northeast tomorrow afternoon. Mist and fog patches are
expected to develop in the western suburbs overnight , and there is a
slight chance that the airport may be affected. See code grey. Fine
conditions are expected tomorrow.

Thunderstorm Potential
Nil chance within 20nm of Sydney Airport.

Other Possibilities
10% chance of fog 18/23Z.
20% chance of N/NE winds delayed until 04Z tomorrow.

Sydney Outlook
Monday       Chance showers.  City Max:  25
Tuesday      Fine. Partly cloudy City Max:  25

CODE GREY
Yes, 10% chance of fog 18/23Z.

Regards Tad till 7am, then Dmitriy.

Sydney Airport Meteorological Unit

NOTES:

1. This briefing note is issued four times per day and is not amended
between issues. For operational planning reference should be made to
the latest TAF YSSY and TTF YSSY.

2. Code Grey provides early advice of a possible later TAF amendment.
It is used if there is a small but realistic chance of a thunderstorm
or below special alternate conditions between 1400Z and 2400Z. Special
alternate conditions for YSSY are BKN or OVC cloud below 400ft and/or
visibility less than 2000m.northwest
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Sydney Airport Weather Briefing
Issued at 1733Z on 14/04/07

Sydney TAF
TAF YSSY 141648Z 14 1818 32007KT CAVOK
FM02 02015KT 9999 FEW040 SCT080
FM12 29008KT 9999 FEW040
RMK
T 17 17 24 26 Q 1020 1020 1019 1016

TAF Summary
A high in the Tasman is directing a northerly flow over Sydney. Winds
at the airport will be light northwest this morning, tending moderate
to fresh northeast in the afternoon. Some mist and isolated fog
patches have formed in the western suburbs, but visibility should not
be significantly affected at the airport. Fine conditions are
expected with cloud at times during the day. A trough moving through
Victoria will bring a southerly change Monday morning.

Thunderstorm Potential
Slight chance within 20nm seawards of Sydney Airport from late
morning.

Other Possibilities
20% chance of haze reducing visibility to 7000m 19/23Z.
10% chance of a shower this afternoon.
10% chance of a S change around 16Z Monday morning.

Sydney Outlook
Monday     City Max:  25  Chance showers.
Tuesday    City Max:  25  Fine. Partly cloudy

Regards Tad till 7am, then Dmitriy.

Sydney Airport Meteorological Unit
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Sydney Airport Weather Briefing
Issued at 2218Z on 14/04/07

Sydney TAF
TAF YSSY 142218Z 15 0024 32007KT CAVOK
FM02 02015KT 9999 FEW040 SCT080
FM12 29008KT 9999 SCT080
FM18 22012KT 9999 SCT080
RMK
T 23 27 25 23 Q 1020 1017 1015 1015

TAF Summary
A high in the Tasman is directing a northerly flow over Sydney. Winds
at the airport will be light northwest at first, tending moderate to
fresh northeast in the afternoon. Fine conditions are expected with
middle level cloud at times. A prefrontal trough moving through
Victoria will bring a shift to southwesterlies early tomorrow.

Thunderstorm Potential
Small chance within 20nm seawards of Sydney Airport in the afternoon.

Other Possibilities
20% chance of haze reducing visibility to 7000m 19/23Z tomorrow
morning.
10% chance of a shower this afternoon and from 16Z.
10% chance of winds shifting SW as early as 16Z.

Sydney Outlook
Monday      City Max:  25  Chance showers.
Tuesday     City Max:  25  Fine. Partly cloudy

Regards Dmitriy till 7pm, then Tad.

Sydney Airport Meteorological Unit
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SYDNEY AIRPORT METEOROLOGY UNIT
Department of the Environment
Sydney Airport Weather Briefing
Issued at 0626Z on 15/04/07

Sydney TAF
TAF YSSY 150548Z 15 0606
02015KT 9999 -SHRA FEW040 SCT080
FM13 29008KT 9999 SCT080
FM18 22012KT 9999 SCT080
FM02 17015KT 9999 -SHRA SCT035 SCT060
PROB30 INTER 0610 4000 TSRA SCT030 SCT060CB
RMK
T 25 23 22 19 Q 1015 1015 1015 1015

TAF Summary
NE/NW airstream prevails over Sydney ahead of approaching prefrontal
trough currently in the eastern Bass Strait. Moderate N/NE winds will
become light NW tonight before shifting SW early tomorrow with the
trough passage. Winds are expected to freshen and become S/SE around
midday tomorrow. Possible shower or thunderstorm could affect Sydney
airport tonight. There is small chance of fog early tomorrow. Light
showers are likely tomorrow afternoon, but no significant
deterioration in cloud or visibility is expected.

Thunderstorm Potential
30% chance within 20nm of Sydney Airport till 10Z, 10% chance till
12Z and small chance seawards tomorrow afternoon.

Other Possibilities
10% chance of fog 18/23Z tomorrow morning.
10% chance of a thunderstorm till 12Z and tomorrow afternoon.
10% chance of winds shifting SW as early as 16Z.
20% chance of S/SE wind developing +/-1 hour of time indicated.

Sydney Outlook
Tuesday     Fine. Partly cloudy City Max:  24
Wednesday   Fine. Mostly sunny. City Max:  25

CODE GREY
Yes, 10% chance of fog 18/23Z.

Regards Dmitriy till 7pm, then Lily.

Sydney Airport Meteorological Unit

NOTES:

1. This briefing note is issued four times per day and is not amended
between issues. For operational planning reference should be made to
the latest TAF YSSY and TTF YSSY.

2. Code Grey provides early advice of a possible later TAF
amendment. It is used if there is a small but realistic chance of a
thunderstorm or below special alternate conditions between 1400Z and
2400Z. Special alternate conditions for YSSY are BKN or OVC cloud
below 400ft and/or visibility less than 2000m.northwest
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### Aerodrome Warnings
Sydney Airport, issued on 15/05/2007

```
YSSY AD WRNG 1 VALID 150650/151000Z
AERODROME WARNING NUMBER 1 FOR SYDNEY VALID 041650/042000 LOCAL
THUNDERSTORMS
```

