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

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

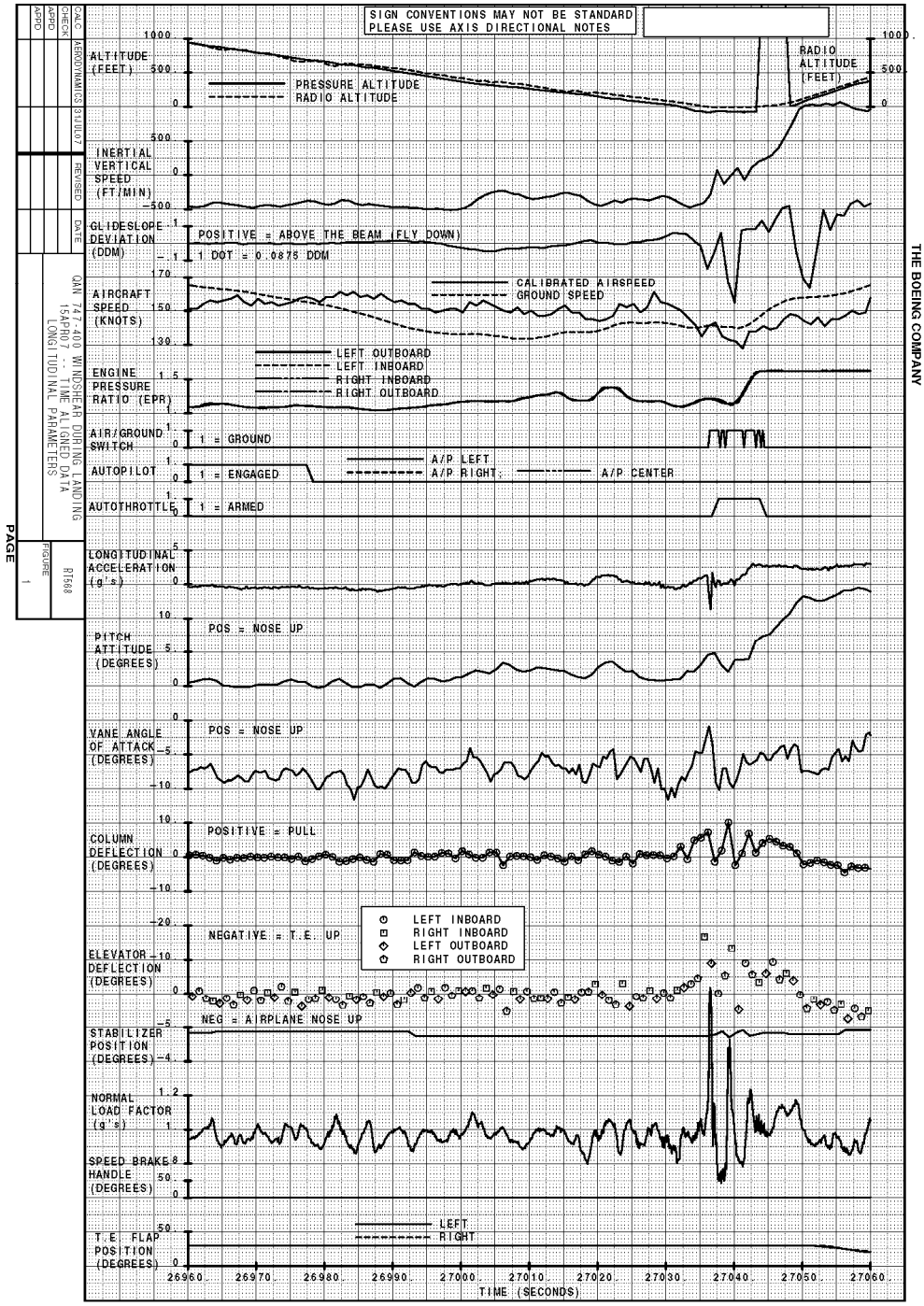
A simulation analysis of the approach portion of the event was performed comparing the recorded data to an engineering model of the aerodynamic performance of the 747-400. This analysis identified the horizontal wind shift with resulting airspeed loss as the primary contributor to the large touchdown 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.

