Environmental Research and Consultancy Department

Civil Aviation Authority

ERCD REPORT 0906

Accuracy of Data in the Noise and Track Keeping System at the London Airports

S White

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Summary

This report describes a study that was undertaken to assess the accuracy of the flight path information provided by ANOMS 8 – the Noise and Track Keeping (NTK) system installed at the London airports. Aircraft positional data recorded using Mode S/ADS-B receiving equipment were used for independent comparison against ANOMS 8 outputs, which are based on Mode C Secondary Surveillance Radar. For the sample of flights analysed, the results indicate that the accuracy of ANOMS 8 NTK data is, on average, no worse than ±55 ft in aircraft height and no worse than 30 m in position. These are within the expected tolerances of the radar data. The study has shown no clear evidence of a consistent bias in the NTK height or position data at any of the airports.

September 2009

The author of this report is employed by the Civil Aviation Authority. The work reported herein was carried out under a Letter of Agreement placed on 31 March 2009 by the Department for Transport. Any views expressed are not necessarily those of the Secretary of State for Transport.

ISBN 978 0 11792 290 7

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The latest version of this document is available in electronic format at www.caa.co.uk, where you may also register for e-mail notification of amendments.

Published by TSO (The Stationery Office) on behalf of the UK Civil Aviation Authority.

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Glossary of Terms

aal	Aircraft height above the aerodrome level
ADS-B	Automatic Dependent Surveillance-Broadcast. Aircraft equipped with ADS-B continuously broadcast precise position and velocity information derived from the aircraft's onboard navigation system.
BAA	BAA Airports Limited. The company which owns and runs Heathrow, Gatwick and Stansted airports (amongst others).
ERCD	Environmental Research and Consultancy Department of the Civil Aviation Authority.
FDR	Flight Data Recorder (Quick Access Recorder)
Flight Levels	Surfaces of constant atmospheric pressure which are related to a specific pressure datum, 1013.25 hPa, and are separated by specific pressure intervals.
GPS	Global Positioning System
hPa	hectoPascal. The international unit for the measurement of atmospheric pressure. The unit is equal to the millibar (mb).
ILS	Instrument Landing System
kt	Knot (nautical mile per hour)
Mode C	A mode of SSR operation in which an aircraft's transponder provides identity and altitude information.
Mode S	Mode Select (Mode S) is an improvement on classical SSR and provides enhanced surveillance capability and a capacity to handle increased levels of air traffic.
NATS	Previously known as National Air Traffic Services Ltd. NATS provides air traffic control services at several major UK airports, including Heathrow, Gatwick and Stansted.
nm	Nautical mile
NTK	Noise and Track Keeping monitoring system. The NTK system associates radar data from air traffic control radar with related data from both fixed (permanent) and mobile noise monitors at prescribed positions on the ground.
QNH	The international code used to represent the atmospheric pressure at mean sea level.
SSR	Secondary Surveillance Radar. The SSR system is dependent on transponders fitted to aircraft receiving 'interrogations' from radars, which then send back corresponding 'replies' that are used to display the position, altitude and identity of aircraft on controllers' radar displays.

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1 Introduction

1.1 The Environmental Research and Consultancy Department (ERCD) of the CAA provides a range of research and advisory services in the field of aviation and the environment. Much of this work involves the collection and analysis of data from the Noise and Track Keeping systems (NTK) installed at Heathrow, Gatwick and Stansted airports. The NTK system at each airport matches air traffic control radar data (i.e. aircraft flight paths) to related noise measurements from noise monitors at prescribed ground positions. ERCD obtains data from the airports' NTK systems via a link to the remote servers.

1.2 In March 2003, ERCD published the results of a study to assess the general accuracy of the flight path information contained in the then current NTK system, which was called GEMS – see ERCD Report 0209 (Ref 1). The report concluded that there was no clear evidence of a consistent bias in the NTK height or position data at any of the airports, and thus the data were considered sufficiently accurate for the types of studies undertaken by ERCD. It should be noted that ERCD Report 0209 is concerned only with the accuracy of flight path information; the accuracy of noise data is discussed in ERCD Report 0506 (Ref 2).

1.3 In June 2007 the GEMS system at the London airports was replaced with a new NTK system called ANOMS 8. Although ANOMS 8 still uses Mode C Secondary Surveillance Radar (SSR) for its source of height and position information, additional checks have been undertaken by ERCD to ensure that the new system continues to provide reliable data. Section 2 of this report gives a technical assessment comparing NTK height and position data from all three airports against an independent source. The study conclusions are summarised in Section 3. A general description of the ANOMS 8 system is provided in Appendix A. The relevant sources of uncertainty in the NTK data are discussed in Appendix B.

1.4 It should be recognised that the results from this analysis may not necessarily be representative of the accuracy of similar NTK systems at other airports. It must also be stressed that the purpose of this study was to assess the accuracy of the track and height data reported by the NTK system - it was not intended to examine safety (or any other) issues relating to the use of SSR data. Finally, in keeping with common usage the term 'accuracy' is used quantitatively in this report although, strictly speaking, it is a qualitative concept.

2 NTK data comparisons

2.1 As mentioned above, the source of NTK positional data is Secondary Surveillance Radar. The area of radar coverage in the NTK system at Heathrow is an area approximately 60 nm (east to west) by 60 nm (north to south), centred on the airfield. The areas of coverage at Gatwick and Stansted are slightly less than this. Currently, heights up to approximately 17,000 ft aal are covered at Heathrow, 10,000 ft at Gatwick, and 15,000 ft at Stansted.

2.2 To assess the accuracy of the SSR data, it is necessary to perform direct checks of the NTK data against independently derived precision data. For the previous study, airline FDR information and data recorded on board an ILS calibration aircraft were used to check the NTK data. For this study, the NTK data were checked against height and positional information supplied by Mode S/ADS-B broadcasts using a portable receiver that decodes transponder signals from aircraft. Because Mode S/ADS-B data are now routinely available, broader comparisons can be made at lower cost than before. Aircraft equipped with Mode S transponders provide altitude reporting in 25 ft intervals (compared to 100 ft for Mode C), with ADS-B adding global navigation data typically obtained from the aircraft's GPS receiver.

2.3 The aerial rotation period of the radar head at each London airport is typically four seconds, whereas Mode S/ADS-B position and velocity messages are broadcast twice every second on average. In addition, since GPS can generally provide position data accurate to ±20 m or better (Ref 3), a Mode S/ADS-B receiver enables accurate determination of an aircraft's position at any given time for independent comparison against ANOMS 8 outputs.

2.4 Mode S/ADS-B data for flights at Stansted were logged by ERCD on 15 July 2008. At Gatwick, recordings were made on 22 June 2009, and at Heathrow on 1 July 2009. Because the Mode S/ADS-B receiver relies on a good 'line-of-sight' to the aircraft, the signal can occasionally be interrupted by nearby buildings or other large obstructions. This resulted in occasional broken tracks in some of the logged data, which meant that some of the radar points could not be matched to Mode S/ADS-B data for comparison.