### Thunderstorm Alerts for Ground Staff
Sydney Airport, issued on 15/05/2007

```
10 nm Thunderstorm Alert for Airport Ground Staff Sydney
Issued at 1650 on Sunday the 15th of April 2007

Thunderstorms have been observed within 10 nm of Sydney Aerodrome and
are forecast to cross the aerodrome.

Note:  This service has been designed to cope with discrete thunderstorms that move over
the aerodrome by using weather radar rainfall echoes as the primary tool for
identification and tracking. The position of lightning activity associated with
thunderstorms cannot be accurately stated, however users should be aware that all
thunderstorms have the potential to produce lightning that strikes the ground. Indeed in
some cases lightning can strike the ground several nautical miles away from the radar
location of the thunderstorm, which is identified by its areas of maximum rainfall.

Duty Forecaster
Sydney Airport Meteorological Unit
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```
Cancellation of Thunderstorm Alert for Airport Ground Staff Sydney
Issued at 1751 on Sunday the 15th of April 2007

New alerts will be issued if further thunderstorms are expected
within 10 nm of Sydney Aerodrome and forecast to cross the aerodrome.

Note:  This service …

Duty Forecaster
Sydney Airport Meteorological Unit
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```
10 nm Thunderstorm Alert for Airport Ground Staff Sydney
Issued at 1857 on Sunday the 15th of April 2007

Thunderstorms have been observed within 10 nm of Sydney Aerodrome and
are forecast to cross the aerodrome.

Note:  This service …

Duty Forecaster
Sydney Airport Meteorological Unit
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```
Cancellation of Thunderstorm Alert for Airport Ground Staff Sydney
Issued at 1953 on Sunday the 15th of April 2007

New alerts will be issued if further thunderstorms are expected
within 10 nm of Sydney Aerodrome and forecast to cross the aerodrome.

Note:  This service …

Duty Forecaster
Sydney Airport Meteorological Unit
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## Area Forecasts

Area 20 & 21, issued prior to 0923Z on 15/05/2007

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AMEND  AREA FORECAST 150600 TO 151700 AREA 20

OVERVIEW:
ISOLATED SHOWERS WITHIN AREA YSDU/YBIA//YGFN/YWLM, EXTENDING TO
COAST/SEA N OF YWLM BY 09Z. ISOLATED THUNDERSTORMS WITHIN SAME AREA
TILL 11Z.

WIND:
 2000     5000     7000      10000         14000         18500
330/15   290/15   270/15   250/20 PS01   240/20 MS06   240/25 MS15

CLOUD:
ISOL CB 6000/30000 TILL 11Z WITHIN AREA YSDU/YBIA/YGFN/YWLM,
CONTRACTING TO SEA/COAST N OF YWLM AFTER 09Z.
SCT ST 3000/4500 RANGES IN PRECIPITATION.
SCT CU/SC 3500/9000 SEA/COAST, ISOL TOPS TO 15000 N OF YTRE AFTER
09Z.
SCT CU 6000/12000 RANGES, ISOL TOPS TO 18000 BEFORE 11Z.
SCT AC/AS ABOVE 12000.

WEATHER
TS, SH.

VISIBILITY:
3000M TS, 5000M SH.

FREEZING LEVEL:
11000.

ICING:
MOD IN AC/AS.

TURBULENCE:
MOD IN CU.

AMD CRITICAL LOCATIONS [HEIGHTS ABOVE MSL]:
AMD MT VICTORIA [3700FT]: 9999 -SHRA SCT CU 6000 SCT AC/AS 10000
                      PROB30 INTER 0610 3000 TSRA FEW CB 6000
AMD MURRURUNDI [2300FT]:  9999 -SHRA SCT CU 6000 SCT AC/AS 10000
                     PROB30 INTER 0610 3000 TSRA FEW CB 6000
```

```
AMEND AREA FORECAST 150600 TO 151700 AREA 21

OVERVIEW:
TROUGH APPROACHING FROM W, NEAR SW CORNER AT 06Z, YFBS/YMRY BY 11Z
AND FAR NE BY 17Z. ISOLATED SHOWERS AND THUNDERSTORMS E OF YORG/YTMU.
LOCALLY BROKEN LOW CLOUD IN PRECIPITATION. AREAS OF SMOKE HAZE IN SE.
MODERATE TURBULENCE BELOW 7000FT LEE OF RANGES, DECREASING BEHIND
TROUGH.

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

WIND:
    2000     5000     7000      10000          14000          18500
A: 330/20   310/25   290/25   280/25 MS01   260/30 MS08   260/35 MS17
B: 230/20   250/20   260/20   260/20 MS02   250/25 MS09   250/30 MS18

CLOUD:
ISOL CB 5000/28000 AS PER OVERVIEW.
BKN ST 1000/2000 SEA/COAST, 3000/4500 RANGES IN SH/TS.
SCT CU/SC 3500/9000 SEA/COAST, 5000/9000 RANGES/W SLOPES, TENDING BKN
RANGES/COAST/SEA IN FAR S WITH ISOL CU TOPS TO 18000.
SCT AC/AS ABOVE 10000.

WEATHER:
TS, SH, SMOKE, HAZE.

VISIBILITY:
3000M TS, 5000M SMOKE/SHRA, 8KM HAZE.

FREEZING LEVEL:
11000.

ICING:
MOD IN LARGE CU TOPS AND IN AC/AS.

TURBULENCE:
MOD BLW 7000FT LEE RANGES IN S, DECREASING BEHIND TROUGH.
MOD IN CU/AC.

AMD CRITICAL LOCATIONS [HEIGHTS ABOVE MSL]:
AMD MT VICTORIA [3700FT]: 9999 -SHRA SCT CU 6000 SCT AC/AS 10000
                          PROB30 INTER 0610 3000 TSRA FEW CB 6000
AMD BOWRAL [2200FT]: 9999 -SHRA FEW CU 5500 SCT AC/AS 10000
                        PROB30 INTER 0610 3000 TSRA FEW CB 6000

FOR MORE INFORMATION RING 02 9296 1527
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AMEND AREA FORECAST 150900 TO 152300 AREA 21

AMD OVERVIEW:
