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Australian Transport Safety Bureau

TECHNICAL ANALYSIS REPORT NO. 09/04

Occurrence Number: 200305497
Technical Analysis Investigation in support of BO/200303579
OASIS Job: RAD200300016

Factual Report:
Readout of Recorded Radar Data

Cessna 404, VH-ANV
Jandakot, WA
11 August 2003

CONTENTS

1. INTRODUCTION

At 0735 UTC on 11 August 2003, VH-ANV was cleared on a MANTL 1 departure from runway 24R at Jandakot airport. Onboard were the pilot and five passengers. The aircraft called ready and was cleared to climb to 3,000 feet. The aircraft rotated and the tower staff noticed a sound similar to an asymmetric operation. The aircraft was turned left and subsequently impacted the ground to the southeast of the tower near the NDB site. This Technical Analysis Investigation report should be read in conjunction with ATSB report BO/200303579.

2. RADAR DATA

2.1 Background

Primary radar returns are produced by radar transmissions which are passively reflected from an aircraft and received by the radar antenna. The received signal is relatively weak and provides only position information. Primary radars, which are only located near capital city airports, have a nominal range of 50 NM.

Secondary radar returns are dependent on a transponder in the aircraft to reply to an interrogation from the ground. As the aircraft transponder directly transmits a reply, the signal received by the antenna is relatively strong. Consequently, an aircraft which has its transponder operating can be more easily and reliably detected by radar.

For civilian general aviation aircraft the interrogations are either Mode A or Mode C. Following a Mode A interrogation the aircraft transmits an encoded pulse train containing the secondary surveillance radar (SSR) identification code. This code is set by the pilot and consists of four octal digits. Following a Mode C interrogation the aircraft transmits an encoded pulse train containing the aircraft's pressure altitude. The pressure altitude data is obtained from an encoder in the aircraft and is automatically sent to the transponder.

A transponder-equipped aircraft is not always detected by secondary radar. This could be due to one of the following reasons:

- aircraft is outside of the range of the radar
- transponder is not switched on
- transponder is unserviceable
- loss of aircraft power to the transponder
- terrain shielding
- aircraft transponder aerial is shielded from the radar due to aircraft manoeuvring

It is normal practice for the pilot to activate the transponder when lining up on the runway for takeoff. This involves switching the transponder from STBY to ALT. The ALT position enables the transponder to reply to Mode A and Mode C interrogations.

The radar tracker software generates missed returns when an aircraft on an established track disappears from radar coverage. If a valid return is not received before three missed returns are generated then the track is dropped.

2.2   Method

It was reported that VH-ANV was using SSR code 4473. Radar data received from the secondary surveillance radar at Mount Kalamunda was filtered using the following criteria:

- Mode A = 4473
- Time stamp > 0730 UTC 11 August 2003
- Time stamp < 0745 UTC 11 August 2003

The resulting data was extracted by AirServices Australia and forwarded to the ATSB.

A radar tape, containing data recorded at the time of the reported incident, was received at the Bureau's Perth Office on 18 August 2004 and quarantined.

The Mount Kalamunda secondary surveillance radar site (31º 59' 32" S and 116º 4' 12" E) is located approximately 12 NM North-East of Jandakot airport and generally has line-of-sight coverage of the airport. Refer to Appendix 7.5. The elevation of the radar site is 333 metres (1,093 feet). The nominal range of the radar is 250 NM but radar coverage to the East is limited due to terrain shielding.

Recorded radar position data (X and Y coordinates) has its origin at the radar site and the Y axis is aligned with True North.

Recorded Mode C pressure altitude is referenced to 1013 hPa. As the reported QNH was 1002 hPa approximately 330 feet needs to be added to the recorded Mode C values to give pressure altitude referenced to QNH. The pressure altitude data was received with this correction already applied. The elevation of Jandakot Airport is 99 feet.

2.3   Accuracies

Timing

The radar rotates at 16.2 RPM giving a scan rate of 3.7 seconds.

Position

The accuracy of the radar position data is proportional to the range of the aircraft from the radar site. Typical accuracies for a monopulse SSR are:

Range Accuracy   : $\pm$ 0.05 NM RMS
Azimuth Accuracy   : $\pm$ 0.05° RMS

The overall accuracy can be affected by terrain or meteorological conditions.

The first three valid returns (at 0734:22 UTC, 0735:10 UTC and 0735:21 UTC) were converted to latitude and longitude using the Coordinates Calculator software (Version 2.5) from AirServices Australia. These points were plotted on a Jandakot runway chart (refer to Appendix 7.4). As the aircraft was assumed to be on the runway 24R centre-line at these

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times a fixed offset was applied to best fit the radar positions to the centre-line. This offset (approximately 120 metres) was applied to all the radar returns.