2.5 **Figures 1 to 6** compare the NTK radar data against the recorded Mode S/ADS-B data for a sample of six Heathrow flights (three arrivals and three departures). Equivalent data for samples of Gatwick and Stansted flights are presented in **Figures 7 to 12** and **Figures 13 to 18** respectively. In each figure, the upper graph shows height[1] above the aerodrome plotted against time, and the lower graph shows the corresponding ground track.

2.6 The radar points are the raw (unsmoothed) values from the NTK system. Because radar data for Flight Levels above FL060 (corresponding to an altitude of approximately 6,000 ft) are not converted by NATS to the altitude relative to mean sea level at the London Area local atmospheric pressure, data above 6,000 ft have not been analysed (see Appendix A). Despite this restriction, radar data for ranges up to at least 25 km from each airport were included in the analyses.

2.7 Height data

2.7.1 It can be seen in **Figures 1 to 18** that agreement between the NTK and Mode S/ADS-B height data is consistently good. **Table 1** shows that the average height difference measured for each airport is within ±55 ft, which is within the expected tolerance of the radar data (i.e. ±75 ft in height, see Appendix B). A large average height difference would indicate a consistent bias in the NTK heights, but there is no clear evidence of this at any of the airports.

[1] Mode S/ADS-B data output is referenced to the standard pressure of 1013.25 hPa (the pressure at mean sea-level in a 'standard atmosphere'). Because the radar height data coming into the NTK system have been corrected for local atmospheric pressure and airfield elevation, it is necessary to correct the Mode S/ADS-B data for each airport in the same way. This was done by taking into account the local atmospheric pressure at the time, and also correcting for each aerodrome's elevation above mean sea level. It should be noted that this local pressure correction is also subject to some uncertainty (e.g. a pressure adjustment error of 1 hPa would correspond to a height difference of approximately 27 ft).

Table 1 Measured height differences, ft (NTK *minus* Mode S/ADS-B)

Airport	Number of radar points analysed	Average	Std Dev	5th / 95th percentile
Heathrow	304	31	40	-16 / 86
Gatwick	407	27	33	-23 / 78
Stansted	356	54	34	11 / 112

2.7.2 To provide an indication of the range of measured height differences between the two sources of data, the 5th and 95th percentile values (of the differences at each airport) are also shown in **Table 1**. The 95th percentile is the point below which 95% of all the measured differences fall, and the 5th percentile is the point below which 5% of the measured differences fall. In all but one case, the percentile values for the sample of flights analysed are within ±100 ft. Although the 95th percentile of the Stansted data is 112 ft, such a difference is to be expected from time to time (not just at Stansted but also at any of the three airports) due to the 100 ft resolution of Mode C radar data and the other sources of uncertainty described in Appendix B.

2.8 Position data

2.8.1 The ground track comparisons shown in **Figures 1 to 18** show close agreement between the NTK position data and the Mode S/ADS-B data. The measured positional differences have been quantified in further detail. Comparison of the position data at any given point in time can be strongly affected by any small time synchronisation differences between the two data sets; for example, at a speed of 200 kt a one second time synchronisation difference would itself account for a positional difference of about 100 m in the direction of flight. To allow for this as far as possible in this assessment, the Mode S/ADS-B position points were interpolated in order to calculate the closest distance from the Mode S/ADS-B ground track to each radar point. The average measured positional differences are summarised in **Table 2**.

Table 2 Measured positional differences, m

Airport	Average
Heathrow	26
Gatwick	27
Stansted	28

2.8.2 The average difference in ground track position is less than 30 m at each airport, which is within the expected tolerance of the radar data (i.e. ± 60 m in range, see Appendix B). Note that the average positional difference is always a positive number, since it is the average distance, in any direction, between the two data sources. Whilst this tells us that the NTK radar and Mode S/ADS-B positional data are very close, it does not tell us if there is a particular bias in any given direction. Because raw (unprocessed) radar data are based on the range and azimuth (bearing) of aircraft relative to a reference point, even after conversion to a Cartesian coordinate system there is no reason to expect larger differences in one coordinate direction compared to the other, since position errors should generally be normally distributed. However, because the data in ANOMS are processed through different coordinate systems it is nevertheless reasonable to confirm that the system does not introduce a bias in one particular coordinate direction. **Table 3** shows the average measured differences in each Cartesian axis direction between the two data sets.

Table 3 Measured positional differences in each axis direction, m (NTK *minus* Mode S/ADS-B)

Airport	Average 'X'	Average 'Y'
Heathrow	-35	3
Gatwick	21	-19
Stansted	12	10

2.8.3 The average X and Y differences of the individual radar data points are no greater than ±35 m. Considering that the radar range measurement has a distance resolution of 1/16 nm or 116 m, while the azimuth error increases with range – e.g. about 10 m at 3 nm, 50 m at 15 nm, and so on, the average differences are well within these values, thus confirming that there is no systematic bias in the NTK positional data. Again, it should be recognised that these results can be strongly affected by any small time synchronisation differences between the individual data points. In addition, the Mode S/ADS-B position data against which NTK is compared are of course also subject to some uncertainty.

3 Conclusions

3.1 The results from the comparisons made for this study indicate that the accuracy of ANOMS 8 NTK data is, on average, no worse than ±55 ft in aircraft height and no worse than 30 m in position. These are less than the *estimated* uncertainties of the NTK data described in Appendix B (i.e. ±75 ft in height and ±60 m in position). The average X and Y differences of the individual data points were found to be within ±35 m. For the flights analysed, the study has shown no clear evidence of a consistent bias in the NTK height or position data at any of the airports.

3.2 These results are based on a sample of flights from each airport and are therefore subject to sampling variation (so that a different sample of flights would give different results). It is also likely that some of the measured differences could be due to the inaccuracies of the Mode S/ADS-B data or from small time synchronisation differences between the data sets. Finally, it is worth noting that since much of ERCD's work is based on large samples of data (rather than individual flights), the effect of any possible inaccuracy in the NTK radar data is normally mitigated.