TROUGH APPROACHING IN W, EXPECTED IN NE BY 23Z. ISOLATED SHOWERS AND
THUNDERSTORMS E OF YORG/YTMU, CONTRACTING TO SEA/COAST BY 17Z.
LOCALLY BROKEN LOW CLOUD IN PRECIPITATION. AREAS OF SMOKE HAZE IN SE.
MODERATE TURBULENCE BELOW 7000FT LEE OF RANGES, DECREASING BEHIND
TROUGH.

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

WIND:
    2000     5000     7000      10000         14000         18500
A: 330/20   310/25   290/25   280/25 MS01   260/30 MS08   260/35 MS17
B: 230/20   250/20   260/20   260/20 MS02   250/25 MS09   250/30 MS18

CLOUD:
ISOL CB 5000/28000 AS PER OVERVIEW.
BKN ST 1000/2000 SEA/COAST, 3000/4500 RANGES IN SH/TS.
SCT CU/SC 3500/9000 SEA/COAST, 5000/9000 RANGES/W SLOPES, TENDING BKN
RANGES/COAST/SEA IN FAR S WITH ISOL CU TOPS TO 18000.
SCT AC/AS ABOVE 10000.

WEATHER:
TS, SH, SMOKE, HAZE.

VISIBILITY:
3000M TS, 5000M SMOKE/SHRA, 8KM HAZE.

FREEZING LEVEL:
11000.

ICING:
MOD IN LARGE CU TOPS AND IN AC/AS.

TURBULENCE:
MOD BLW 7000FT LEE RANGES IN S, DECREASING BEHIND TROUGH.
MOD IN CU/AC.

CRITICAL LOCATIONS [HEIGHTS ABOVE MSL]:
MT VICTORIA [3700FT]: 9999 -SHRA SCT CU 6000 SCT AC/AS 10000
                      PROB30 INTER 0910 3000 TSRA FEW CB 6000
BOWRAL [2200FT]: 9999 -SHRA FEW CU 5500 SCT AC/AS 10000
                 PROB30 INTER 0910 3000 TSRA FEW CB 6000

FOR MORE INFORMATION RING 02 9296 1527
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## Appendix 3: Other Relevant Information

## Sydney Airport Wind Shear encounter 15 April 2007

Bureau of Meteorology Research Centre
16 May 2007

### Introduction

At approximately 0923 UTC, 15 April 2007 a Boeing 747 encountered wind shear when attempting to land on Rwy 16R at Sydney Airport. In this report we focus on a detailed analysis of the evolution of the weather in the vicinity of Sydney Airport and the wind data recorded by the aircraft Flight Data Recorder. A separate Aviation Safety Incident Report will be prepared that presents broader details of the weather on the day.

### Data

The data used in this study includes radar data from the Bureau of Meteorology's Sydney weather radar and Kurnell weather radar, automatic weather station (AWS) data from stations around the Sydney Basin and high resolution wind data from the anemometer network at Sydney Airport and the Kurnell AWS located on a shipping wharf in the southeast of Botany Bay. The Kurnell radar records volumetric Doppler radar data with an update rate of 5 minutes. The start time for each volume is exactly on the hour and each 5 minute interval thereafter. The high resolution anemometer data is available at 10 second intervals and provides 10 second averages of the wind at each location.

Flight Recorder Data from the aircraft concerned is also examined in the context of the meteorological observational data indicated above.

### Meteorological analysis

In this analysis we focus on the period 0900-1000UTC during which a line of showers and thunderstorms moved across the airport from the southwest at around 22 knots. It is important to note that in this period the showers/storms were high based with a reported base generally around 12000ft. There was only light intermittent precipitation reported at the airport during this period and there was no associated reduction in visibility.
The evolution of the weather in the Sydney Airport area is described below and this relates to Fig.1 that shows a sequence of images of Kurnell radar data and wind data over Sydney Airport for corresponding times.

***0900 UTC:*** At this time the radar data shows the line of showers/storms approximately 5 NM to the southwest of the airport. The wind data shows a NE airflow 10-15 kts over the airport and Botany Bay.

***0905 UTC:*** Wind data shows NNE airflow 10-15 kts over the airport. The wind at the Kurnell anemometer has shifted SW 15 kt following the passage of a gust front ahead of the line of showers/storms.

***0910 UTC:*** At this time the radar data shows the leading edge of the showers/storms around 3 NM to the southwest of the airport. The gust front ahead of this lies across the airport with the SW winds 10-15 kt evident at the thresholds of runways 34L, 34R and 07. The wind at the thresholds of runways 16R, 16L and 25 is northeasterly around 10 kt.

***0915 UTC:*** At this time the gust front has moved to the northeast of the airport with SW winds 15-20 kt across the airport. The Kurnell anemometer has shifted Nly 15-20 kt (change occurred at 0913 UTC) and this is associated with the presence of a convective cell over the anemometer that is evident in the radar data. The Kurnell wind data suggests the presence of a strong divergent outflow associated with the cell.

***092000 UTC:*** The leading edge of the showers/storms is now over the airport. The associated radar reflectivity over the airport is 20-30 dBZ which is relatively weak. There are more intense cells over the south of Botany Bay and the Kurnell Peninsula. The airport anemometer data shows an intensifying divergence flow over the northern end of Rwy 16R that is associated with a developing microburst.
The wind at the Kurnell anemometer has shifted westerly ahead of the cell immediately to the west.