Pressure Altitude

The Mode C Pressure Altitude data accuracy is determined by the aircraft's encoding altimeter accuracy plus the transponder quantisation of 100 feet. An encoding altimeter can suffer from lag when experiencing high vertical speed changes.

Groundspeed

The recorded groundspeed data is derived from the rate of change of aircraft position and is smoothed. It does not represent the instantaneous value of groundspeed.

3. RESULTS

Radar data was recorded for VH-ANV from 0734:22 UTC until 0736:53 UTC – a duration of 2 minutes and 31 seconds. Twenty-one valid returns were received. In addition ten missed returns were recorded including three before takeoff, four during the flight and three at the end of the recording after the final valid return was received. The missed returns do not correspond to actual returns from VH-ANV and consequently they have been ignored.

Time (UTC):	Comment:
0734:22	This was the first return received from ANV. The aircraft was stationary on runway 24R awaiting takeoff clearance.
0734:25	*First missed return.*
0734:29	*Second missed return.*
0734:33	*Third missed return – track dropped.*
0735:10	A valid return was received from ANV. A new track was created.
0735:21	ANV near runway centre-line.
0735:24	*First missed return.*
0735:28	ANV has tracked to the right of the runway centre-line. Mode C pressure altitude showed an altitude gain of 100 feet from the value on the ground.
0735:32	ANV has tracked further to the right of the runway centre-line.
0735:35	*First missed return.*
0735:39	ANV has maintained its offset right of the centre-line.
0735:43	*First missed return.*
0735:47	*Second missed return.*
0735:50	ANV has tracked to the left of the centre-line and was in a left turn.
0735:54	The left turn has continued.
0735:58	The left turn has continued.
0736:01	A track of approximately 130º T was maintained.
0736:05	A track of approximately 130º T was maintained.
0736:09	ANV was in a left turn.
0736:12	
0736:16	
0736:20	The left turn was continued during this period.
0736:23	
0736:27	
0736:31	
0736:34	A track of approximately 035ºT was maintained.
0736:38	A track of approximately 035ºT was maintained.
0736:42	A track of approximately 035ºT was maintained. This was the final valid return received from ANV. The recorded ground speed was 98 knots. The distance between this return and tree contact was approximately 350 metres. At a groundspeed of 98 knots this distance would be covered in 7 seconds.
0736:46	*First missed return.*
0736:49	*Second missed return.*
0736:53	*Third missed return – track dropped.*

Recorded Mode C altitude values showed that the flight was conducted at low level as the altitude only increased by one unit (ie. one hundred feet) after takeoff and remained at this value until radar returns ceased.

Average groundspeed values were:

- Upwind   (0735:39 UTC – 0735:50 UTC)   83 knots
- Crosswind   (0735:58 UTC – 0736:16 UTC)   83 knots
- Downwind   (0736:20 UTC – 0736:42 UTC)   98 knots

The following figures were produced from the radar data:

- Figure 1:   Plot of Ground Track (0734:22 UTC – 0736:53 UTC)
- Figure 2:   Plot of Ground Track Overlayed on an Aerial Photograph

Examination of the accident site showed that the aircraft contacted the canopy of a tree at a latitude of 32º 6.242' S and a longitude of 115º 53.256' E. The wreckage coordinates were 32º 6.176' S and 115º 53.283' E. These two locations are marked on Figure 2.