References

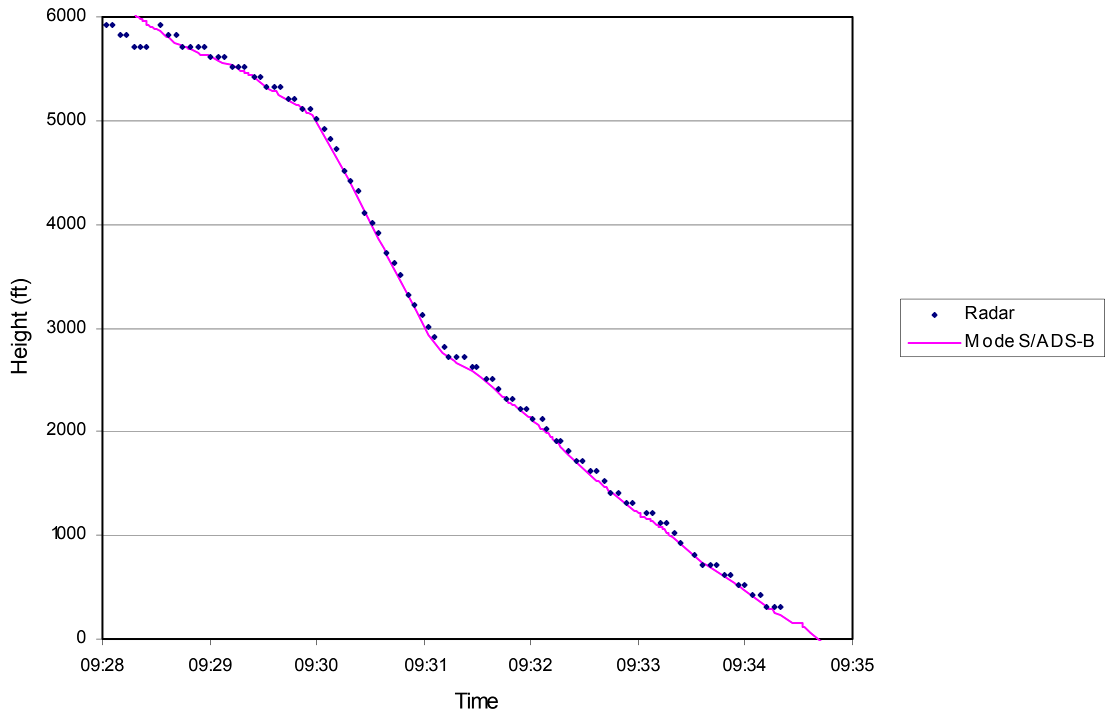
1 Cadoux R E and White S, *An Assessment of the Accuracy of Flight Path Data used in the Noise and Track-Keeping System at Heathrow, Gatwick and Stansted Airports*, ERCD Report 0209, Civil Aviation Authority, March 2003

2 White S, *Precision of Aircraft Noise Measurements at the London Airports*, ERCD Report 0506, Civil Aviation Authority, November 2005

3 Global Positioning System Standard Positioning Service Performance Standard: Assistant Secretary of Defense for Command, Control, Communications, and Intelligence, 6000 Defense Pentagon, Washington D.C., October 2001.

Figure 1 Heathrow arrival, 09:34 hrs

(a) Height Profile



(b) Track Plot

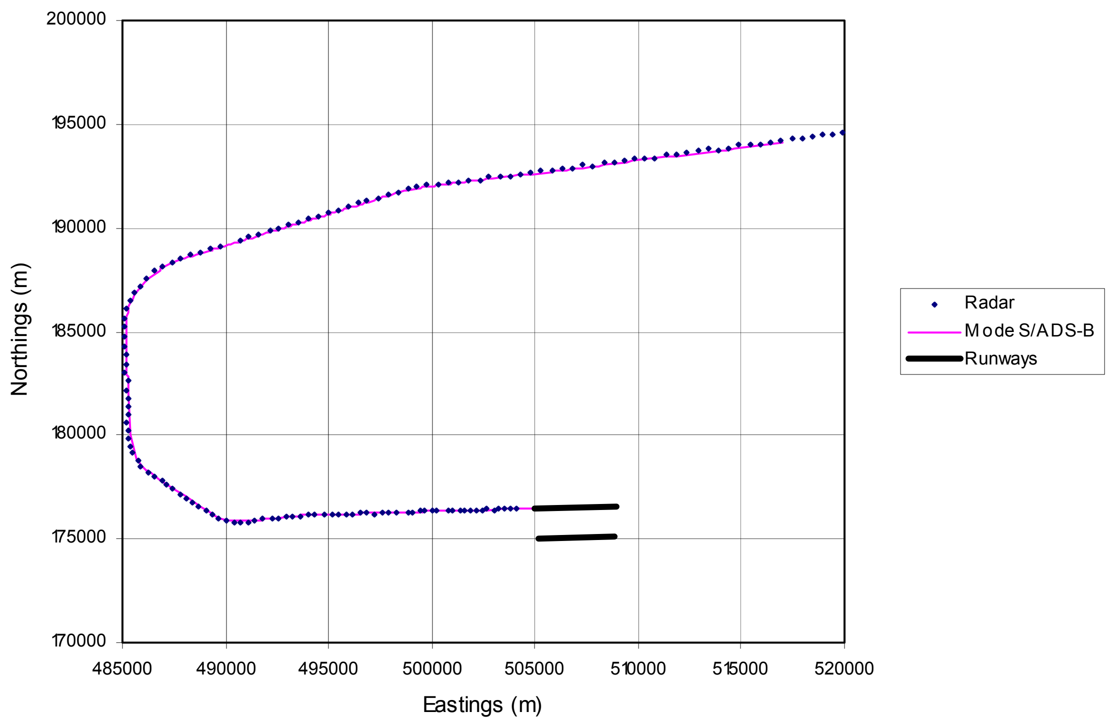
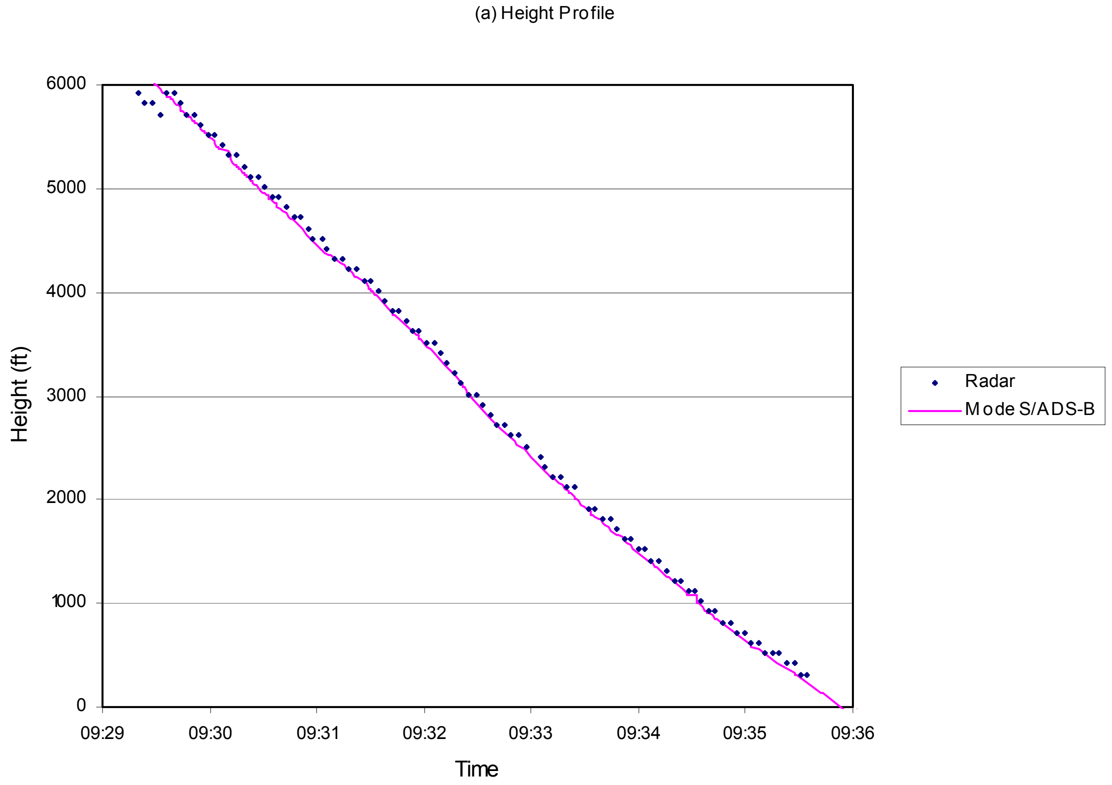