**092131 – 092201 UTC:** The microburst is clearly evident in the anemometer data over the north end of Rwy 16R and was most intense in this period. The maximum divergence observed between the anemometers at the thresholds of runways 16R and 07, a distance of around 1700m, was $12.9 \times 10^{-3}$ $sec^{-1}$ at 092151 UTC. The approach speed for the B747 was around 149 kt and at 092201 UTC the aircraft was around 5 km from the threshold of Rwy 16R.

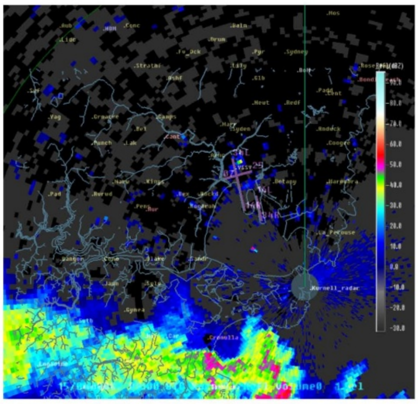
***092301 UTC:*** At this time the wind at the threshold of Rwy 16R has shifted Wly 12 kt and the anemometer data suggests the microburst is centred to the west of the threshold of Rwy 16R.

***0925 UTC:*** At this time the radar shows reflectivities of 30-40 dBZ over the airport with the cell core just to the east. There are northeasterly winds around 10 kt at the northern anemometers (07, 25, 16R and 16L) and this is consistent with the presence of a divergent outflow to the northeast of the airport. The presence of the divergent outflow is evident in the Kurnell Doppler velocity data.

***0930 UTC:*** The radar shows the leading edge of a second line of showers/storms approximately 1 NM to the southwest of the airport. The gust front ahead of this is evident in the anemometer data with 5-10 kt SW winds at southern anemometers (runways 34L, 34R, 07, 16L) and N/NE 5-10 kt winds at northern anemometers runways 16R and 25).

***0935 UTC:*** The radar data shows the second line of showers/storms lying across the airport at this time. The anemometer data clearly shows a divergent outflow with wind speeds of 5-10 kt, indicative of a weak downdraft.

***0940 UTC:*** The radar data shows the most intense line of showers/storms to the east of the Airport with trailing stratiform echoes over the airport. At this time an E/NE airflow of 15-20 kt is evident over the airport. The E/NE winds persisted until around 1030UTC when the strength decreased to 10-15 kt.



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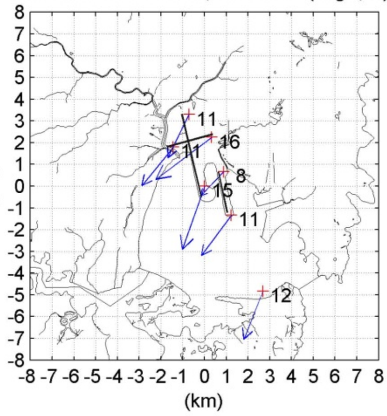


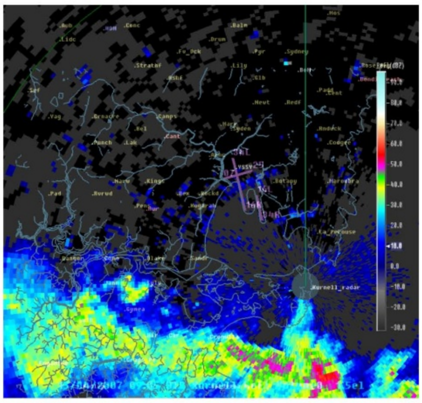

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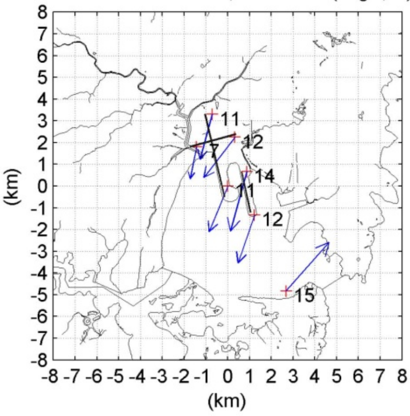


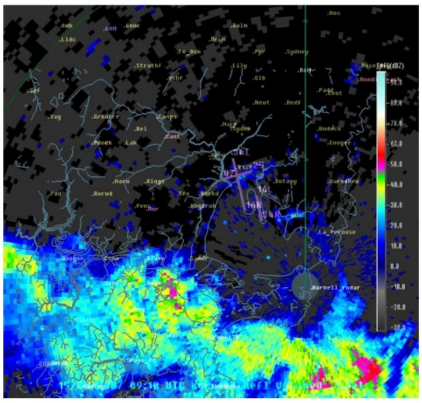

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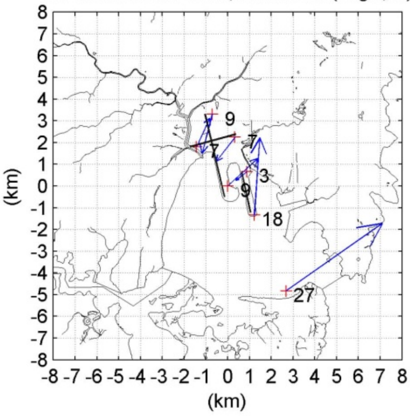

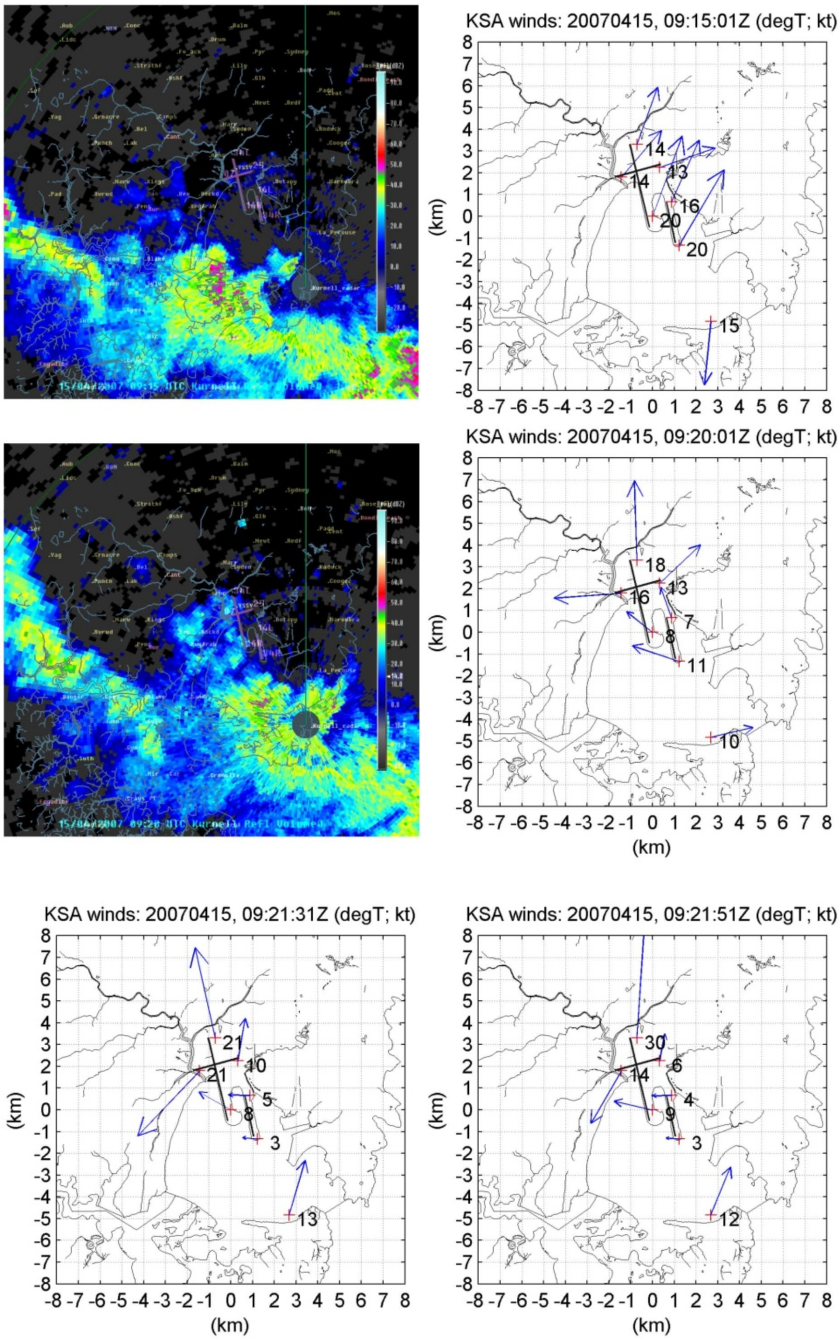
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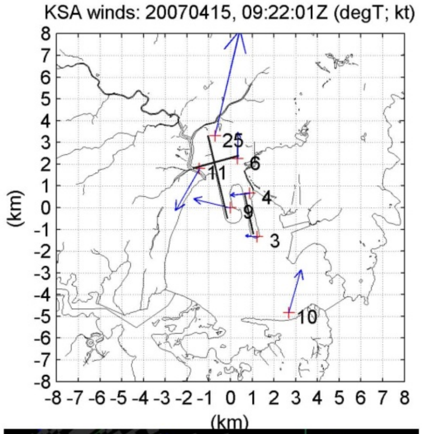
KSA winds: 20070415, 09:20:01Z (degT; kt)
KSA winds: 20070415, 09:21:31Z (degT; kt)
KSA winds: 20070415, 09:21:51Z (degT; kt)
(km)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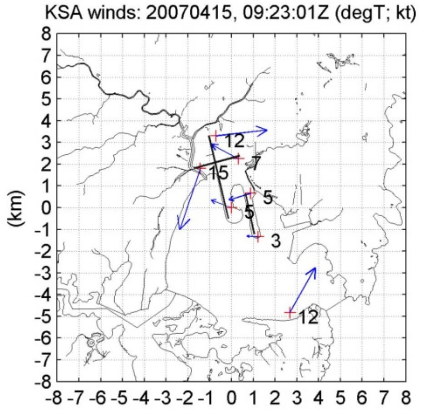
(km)
(km)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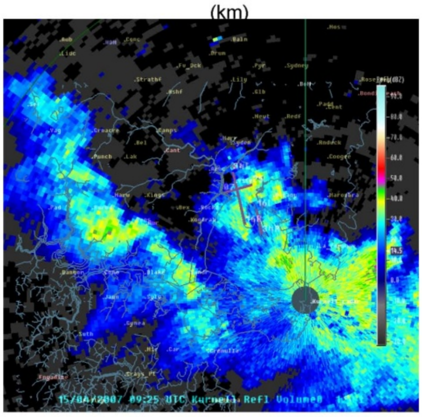
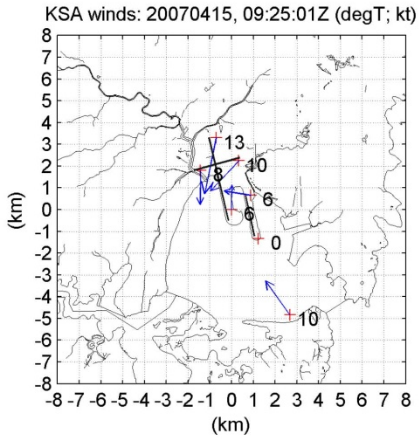
(km)

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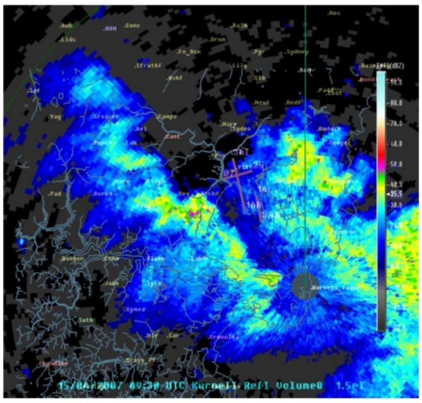
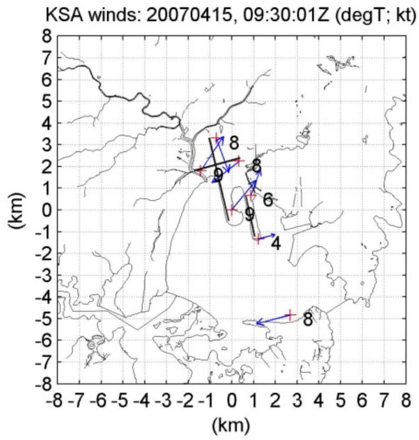
(km)
(km)

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(km)
(km)

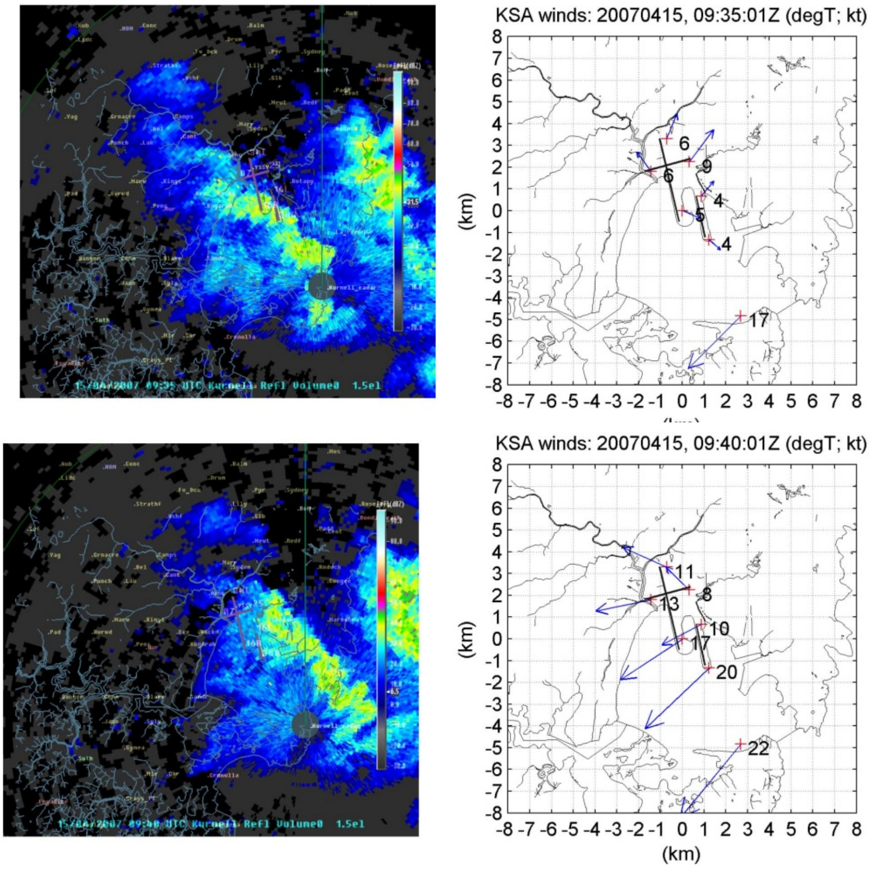


**Figure 1. Radar and anemometer data across the Sydney Airport / Botany Bay area in the period 0900-0940 UTC, 15 April 2007. The anemometer data shows wind speeds in knots.**

**Flight Recorder Data**

Fig. 2 shows Flight Recorder Data from the aircraft concerned as it approached Rwy 16R, touched down at 092318 UTC and then climbed as it aborted the landing. This covers the 3 minute period 092048 – 092348 UTC and shows the radar altitude (ft), the wind direction (degT) and the wind speed (x 10 kt) as the aircraft approached.

As the aircraft descended through 2000 ft it experienced NW winds around 10 kt that shifted NE and increased to 15 kt. At around 092213 UTC when the aircraft was at 800

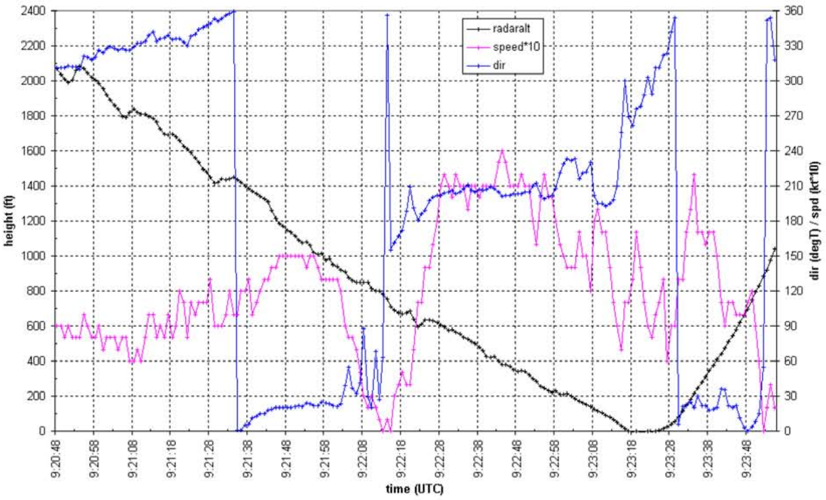


**Figure 2. Flight recorder data for period 092048-092348 UTC.**

ft the wind shifted from NE to S and increased to around 20 kt. At this time the aircraft was around 4 km north of the threshold for Rwy 16R and the observed wind change is consistent with the aircraft descending through the upper boundary of the gust front that passed across the airport earlier. The observed winds are also consistent with those observed at the threshold of Rwy 16R at this time.