(X,Y) Coordinates in NM
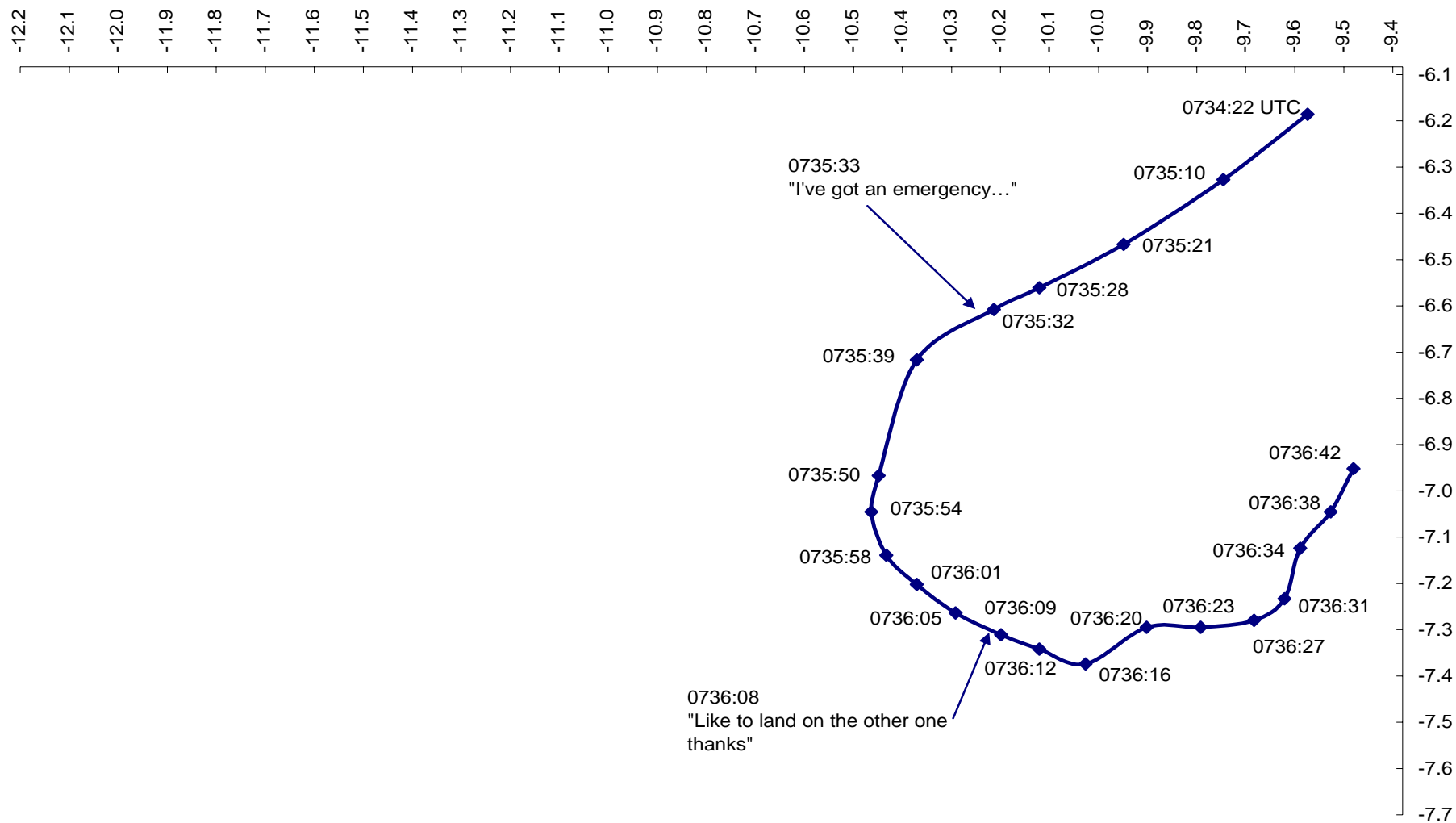

Figure 1 – Track Plot

0735:33 UTC
"I've got an emergency ...."