Figure 2 Heathrow arrival, 09:35 hrs



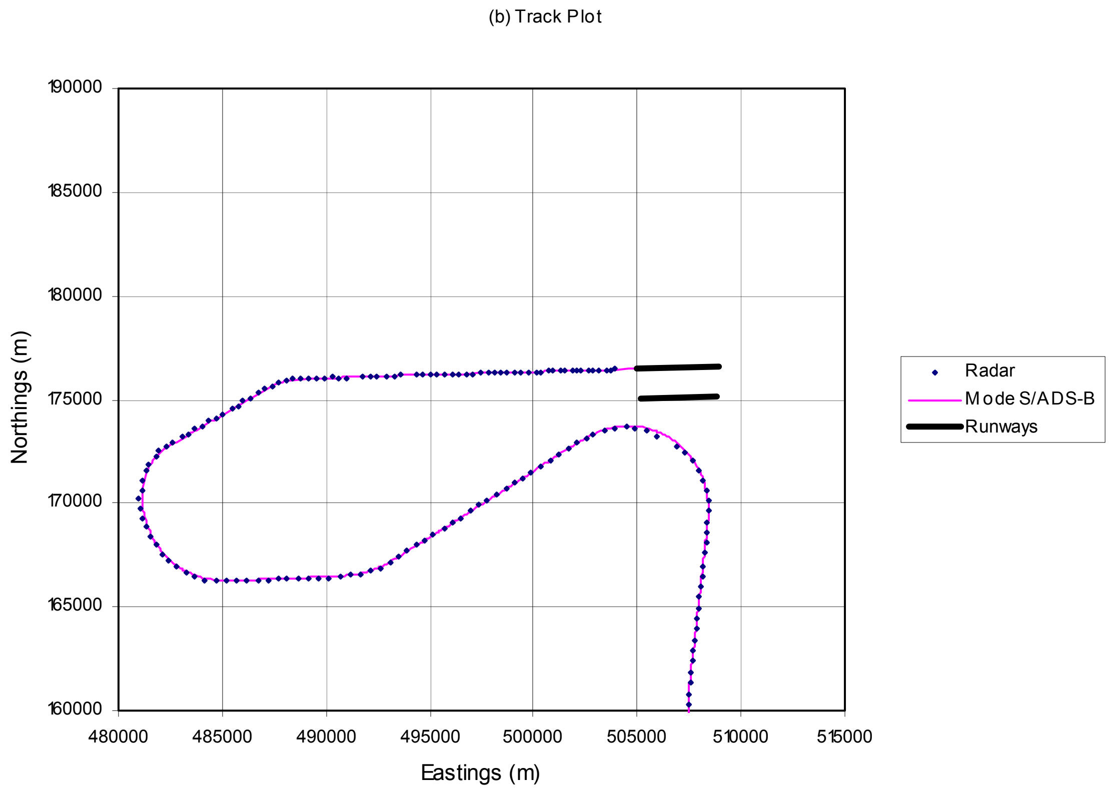
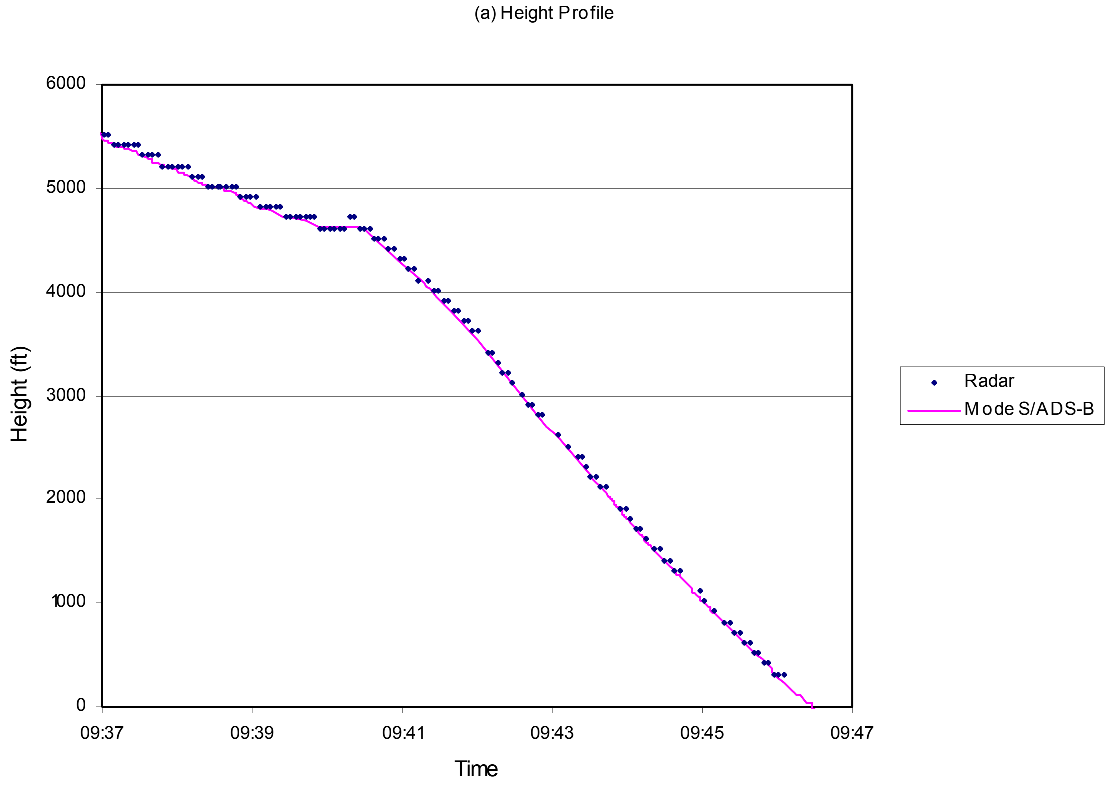