In the period 092311-092316 UTC when the aircraft was at less than 100 ft altitude the wind rapidly shifted from 190/18 kt to 280/12 kt. This is a significant wind change at such a critical stage of landing. The along-track wind component changed from an 18 kt headwind to a 5 kt tailwind with an airspeed loss of 23 kt and there was a rapid increase in the cross wind component. The observed wind change reported by the aircraft is again consistent with the wind observed at the threshold of Rwy 16R where the wind shifted from S to W in the period 092220-092250 UTC.

As the aircraft climbed the observed wind is reported as 020/18 kt consistent with the presence of the divergent outflow.

**Discussion**

Wind shear is defined in the ICAO Manual on Low-level Wind Shear (ICAO 2005) as "a change in wind speed and/or direction in space, including updrafts and downdrafts". It can result from a number of meteorological factors and at low altitudes this includes sea breezes, cold fronts, strong low level winds, terrain, gust fronts and convective downdrafts.

Experience has shown that low-altitude wind shear presents a significant risk to aviation during the landing/take-off phase when the airspeed and ground clearance are near critical. Furthermore, wind shear associated with convective activity, and particularly microbursts, present the greatest threat to aircraft operations and these phenomena have been the cause of a number of major aircraft accidents involving passenger aircraft (National Research Council, 1983). There have been detailed investigations of these events and a number of scientific studies aimed at gaining a better understanding of their characteristics and the factors that cause them (Wilson et al 1984, Hjelmfelt 1988).

As a convective cloud or thunderstorm develops, and precipitation begins to fall, an associated downdraft will develop and descend towards the surface. In some situations the downdraft can cause damaging winds at the surface. Fujita 1981 defined a microburst as a downdraft associated with a sudden outflow of damaging horizontal winds at the surface with a horizontal extent less than 4.0 km. In a study of microburst characteristics using Doppler radar Wilson et al (1984) refined this by classifying a

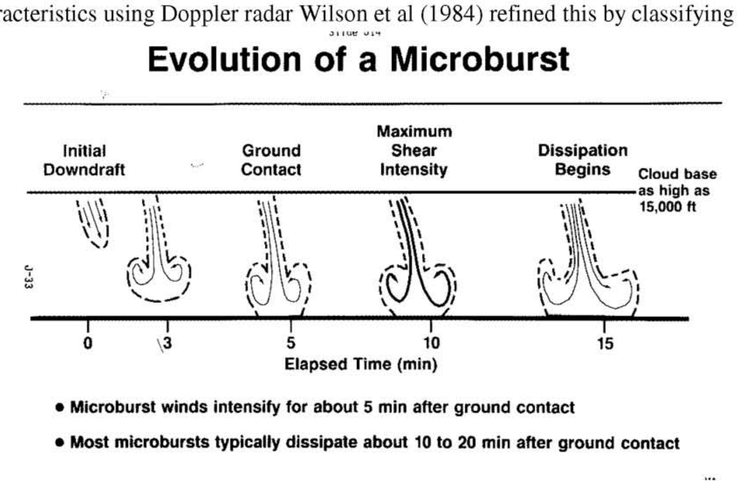


**Figure 3. Evolution of typical microburst. (Adapted from Wilson etal 1984)**

convective downdraft as a microburst when the distance between the maximum radial outflow regions in the initial stages is ≤ 4km and the velocity differential is ≥ 10 m/s (20 kt). They described the evolution of a typical microburst as illustrated in Fig.3 and found the lifetime of a microburst is of the order of 5-15 minutes. A further finding was that in many cases there may be little or no rain at the surface associated with a microburst.

Based on these criteria, the divergent outflow evident in the anemometer data over the north end of Rwy 16R in the period 091951-092300 UTC can be defined as a microburst. Furthermore since there was very little associated rain we can define it as a 'dry' microburst. Based on the anemometer data the lifetime of the event was at least 3:10 minutes. It is possible the lifetime was a little longer but after 092300 UTC the centre of the microburst was outside the anemometer network and the divergent outflow was not so clearly evident. The wind observations recorded by the aircraft Flight Data Recorder are consistent with the surface observations and with a microburst encounter. The observations suggest that at the time the aircraft touched down on the runway at 092318 UTC the microburst was weakening.

A simple analysis of the vector difference between the observed winds at two anemometers showed the maximum divergence occurred at 092151 UTC when the wind at the thresholds of 16R and 07 was 190/30 kt and 040/14 kt respectively. This corresponds to a vector difference of 43 kt (22 $m.s^{-1}$) over a distance of 1.7 km and equates to a divergence of $12.9x10^{-3}$ $s^{-1}$. This is significantly greater than the threshold of 10 $m.s^{-1}$ at $\leq$4 km used by Wilson et al (1984) to define a microburst (equating to a divergence of $2.5x10^{-3}$ $s^{-1}$), and the mean velocity difference reported by Hjelmfelt (1988) of 24 $m.s^{-1}$ over 3.1 km (equating to a divergence of $7.74x10^{-3}$ $s^{-1}$).

The analysis presented here also shows there can be very complex wind flows associated with the passage of thunderstorms and the time scales associated with these events can be very short. This applies in particular to the period that associated wind shear might affect the flight corridor on the approach or departure path for any given operational runway. In these situations only automated systems can be used to detect the wind shear and provide appropriate warnings.

The high resolution wind data at Sydney Airport has been archived for several years as part of an effort to better quantify the level of risk to aviation that is associated with wind shear. The rapid changes that can occur in the wind flow during convective weather events as shown for this event demonstrate the utility of these data for analysis of air safety incidents.