Aircraft Wreckage

Tree Contact

0736:08 UTC
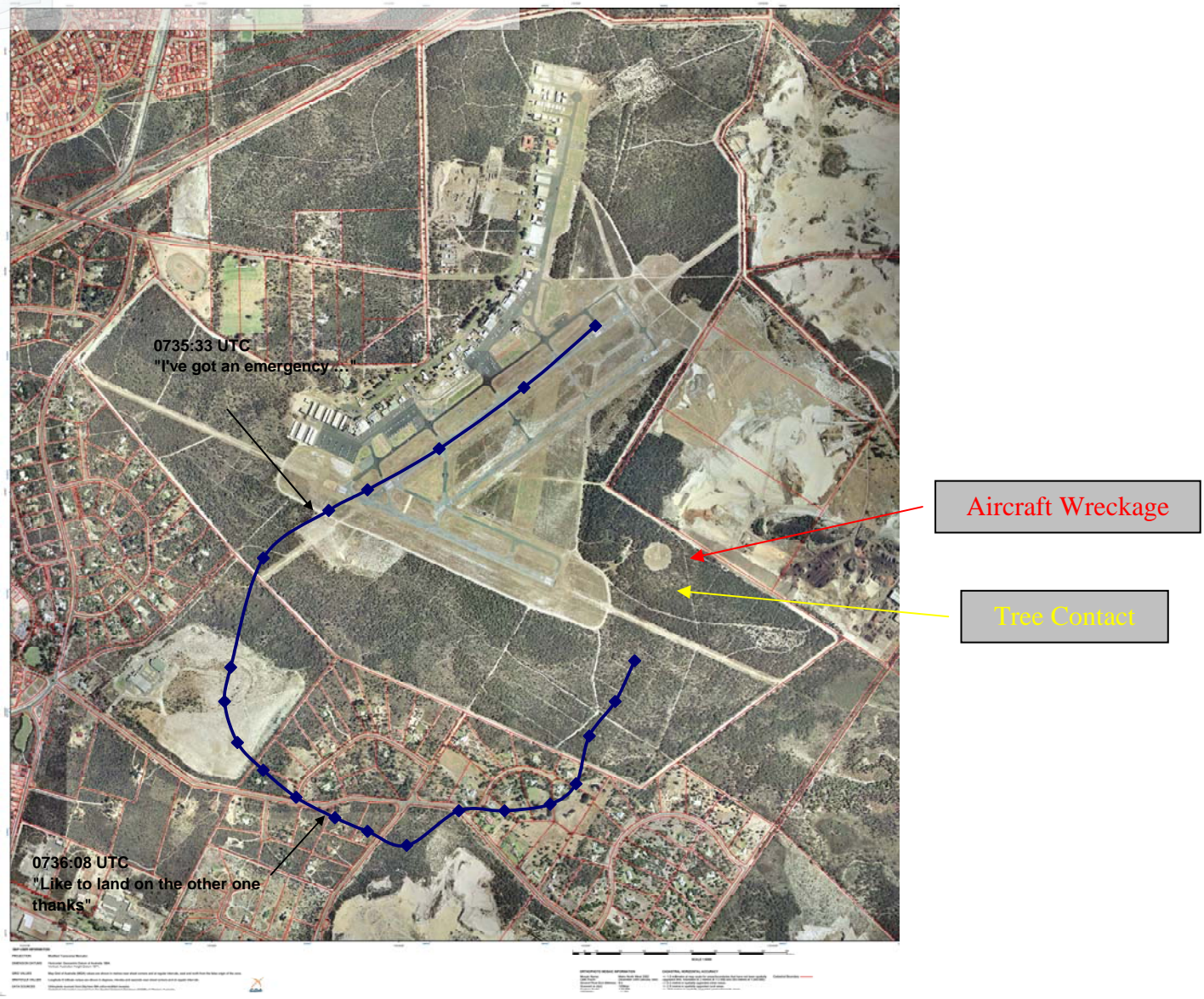**"Like to land on the other one thanks"**

Figure 2 - Track Plot Overlayed on an Aerial Photograph

4.   COMPUTER ANIMATION

The radar data was imported by the ATSB's Hewlett Packard C3000 computer for presentation using RAPS version 5.0 software. A PC version of RAPS, Insight, was used to view the animation. Refer to Figure 3.

The animation shows a twin-engined aircraft (scaled up by a factor of 15) following the position recorded by radar in real-time. Recorded track was used for aircraft heading. No corrections were made to the recorded data in producing the animation. UTC is displayed in a counter format (hh:mm:ss.s). The animation is subject to the accuracy, resolution and sampling rate limitations of the original radar data.

The sampling rate of the radar data is 3.7 seconds while the frame rate of the animation is approximately 60 frames/sec. Intermediate values were linearly interpolated.

Air traffic control communications on the Jandakot Tower frequency (118.1 MHz) was included in the animation.

Examination of the accident site showed that the aircraft contacted the canopy of a tree at a location of 32º 6.242' S and 115º 53.256' E. The wreckage location was 32º 6.176' S and 115º 53.283' E. These points were displayed in the animation as a yellow marker and a red marker respectively. A pylon-mounted electricity power-line was displayed as a blue line.
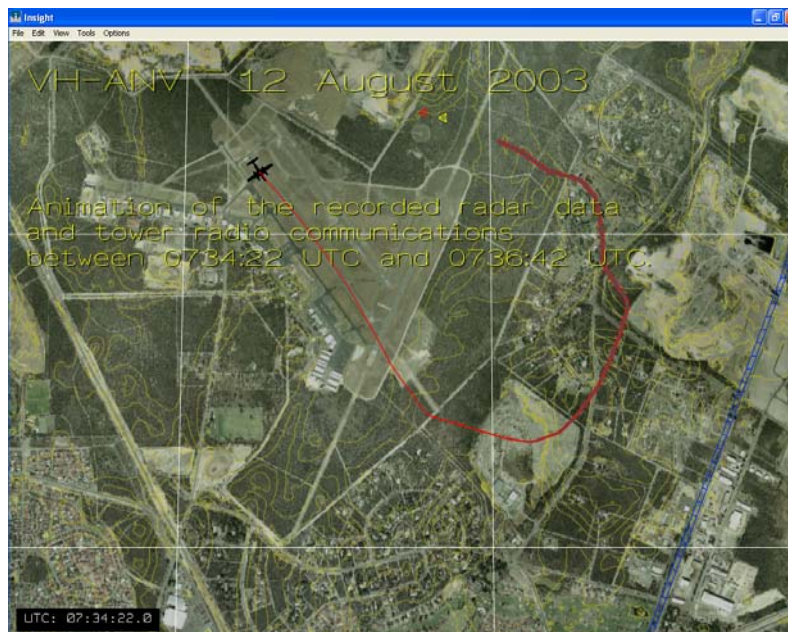