Figure 3 Heathrow arrival, 09:46 hrs



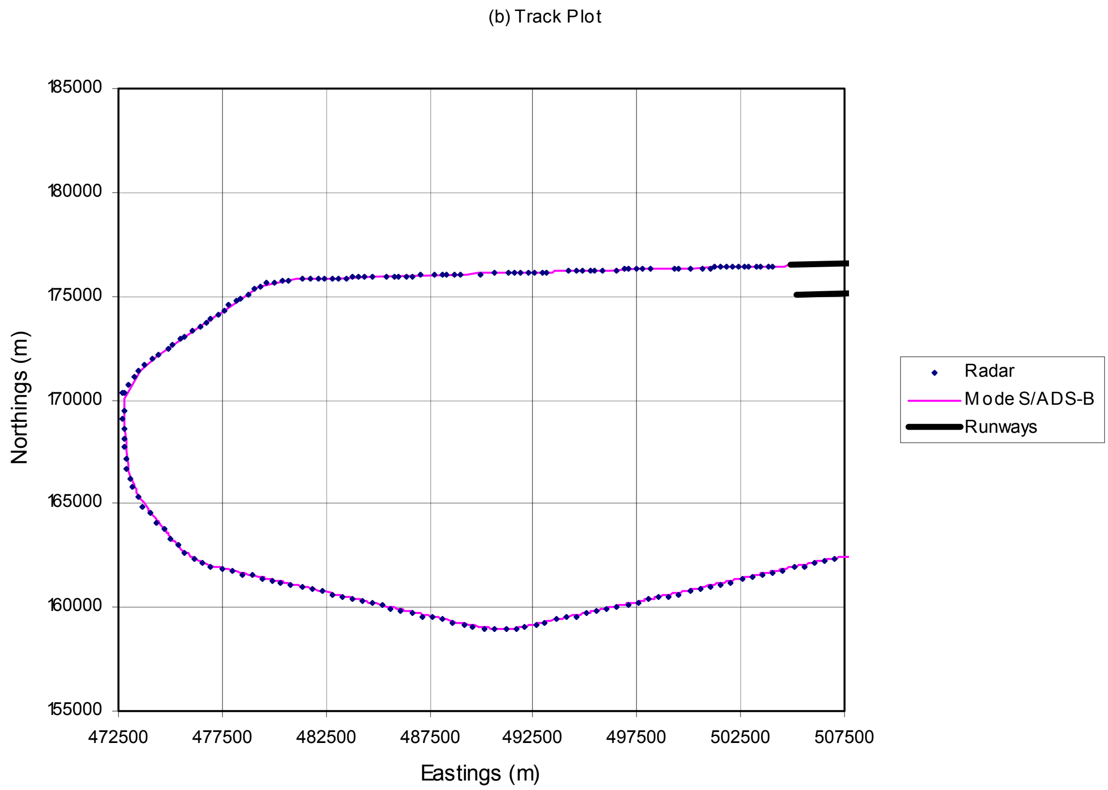
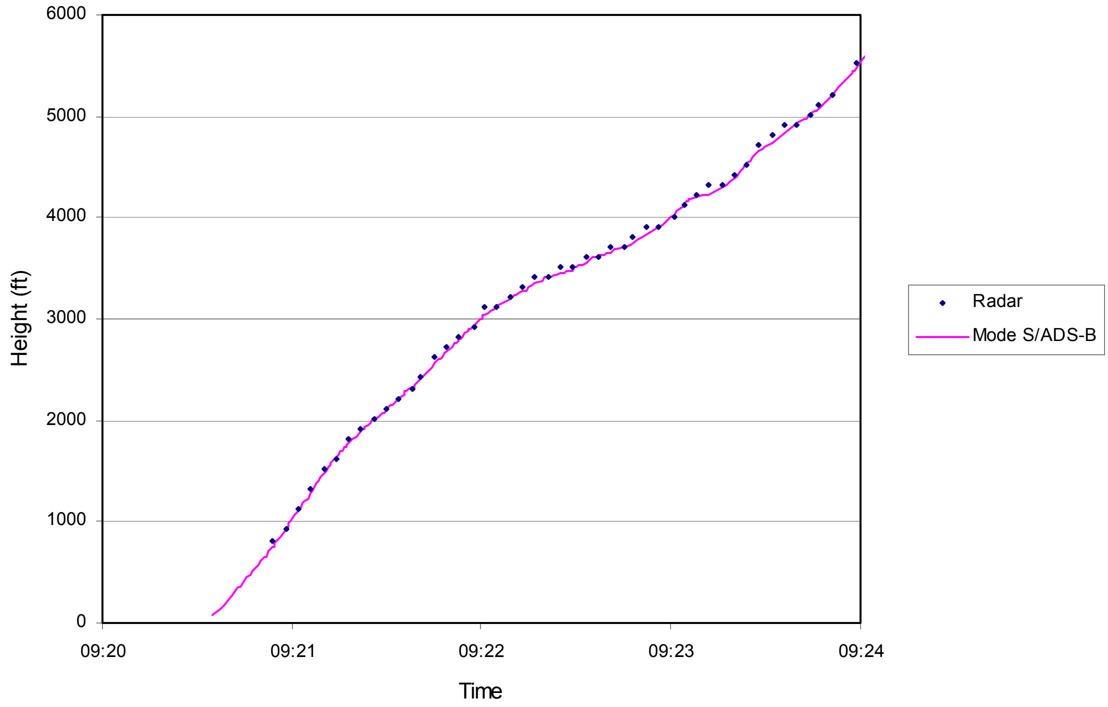


Figure 4 Heathrow departure, 09:20 hrs

(a) Height Profile



(b) Track Plot

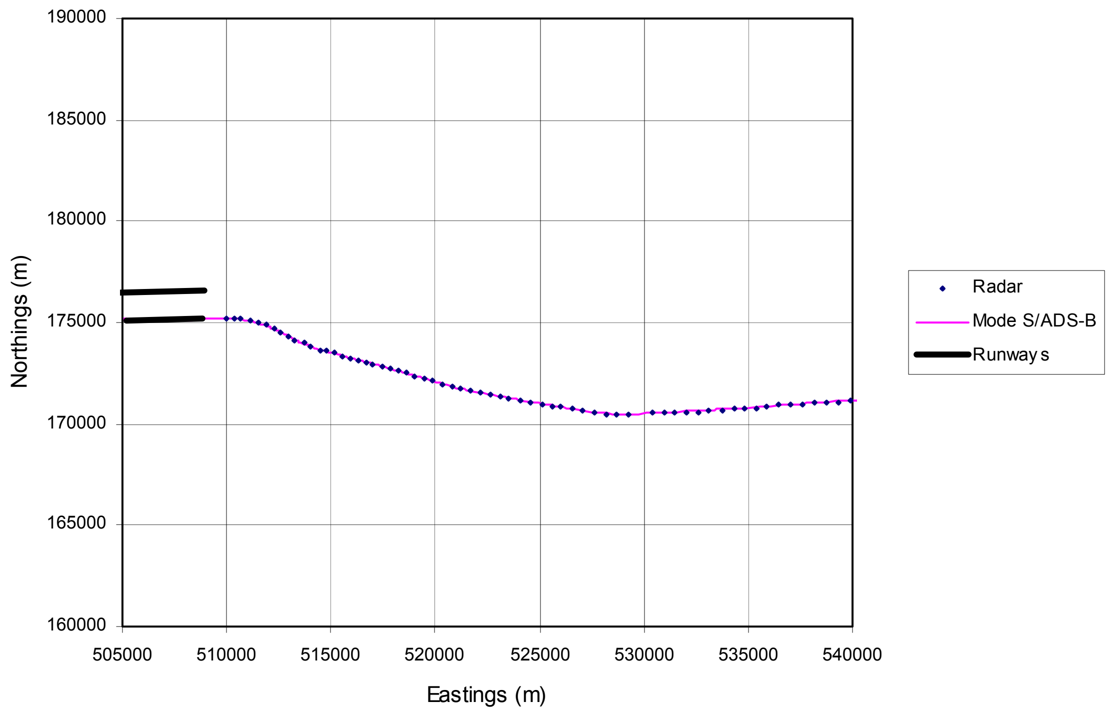
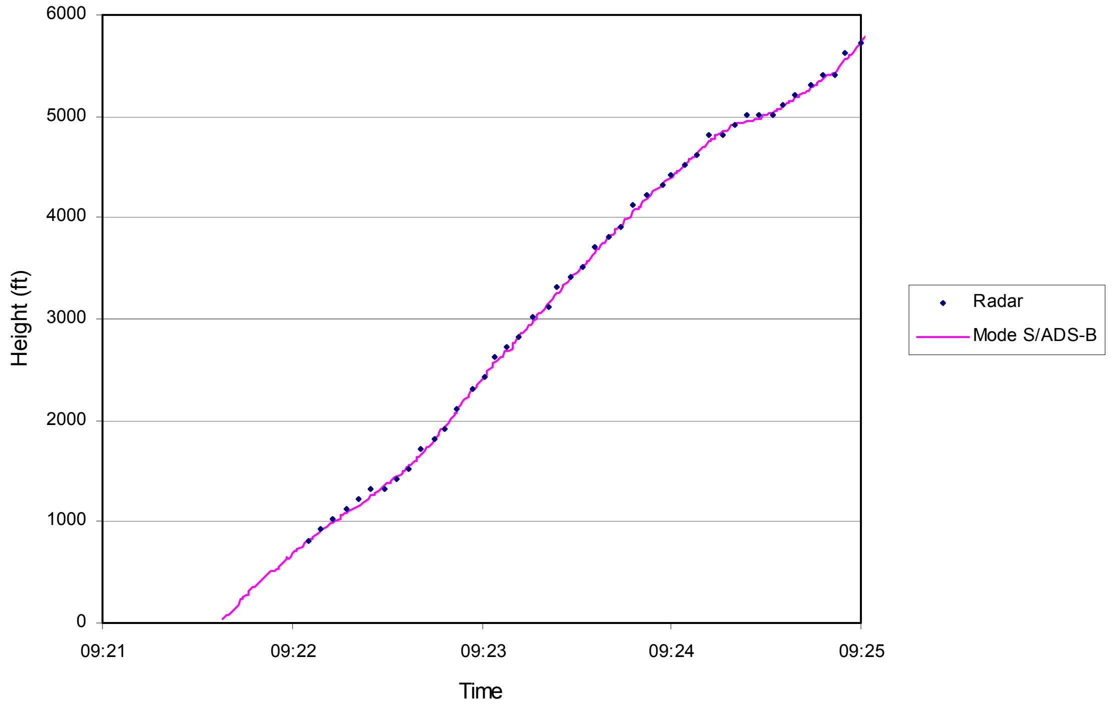