**The impact of wind shear on aviation**

The impact of low-altitude wind shear on aircraft are well understood and the ICAO 'Manual on Low-level Wind Shear' presents considerable detail on the characteristics of wind shear, the impacts on aviation, detection and warning methodologies and training. There are a number of well known issues that must be recognized in relation to the impact of wind shear on aviation:

- The characteristics of wind shear are complex and the phenomena can be caused by a wide range of factors.
- During take-off or landing the available ground clearance may be insufficient for an aircraft to maintain control or recover from some wind shear encounters in time to prevent an accident.
- There is a need to provide appropriate training for meteorologists, ATC personnel and pilots to enable them to recognize the risk of wind shear and provide appropriate warnings or respond in timely and appropriate ways.
- For some wind shear events, including wind shear associated with convection, it is not feasible to provide forecasts due to the small time and space scale of the events. For these events automated detection and warning systems may be required. The cost of installing such systems is significant and the cost effectiveness needs to be determined.

- There is a need for a good understanding of the phenomena that can cause wind shear at any given airport and the level of risk to aviation.

In Australia there have been several studies and several aviation safety incidents associated with wind shear. Potts (2002) provides some background on these and presents details on two recent air safety incidents where aircraft encountered wind shear. The wind shear encounter discussed here supports the conclusion in Potts (2002) that "wind shear associated with convection, namely gust fronts and microbursts, present a risk to aircraft operations in Australia".

**Conclusions**

At approximately 0923 UTC, 15 April 2007 a Boeing 747 encountered wind shear when attempting to land on Rwy 16R at Sydney Airport. In this report we provide a preliminary analysis of meteorological observations in the vicinity of Sydney Airport. This includes Flight Recorder Data from the aircraft,. A separate Air Safety Incident Report will be prepared that presents broader details of the weather on the day.

In the period of interest a line of high based convective cells / thunderstorms moved across the airport. A 'dry' microburst developed over the north end of Rwy 16R at approximately 091951 UTC and this was most intense in the period 092131-092200 UTC with a maximum velocity difference around 40 kt. The B747 encountered the wind shear associated with this microburst in the final stage of landing and aborted the approach. In this process the aircraft touched down at 092318 UTC before climbing. At this time the available observations suggest the microburst was weakening.

**References**

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Hjelmfelt M.R., 1988: Structure and life cycle of microburst outflows observed in Colorado. J.Appl.Meteor. 27, 900-927.

ICAO, 2005: Manual on Low-level Wind Shear. ICAO Doc 9817-AN/449., pp219.

National Research Council, 1983: Low altitude wind shear and its hazard to aviation. National Academy Press, Washington DC., 161pp.

Potts R.J., 2002: Low altitude wind shear at major Australian airports and the risks to aviation. Preprints 10th Conf. on Aviation Range and Aerospace Meteorology, 13-16 May 2002, Portland, Oregon. Amer. Met. Soc.

Wilson J.W., Roberts R.D., Kessinger C., McCarthy J., 1984: Microburst wind structure and evaluation of Doppler radar for airport wind shear detection. J Clim Appl Met., 23, 898-915.

# APPENDIX B: ANALYSIS BY AIRCRAFT MANUFACTURER

Enclosure to 66-ZB-H200-ASI-18347

Performance Analysis – Qantas 747-400 VH-OJR
Windshear Encounter during Approach to Sydney – 15 April 2007

ATSB Preliminary Occurrence Report AO-2007-001 contains the following abstract:

> *On 15 April 2007, a Boeing Company 747-438 aircraft, registered VH-OJR, was being operating on a scheduled passenger flight from Singapore to Sydney, NSW. At 1923 Eastern Standard Time, the aircraft was positioned on a short final approach for a landing on runway 16R when it encountered rapidly changing wind conditions. The aircraft touched down firmly and the crew conducted a go around.*

The ATSB provide FDR/QAR data from the event aircraft and asked that Boeing analyze the event. The results of our analysis follow.

FDR Data Analysis