Figure 3 - Computer Animation

5.   CONCLUSIONS

Secondary radar data from the secondary surveillance radar at Mount Kalamunda, received from VH-ANV on 12 August 2003, was examined. Radar data was recorded for VH-ANV from 0734:22 UTC until 0736:53 UTC – a duration of 2 minutes and 31 seconds. Twenty-one valid returns were received during this period.

The data showed that during takeoff the aircraft deviated to the right of the runway 24R centre-line before commencing a left turn. The left turn was continued for approximately one minute until the aircraft was tracking in a direction of approximately 035ºT. Radar returns were lost shortly afterwards.

Recorded Mode C altitude showed that the flight was conducted at low level as the altitude only increased by one unit (ie. one hundred feet) after takeoff and remained at this value until radar returns ceased.

Average groundspeed values were:

- Upwind   (0735:39 UTC – 0735:50 UTC)   83 knots
- Crosswind   (0735:58 UTC – 0736:16 UTC)   83 knots
- Downwind   (0736:20 UTC – 0736:42 UTC)   98 knots

6. ABBREVIATIONS

Acronyms may be used in upper case or lower case.

ALT	Altitude
E	East
hPa	Hectopascals
QNH	Local Station Pressure Corrected to MSL
MHz	Mega Hertz (frequency)
MSL	Mean Sea Level
NDB	Non-Directional Beacon
NM	Nautical Mile
RAPS	Recovery, Analysis and Presentation System
RMS	Root Mean Square
RPM	Revolutions Per Minute
S	South
SSR	Secondary Surveillance Radar
STBY	Standby
ºT	Degrees True
TAAATS	The Australian Advanced Air Traffic System
UTC	Coordinated Universal Time
VHF	Very High Frequency
VTC	Visual Terminal Chart

7. APPENDICES

Appendix 7.1: Plot of Groundspeed and Aircraft Track

Appendix 7.2: Plot of Mode C Pressure Altitude (QNH Corrected)