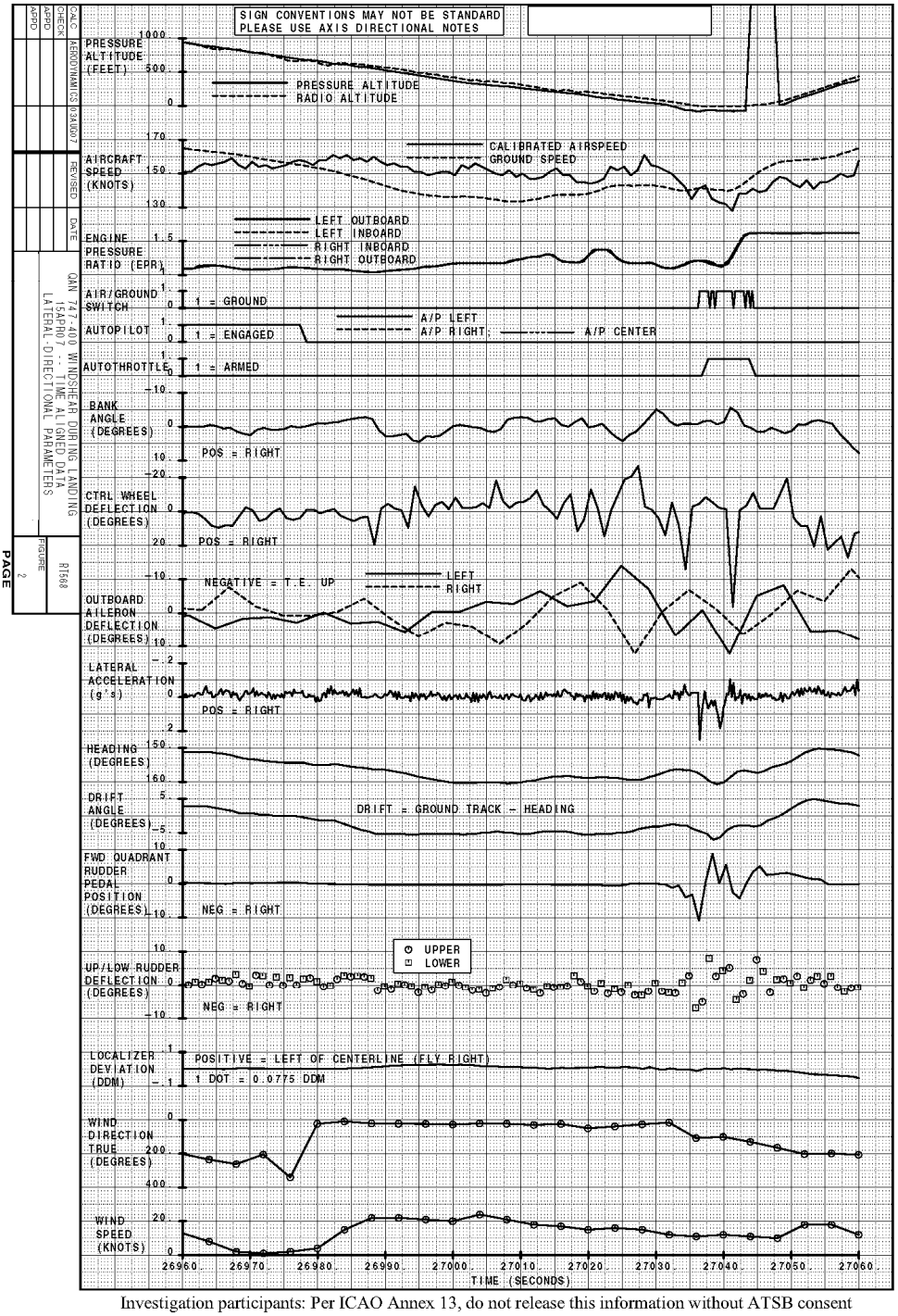
Kinematic Analysis

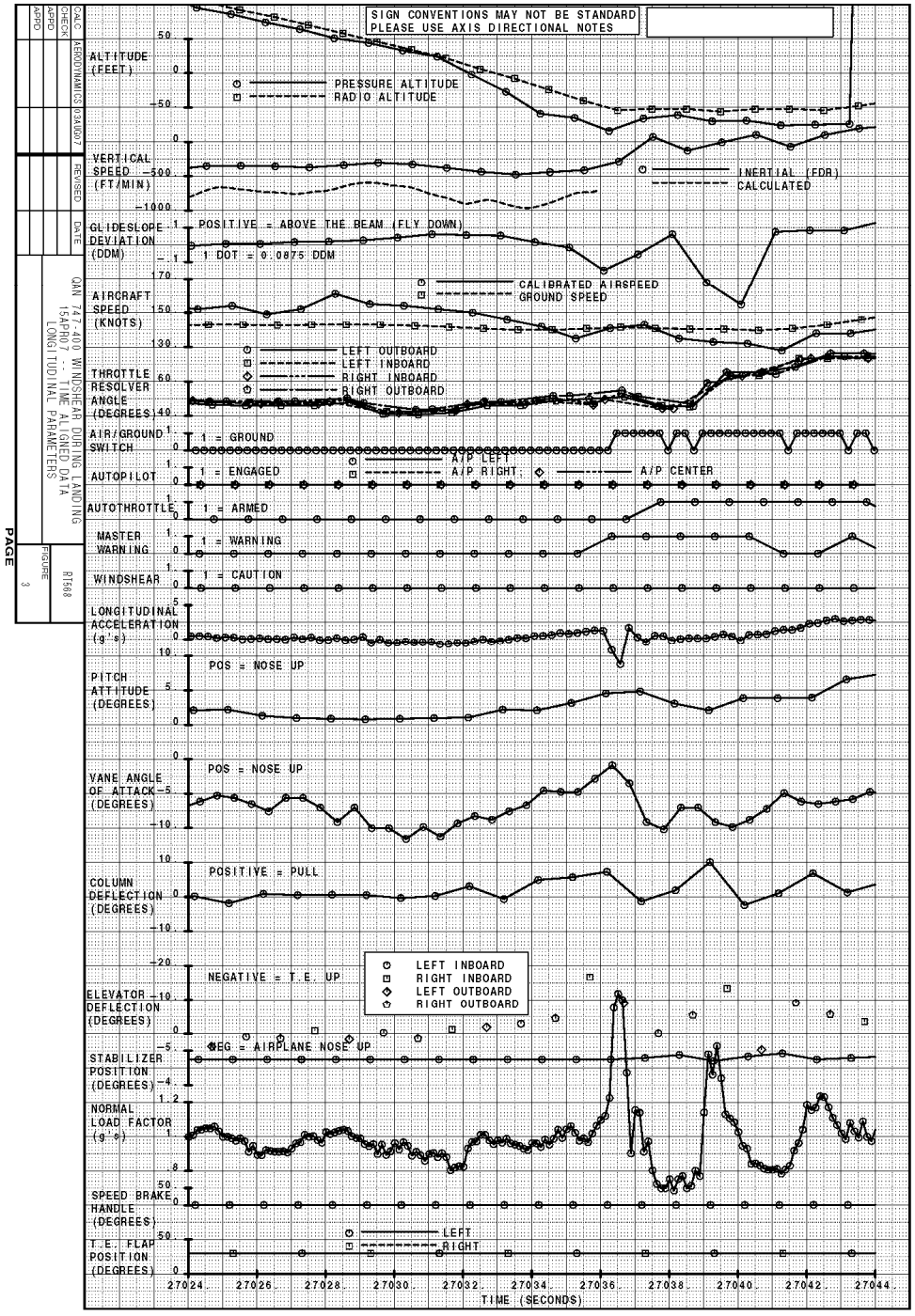
The FDR wind information is a good indication of longitudinal and lateral atmospheric conditions. However, it is recorded at a low sample rate. To better determine the wind conditions, the wind information was predicted kinematically using higher sampled FDR data parameters, 747-400 airplane information, 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.