The FDR data for the event landing are plotted on Figures 1 through 4. Figures 1 and 2 show the longitudinal and lateral-directional parameters respectively for the approach and touchdown. Figures 3 and 4 show the longitudinal and lateral-directional parameters respectively for the aircraft right before and during touchdown. Figure 4 includes kinematically calculated winds and vertical speed. Parameter sign conventions were validated using previous on-ground and in-flight maneuvers available in the data.

The FDR data show the aircraft on a flaps 30 approach at a calibrated airspeed of approximately 154 knots. A comparison of the airspeed and ground speed shows a 15 knot headwind that diminished just before touchdown. The recorded gross weight of the aircraft at this time was 555,000 lbs. The appropriate Vref speed for this aircraft configuration is 144 knots. The approach speed would then be calculated as follows: Vref + ½ headwind component + full gust increment (above the steady wind). The winds during the final approach were reported to be 180 degrees at 22 knots. The gust information was not reported to Boeing. Therefore, this would give an approach speed of at least 154 knots and a touchdown speed of at least 144 knots. These speeds would increase if the gust magnitude was reported to the crew as well.

At time 27029 seconds, the vertical speed began to increase (altitude reduction) as the throttles were reduced. At this same time, a vertical wind occurs, resulting in an 8 ft/sec downdraft just before touchdown. At time 27031 seconds, the thrust was then slightly increased at the same time the flare was initiated. This reduced the sink rate slightly. At time 27032 seconds, the wind direction shifted from a right quartering headwind with a magnitude of 15 knots, to a left crosswind. This shift in headwind caused a 15 knot loss in airspeed just before touchdown. A master warning triggered at time 27035 seconds, just after the aircraft experienced this loss in airspeed. The FDR Windshear caution discrete did not toggle at this time. The master warning light will be set if there is a windshear alert displayed on the primary flight display indicating that there is a windshear. It is unclear why the FDR windshear caution discrete did not toggle, however the master warning triggered near the time the crew reported seeing the windshear alert.

A 35 degree right wheel input was commanded to control the sudden left crosswind. This resulted in a lift loss from the raised spoiler panels causing the sink rate to increase. As a result of this lift and airspeed loss, the aircraft touched down with a calibrated airspeed of 141 knots, a recorded normal acceleration of 1.84 g's and a calculated sink rate of 720 ft/min (12 ft/sec). QAN reported a touchdown normal acceleration of 2.3 g's as recorded in the QAR data. The differences seen between the QAR peak value and FDR peak value

Page 1

Investigation participants: Per ICAO Annex 13, do not release this information without ATSB consent

may be attributed to the sample being recorded at different times within the second. If the FDR data had a higher sample rate, it may have recorded the 2.3 g's seen in the QAR data.

The thrust levers were above idle thrust at the time of touchdown, therefore the speedbrakes did not automatically deploy. A go-around was commanded as the thrust levers were increased at time 27038.5 seconds.

Simulation

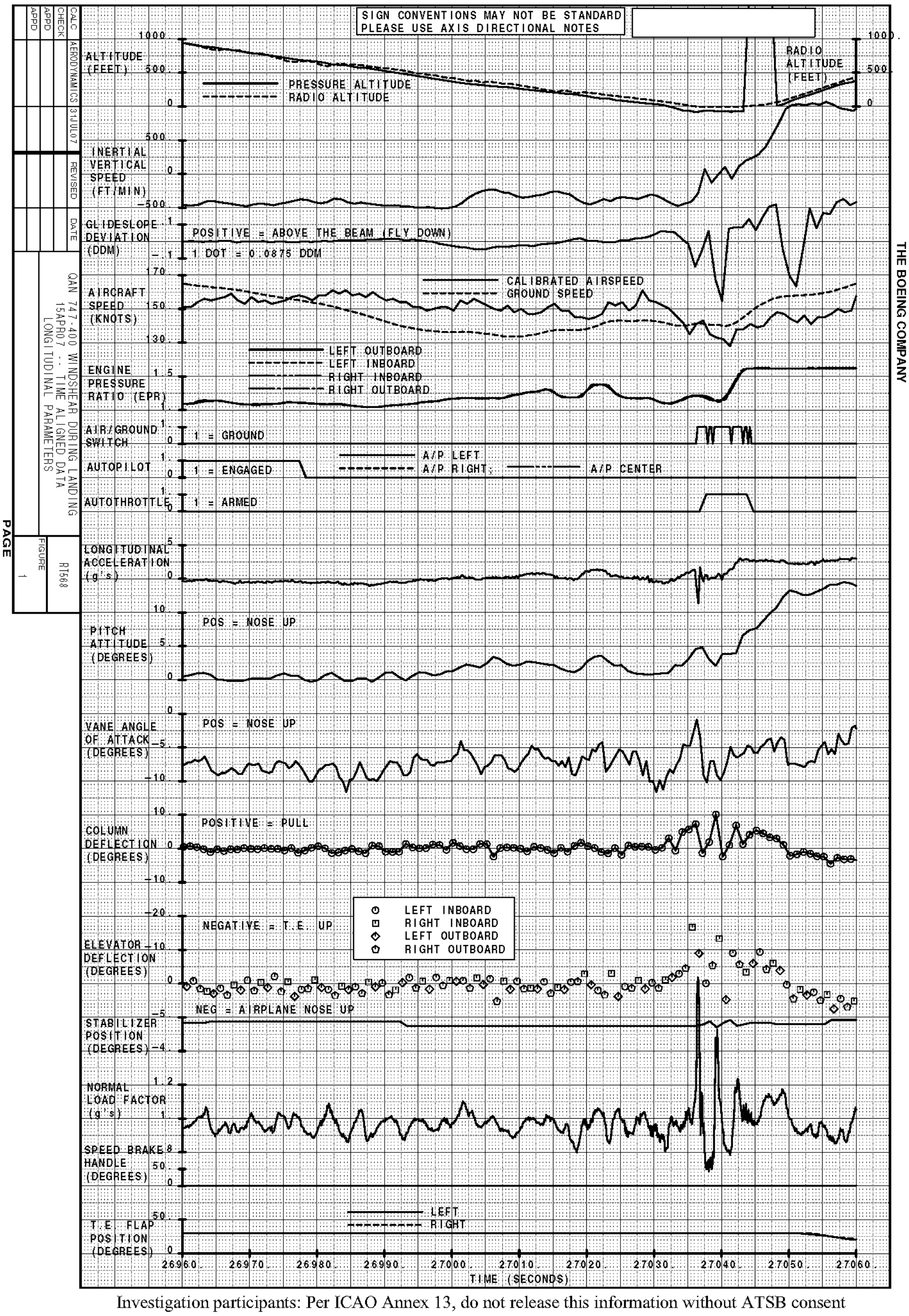
A simulation analysis of the approach portion of the event was performed comparing the recorded data to an engineering model of the aerodynamic performance of the 747-400. This analysis identified the horizontal wind shift with resulting airspeed loss as the primary contributor to the large touchdown sink rate. The vertical wind component and large wheel inputs experienced on final approach were identified as significant but secondary contributors to the large sink rate at touchdown.

Kinematic Analysis

The FDR wind information is a good indication of longitudinal and lateral atmospheric conditions. However, it is recorded at a low sample rate. To better determine the wind conditions, the wind information was predicted kinematically using higher sampled FDR data parameters, 747-400 airplane information, and the equations of motion. This process derives longitudinal, lateral, and vertical wind information that is both at a high sample rate and is consistent with the FDR acceleration information. Figure 4 shows that the kinematic wind calculation agrees closely with the wind data recorded in the FDR data.

Conclusions

QAN reported a windshear event on approach on a 747-400 (RT568) aircraft at the Sydney International Airport (SYD) on 15 April 2007. Analysis of the FDR data indicates that a headwind which shifted to a crosswind caused a loss in airspeed. This loss in airspeed (primary effect), combined with an 8 ft/sec downdraft and a large right wheel input (secondary effects), contributed to a high rate of sink just before touchdown. The flare and the commanded increase in thrust were unable to arrest the high sink rate and the aircraft touched down with a normal acceleration of 1.84 g's and a calculated sink rate of approximately 720 ft/min (12 ft/sec).