Appendix 7.3: Data Listing – Recorded Radar Data

Appendix 7.4: Radar Position Offset

Appendix 7.5: Mount Kalamunda Radar Coverage Plot

Appendix 7.6: Computer Graphics Animation – Compact Disk
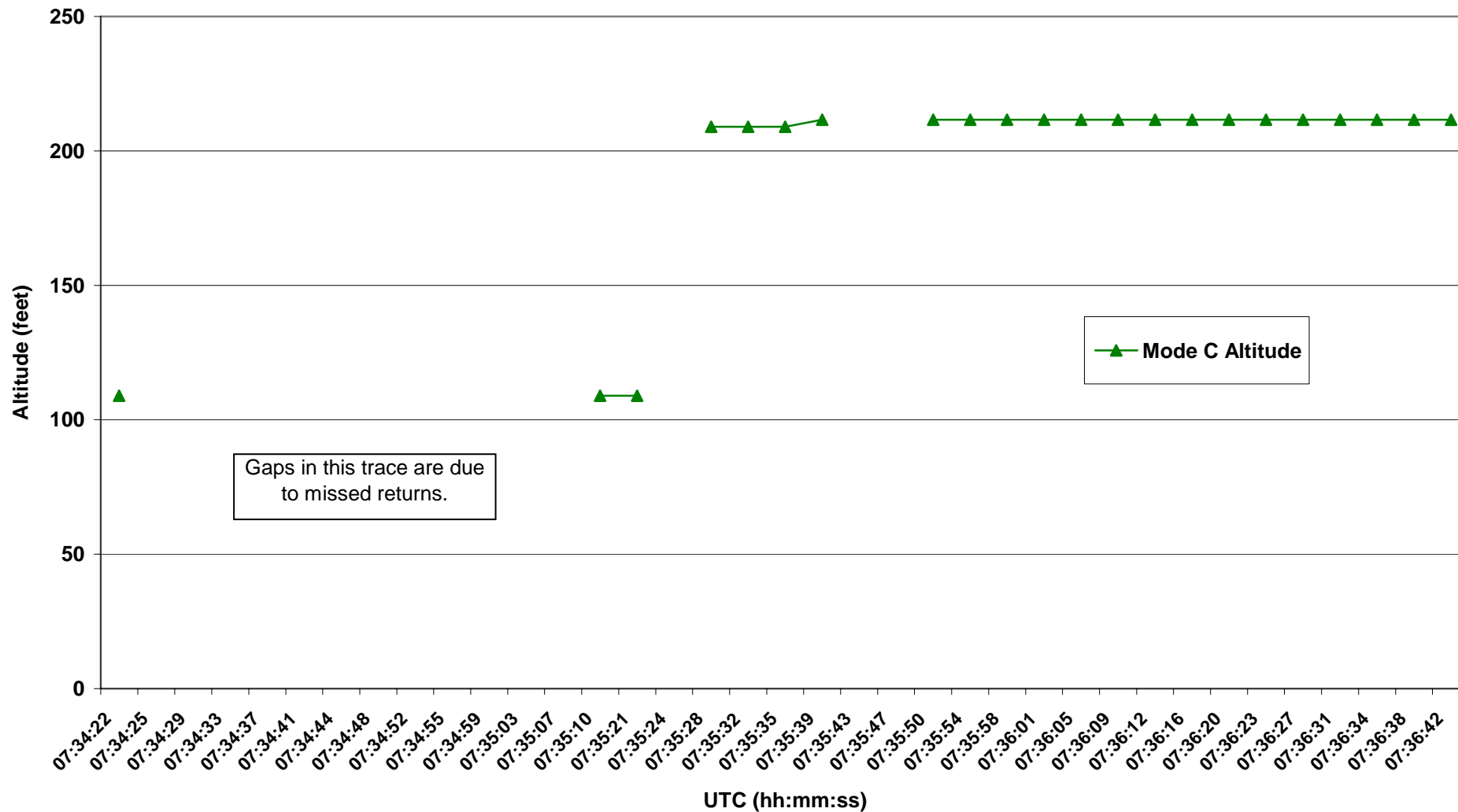
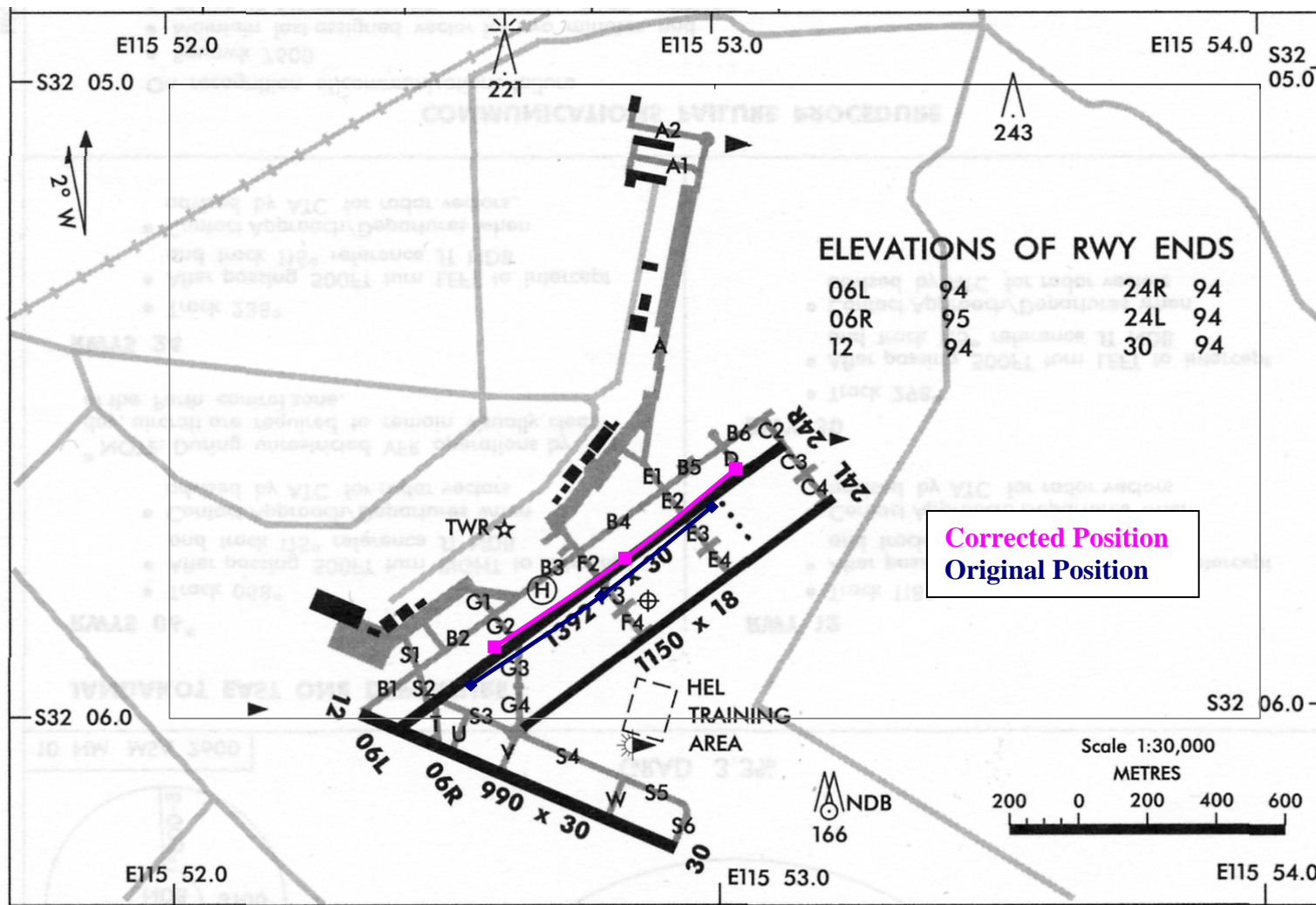**Appendix 7.1**