Figure 5 Heathrow departure, 09:21 hrs

(a) Height Profile



(b) Track Plot

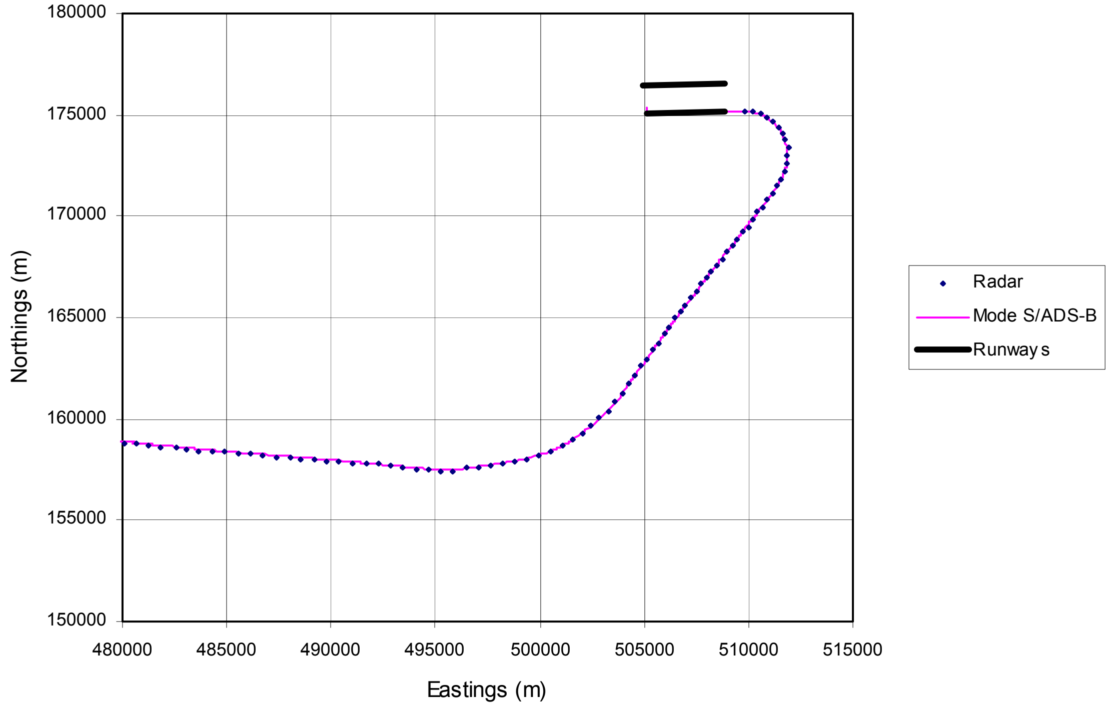
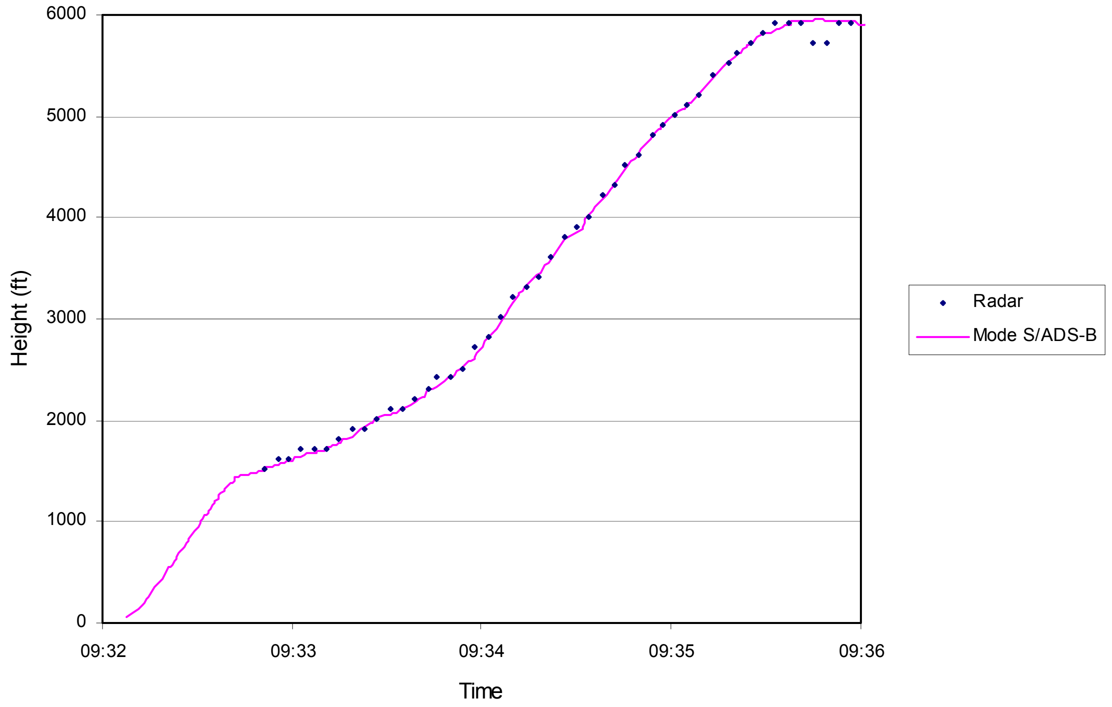