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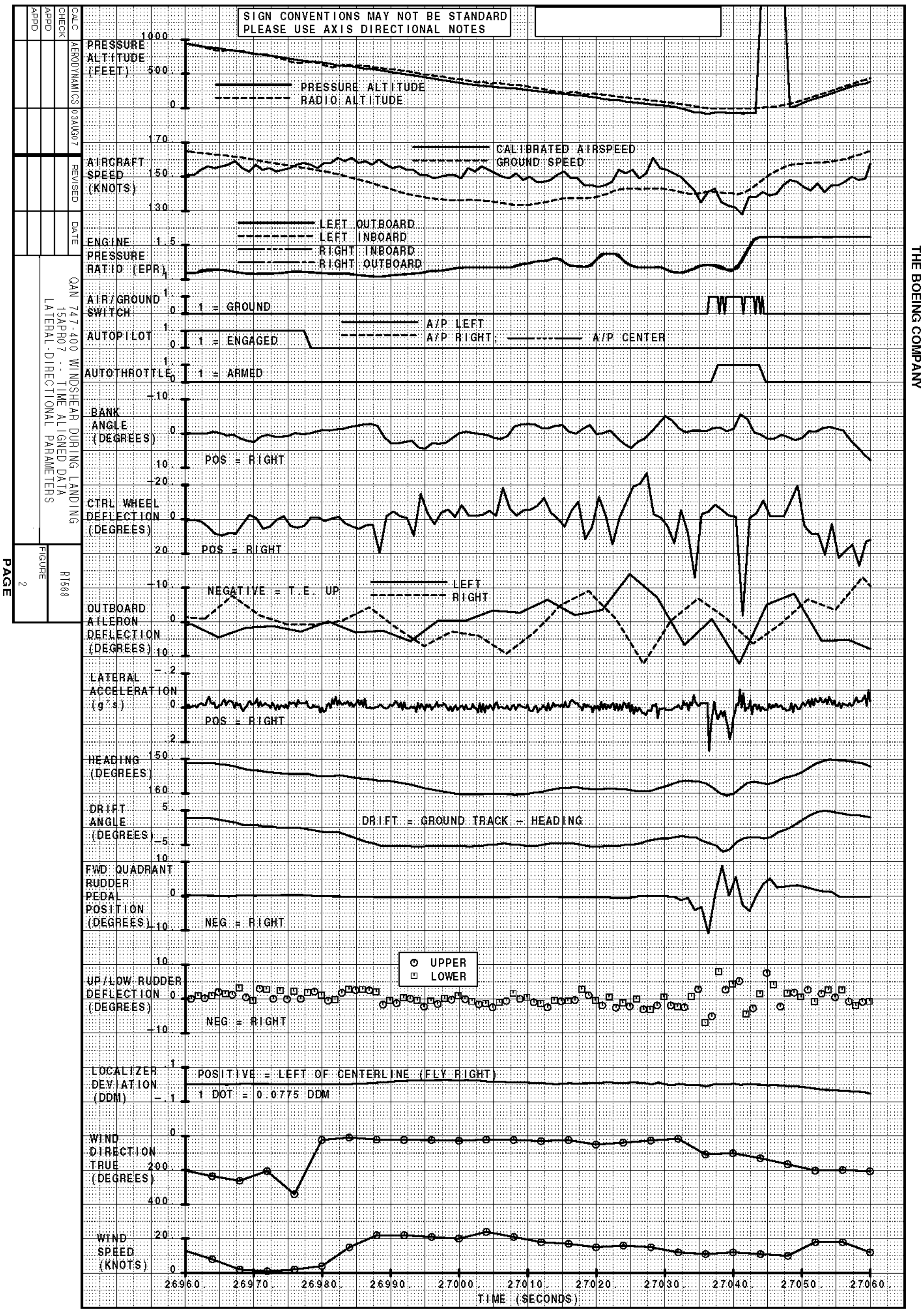


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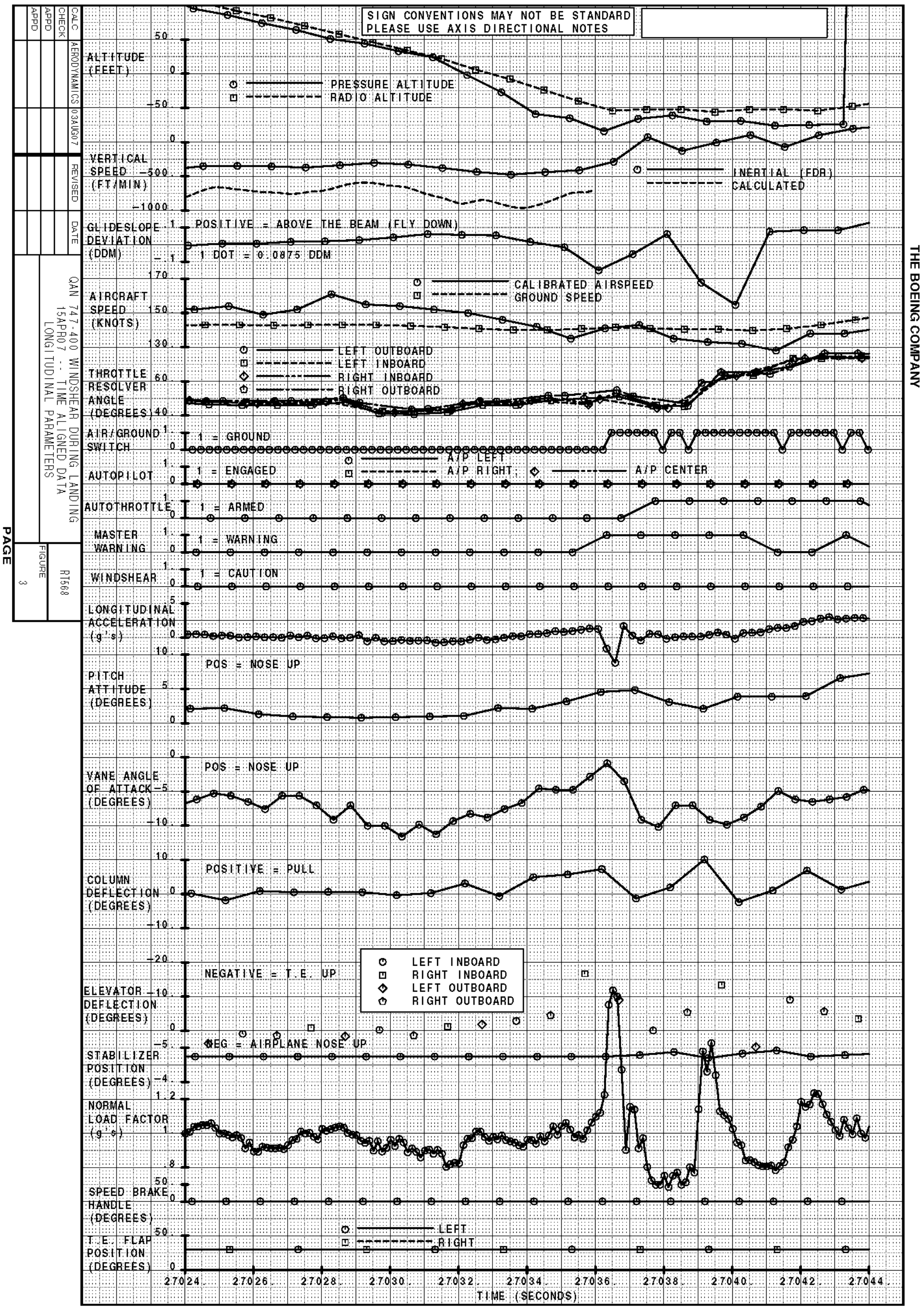
SIGN CONVENTIONS MAY NOT BE STANDARD
PLEASE USE AXIS DIRECTIONAL NOTES
ALTITUDE (FEET)
PRESSURE ALTITUDE
RADIO ALTITUDE
VERTICAL SPEED (FT/MIN)
INERTIAL (FDR)
CALCULATED
GLIDESLOPE DEVIATION (DDM)
POSITIVE = ABOVE THE BEAM (FLY DOWN)
1 DOT = 0.0875 DDM
AIRCRAFT SPEED (KNOTS)
CALIBRATED AIRSPEED
GROUND SPEED
THROTTLE RESOLVER ANGLE (DEGREES)
LEFT OUTBOARD
LEFT INBOARD
RIGHT INBOARD
RIGHT OUTBOARD
AIR/GROUND SWITCH
1 = GROUND
AUTOPILOT
1 = ENGAGED
A/P LEFT
A/P RIGHT
A/P CENTER
AUTOTHROTTLE
1 = ARMED
MASTER WARNING
1 = WARNING
WINDSHEAR
1 = CAUTION
LONGITUDINAL ACCELERATION (g's)
PITCH ATTITUDE (DEGREES)
POS = NOSE UP
VANE ANGLE OF ATTACK (DEGREES)
POS = NOSE UP
COLUMN DEFLECTION (DEGREES)
POSITIVE = PULL
ELEVATOR DEFLECTION (DEGREES)
NEGATIVE = T.E. UP
LEFT INBOARD
RIGHT INBOARD
LEFT OUTBOARD
RIGHT OUTBOARD
STABILIZER POSITION (DEGREES)
NEG = AIRPLANE NOSE UP
NORMAL LOAD FACTOR (g's)
SPEED BRAKE HANDLE (DEGREES)
T.E. FLAP POSITION (DEGREES)
LEFT
RIGHT
27024 27026 27028 27030 27032 27034 27036 27038 27040 27042 27044
TIME (SECONDS)
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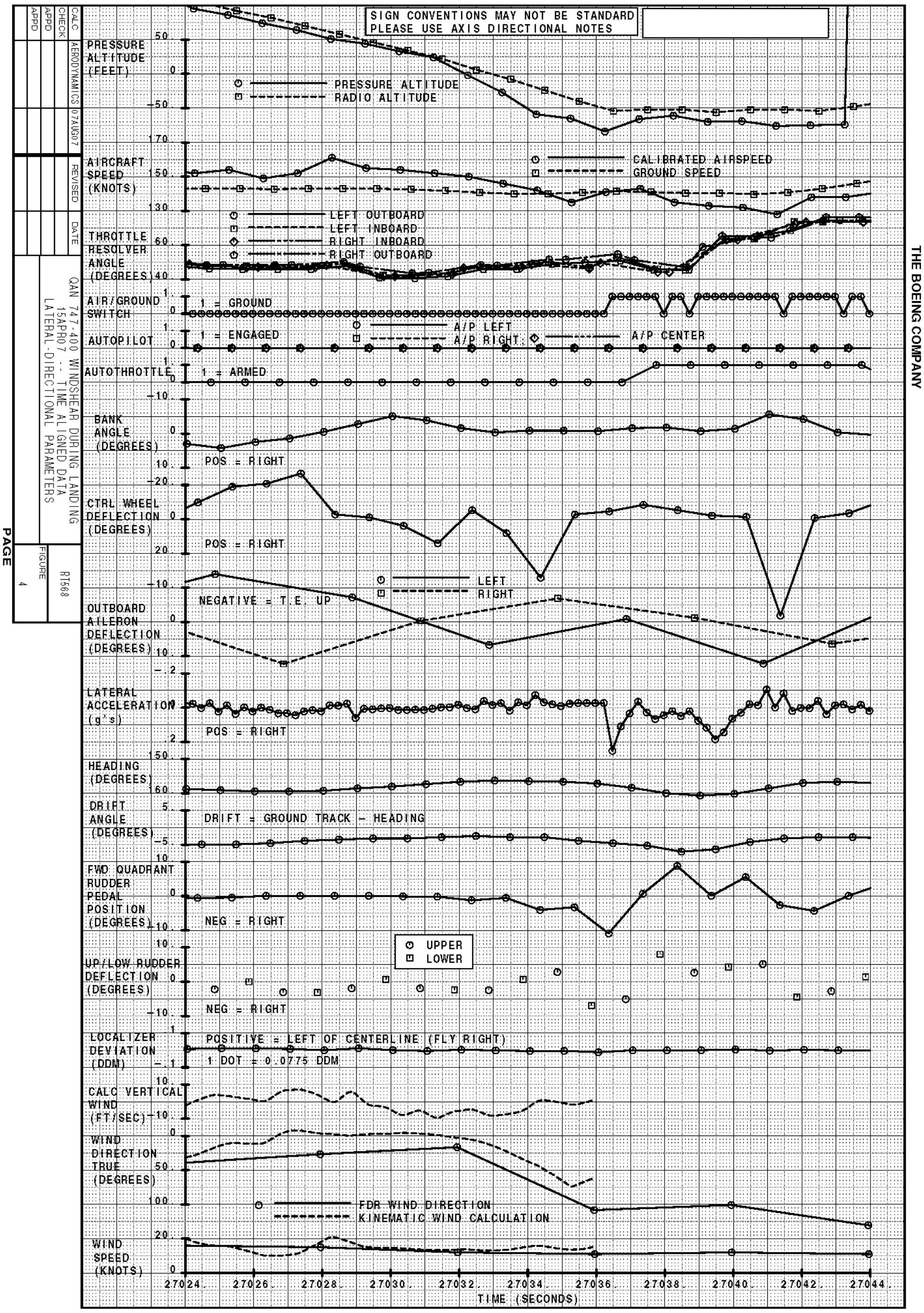


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# APPENDIX C: ANALYSIS BY EGPWS MANUFACTURER

**Analysis of ....... B747-400 Windshear event**
**Rev: New 5-14-2007**

Warning history download data taken from EGPWS P/N 965-0976-003-216-216 S/N 14557 with Terrain database 433. Aircraft type is B747-400.

Windshear Warning event is found at EPGWS flight leg #1647 and occurred on approach into Sydney, Australia at a radio altitude of 12 feet.

The recorded data was formatted and then run through a simulation of the EGPWS Windshear computation as done on the B747-400 aircraft. The recorded data matched very closely the simulated data.

Note the recorded data is provided at a 1 second sample rate. The simulation used data interpolation to provide a 10 hertz simulation rate to match the computation rate of the EGPWS.

Figure 1 below shows a graph of the EGPWS calculated windshear value (total shear) versus the threshold values. The Windshear Caution threshold is set a +0.09 g's, and the Windshear Warning threshold is set to -0.11 g's. The graph also shows separate values for the horizontal and vertical Windshear components as calculated by the EGPWS.

As can be seen from the graph the Windshear Warning threshold was exceeded at time 19 seconds. The Windshear event is triggered by a large horizontal Windshear. Very little vertical shear (downdraft) is detected.

Figure #2 shows the recorded speeds. True Airspeed first increases from 150 knots to a maximum of 163 knots starting at time 10 seconds. Then True Airspeed rapidly decreases from the 163 knot maximum to a minimum of 135 knots (-28 knots) over the next 7 seconds. Ground speed is fairly steady during this time. This rapid decrease in True Airspeed (shear) started at a radio height of 111 feet. This is about 8 seconds before touchdown.

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**Figure 1 – Shear value**

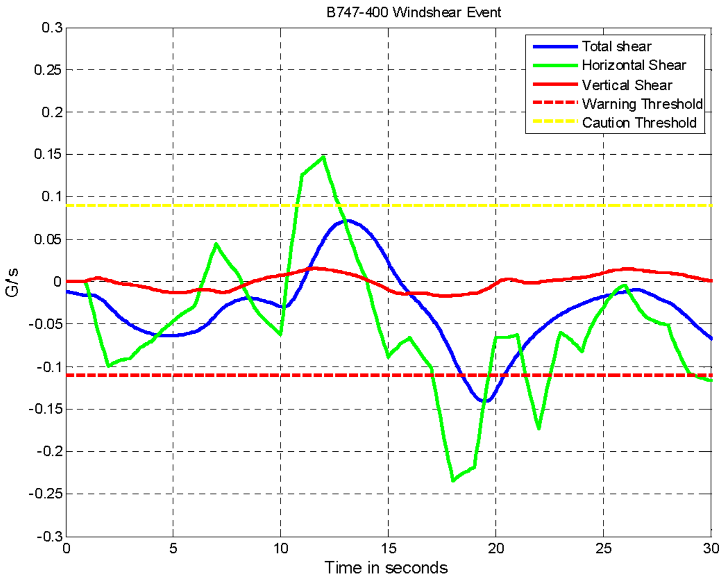


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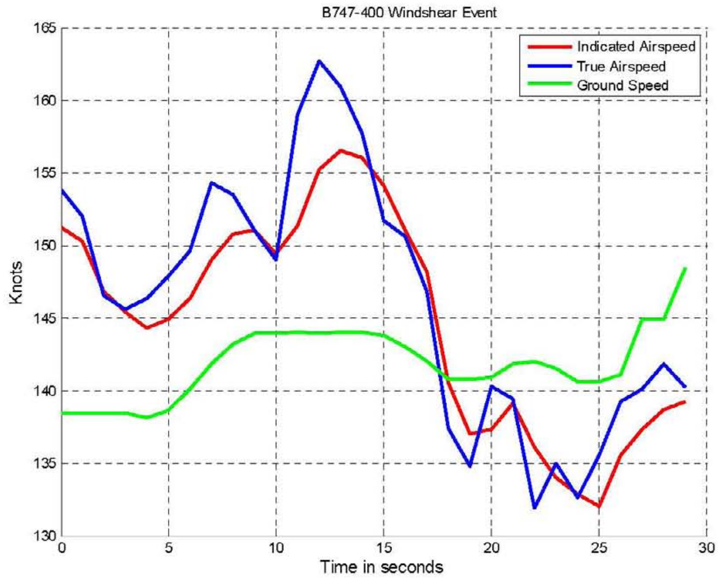
**Figure 2 –**

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# APPENDIX D: SOURCES AND SUBMISSIONS

## Sources of Information

The main sources of information during the investigation included:

- the pilots of VH-OJR
- the aircraft operator
- Airservices Australia
- the Bureau of Meteorology
- the aircraft manufacturer
- the manufacturer of the flight data recorder
- the manufacturer of the enhanced ground proximity warning system.

## References

Schlickenmaier, H. (1988). *Windshear case stud: Denver, Colorado, July 11, 1988 (DOT/FAA/DA-89/19)*. Washington, DC; Federal Aviation Administration.

## Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the Transport Safety Investigation Act 2003, the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the:

- members of the flight crew
- affected air traffic controllers
- aircraft operator
- aircraft manufacturer
- airport operator
- relevant avionics manufacturers
- Civil Aviation Safety Authority
- Airservices Australia
- Bureau of Meteorology
- US National Transportation Safety Board.

Submissions were received from the pilot in command, the aerodrome controller – east, the aerodrome controller – west, the airport operator, Airservices Australia and the aircraft manufacturer. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.