Ground Speed and Aircraft Track

Gaps in these traces are due to missed returns.

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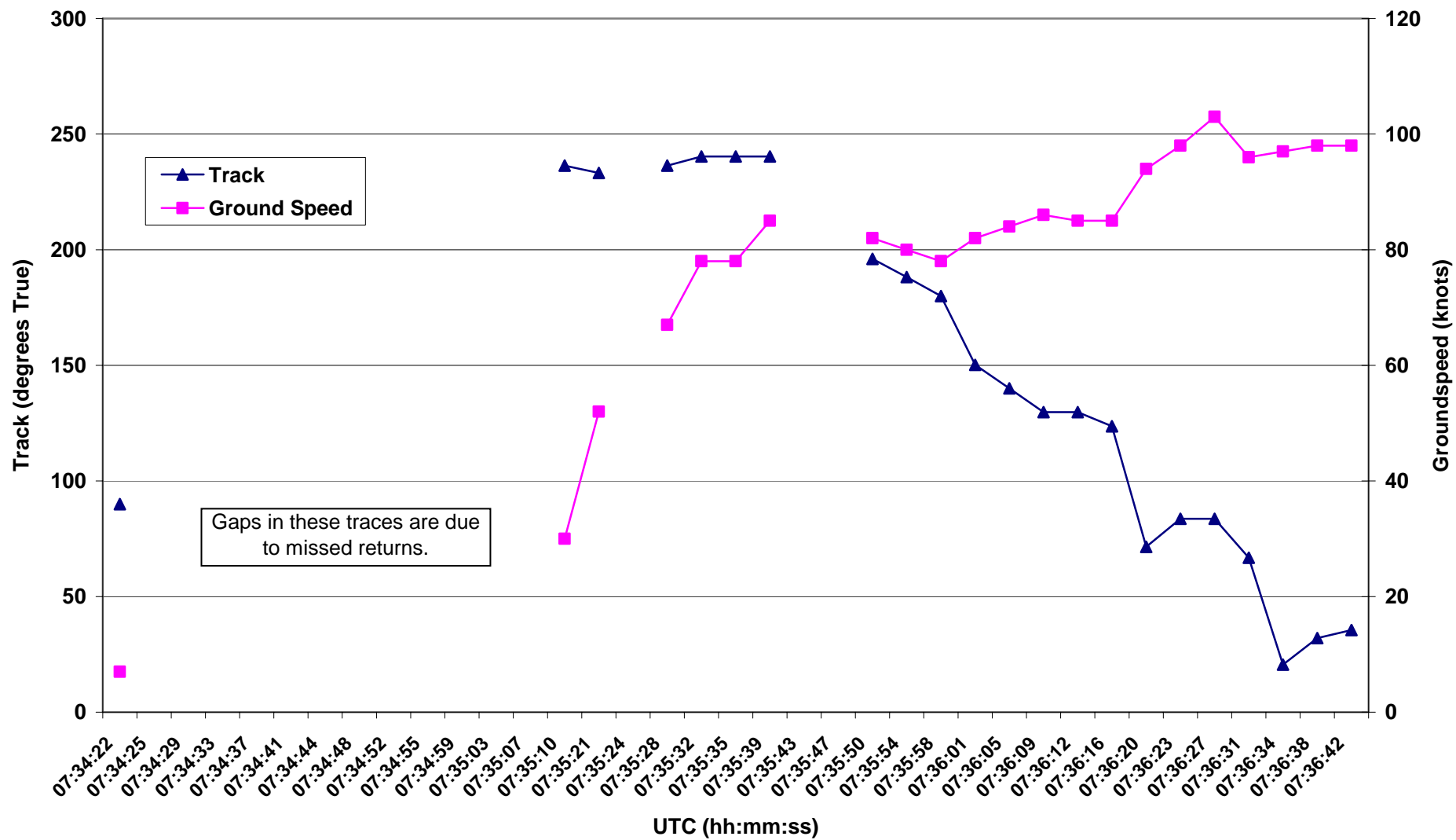
Appendix 7.2