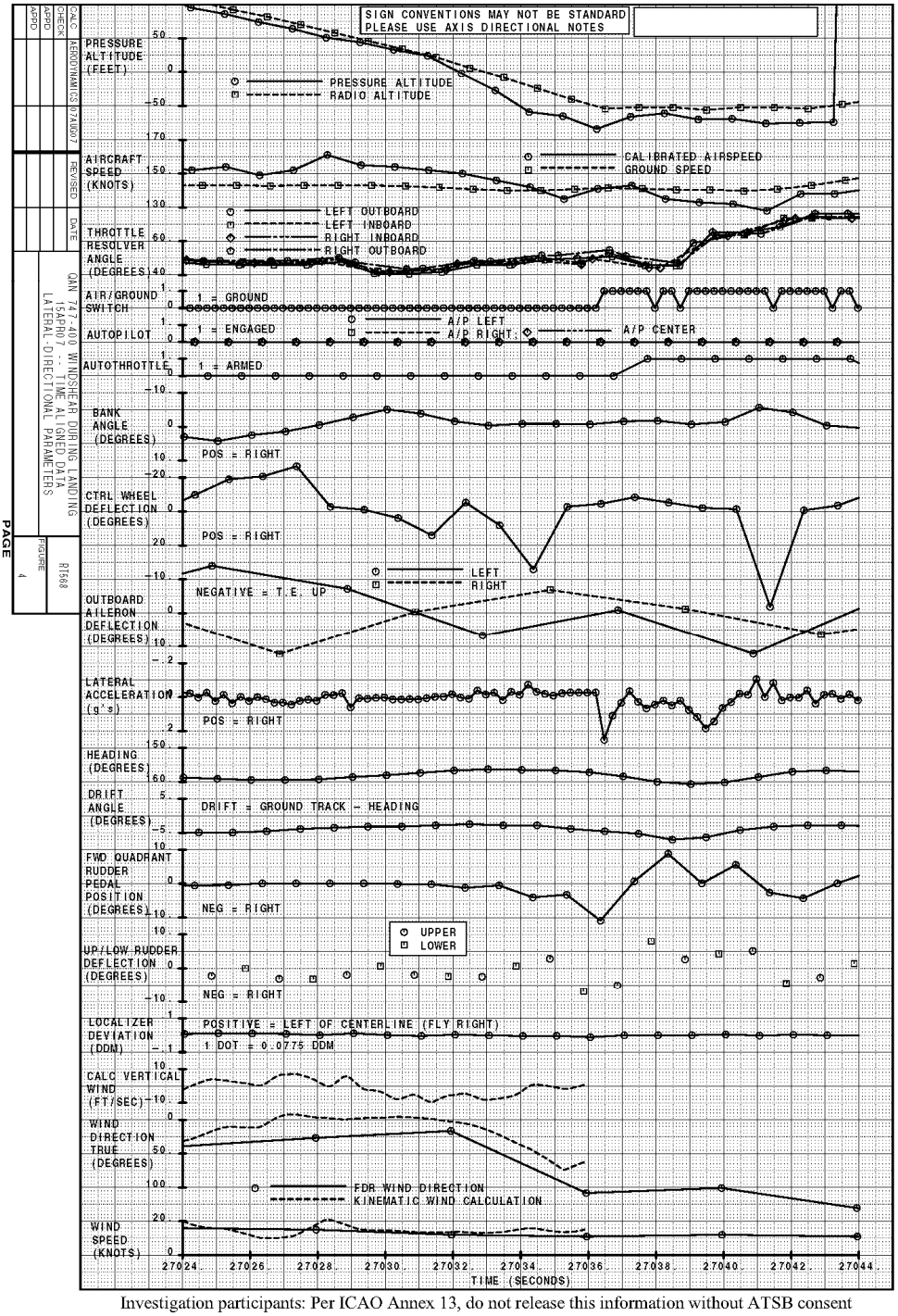
Conclusions

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).









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.

Figure 1 – Shear value

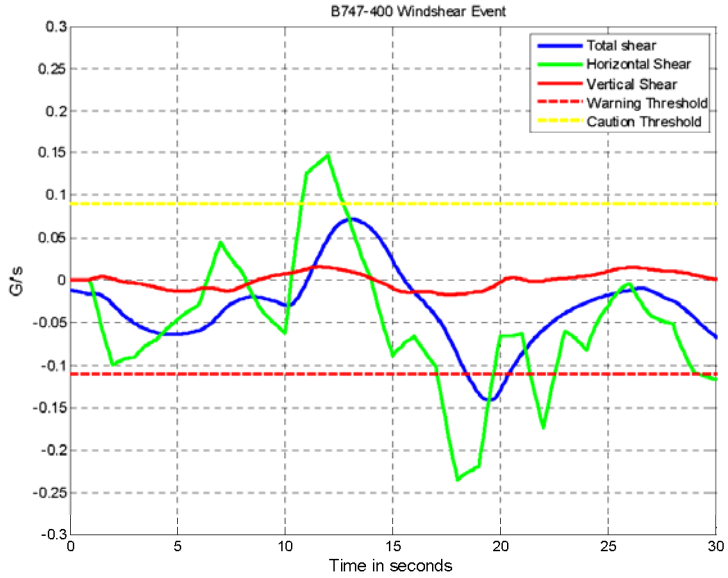
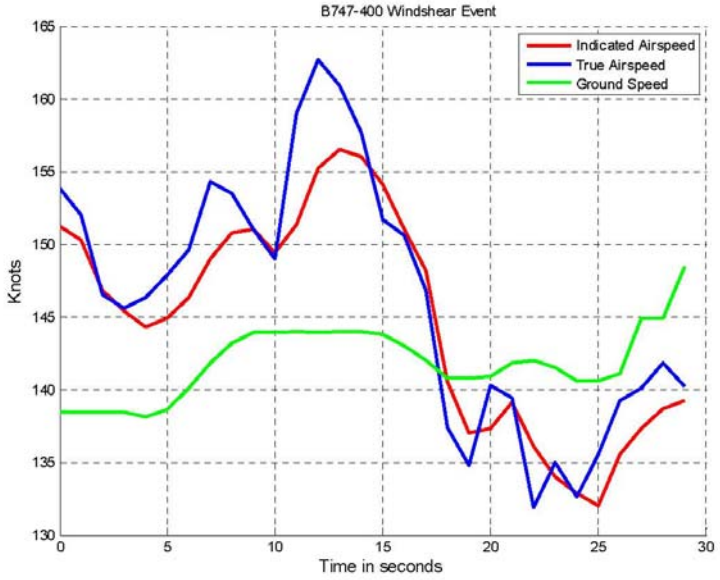


Figure 2 -


B747-400 Windshear Event
Indicated Airspeed
True Airspeed
Ground Speed
Knots
Time in seconds
165
160
155
150
145
140
135
130
0
5
10
15
20
25
30

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.