Figure 6 Heathrow departure, 09:32 hrs

(a) Height Profile



(b) Track Plot

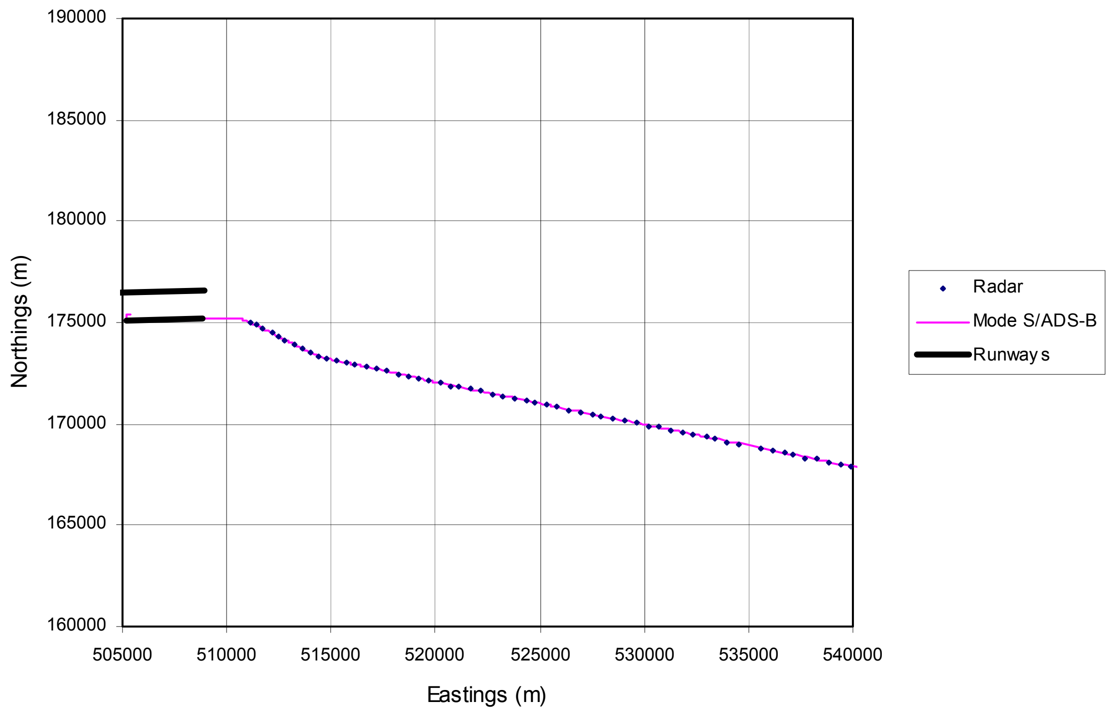
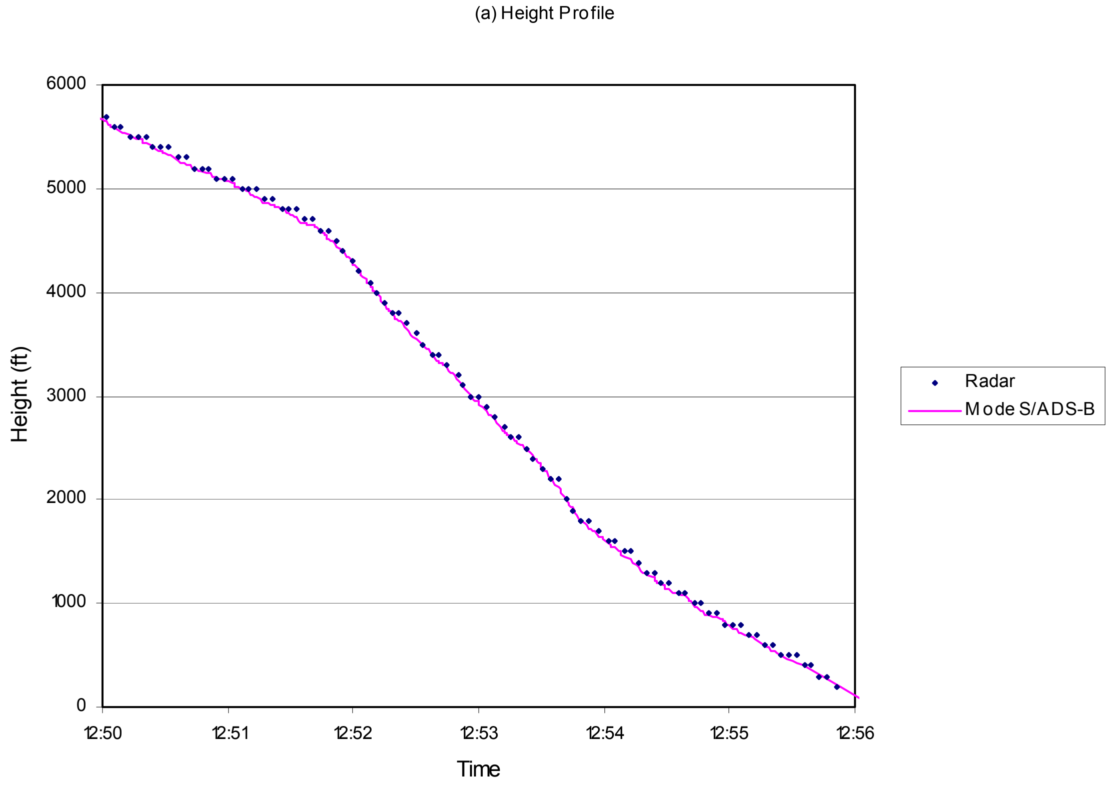