Mode C Pressure Altitude (QNH corrected)

Gaps in this trace are due to missed returns.

Appendix 7.3

UTC	SSR Code	X Coord.	Y Coord.	QNH Corrected Mode C	Track	Groundspeed	Missed Returns	Track Number	Comment:
(hh:mm:ss)		(NM)	(NM)	(feet)	(degrees T*10)	(knots)			
07:34:22	4473	-9.594	-6.203	109.0	900	7	0	229	
07:34:25	4473	-9.578	-6.203	109.0	900	7	1	229	1st missing return.
07:34:29	4473	-9.578	-6.203	109.0	900	7	2	229	2nd missing return.
07:34:33	4473	-9.562	-6.203	109.0	900	7	3	229	3rd missing return - track dropped.
07:35:10	4473	-9.766	-6.344	109.0	2364	30	0	110	New track.
07:35:21	4473	-9.969	-6.484	109.0	2332	52	0	110	
07:35:24	4473	-10.016	-6.516	109.0	2332	52	1	110	1st missing return.
07:35:28	4473	-10.141	-6.578	209.0	2364	67	0	110	
07:35:32	4473	-10.234	-6.625	209.0	2403	78	0	110	
07:35:35	4473	-10.312	-6.672	209.0	2403	78	1	110	1st missing return.
07:35:39	4473	-10.391	-6.734	211.6	2403	85	0	110	
07:35:43	4473	-10.469	-6.781	211.6	2403	85	1	110	1st missing return.
07:35:47	4473	-10.547	-6.828	211.6	2403	85	2	110	2nd missing return.
07:35:50	4473	-10.469	-6.984	211.6	1960	82	0	110	
07:35:54	4473	-10.484	-7.062	211.6	1882	80	0	110	
07:35:58	4473	-10.453	-7.156	211.6	1800	78	0	110	
07:36:01	4473	-10.391	-7.219	211.6	1502	82	0	110	
07:36:05	4473	-10.312	-7.281	211.6	1401	84	0	110	
07:36:09	4473	-10.219	-7.328	211.6	1298	86	0	110	
07:36:12	4473	-10.141	-7.359	211.6	1298	85	0	110	
07:36:16	4473	-10.047	-7.391	211.6	1236	85	0	110	
07:36:20	4473	-9.922	-7.312	211.6	715	94	0	110	
07:36:23	4473	-9.812	-7.312	211.6	836	98	0	110	
07:36:27	4473	-9.703	-7.297	211.6	836	103	0	110	
07:36:31	4473	-9.641	-7.25	211.6	668	96	0	110	
07:36:34	4473	-9.609	-7.141	211.6	205	97	0	110	
07:36:38	4473	-9.547	-7.062	211.6	320	98	0	110	
07:36:42	4473	-9.5	-6.969	211.6	355	98	0	110	Final valid return.
07:36:46	4473	-9.438	-6.891	211.6	355	98	1	110	1st missing return.
07:36:49	4473	-9.391	-6.797	211.6	355	98	2	110	2nd missing return.
07:36:53	4473	-9.328	-6.719	211.6	355	98	3	110	3rd missing return - track dropped.
			Valid	Return					
			Missed	Return					

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Appendix 7.4

Appendix 7.5

COVERAGE PLOT
Nm vs Nm

SITE NAME :
KMD

LATITUDE :
-31 59 32

LONGITUDE :
116 04 12

SITE HEIGHT : 333.0 m
ANTENNA HEIGHT : 20.0 m

COVERAGE HEIGHTS IN FEET :
100
500
1000
1500
2000