Figure 7 Gatwick arrival, 12:56 hrs



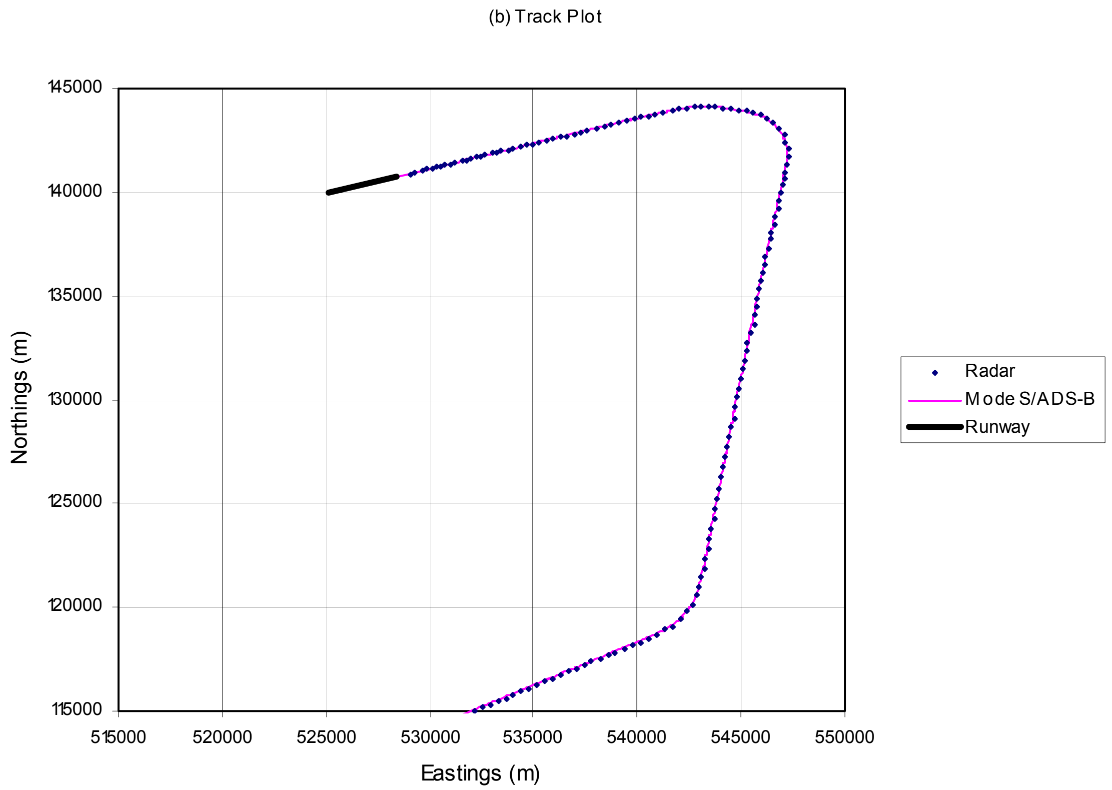
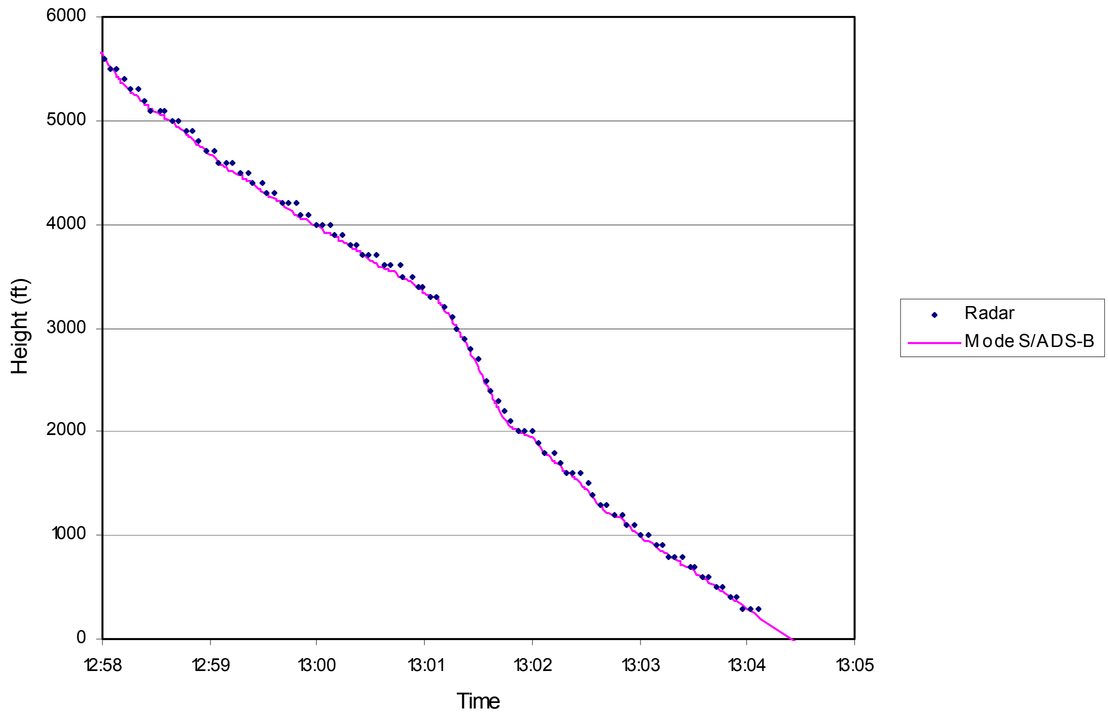


Figure 8 Gatwick arrival, 13:04 hrs

(a) Height Profile



(b) Track Plot

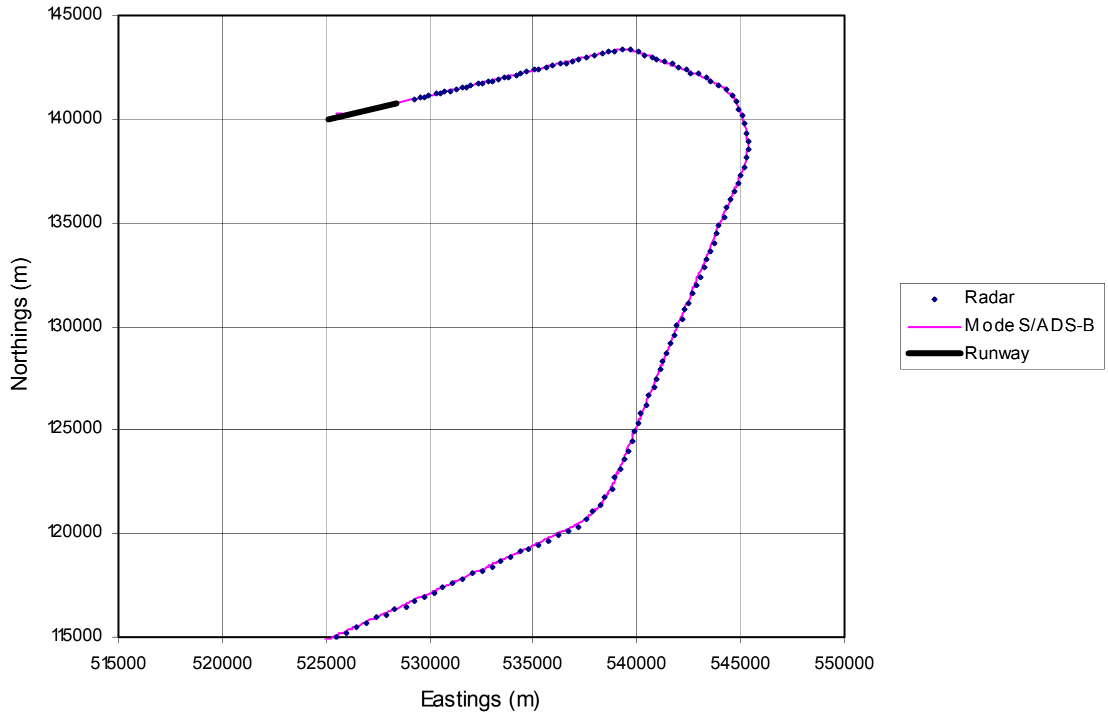
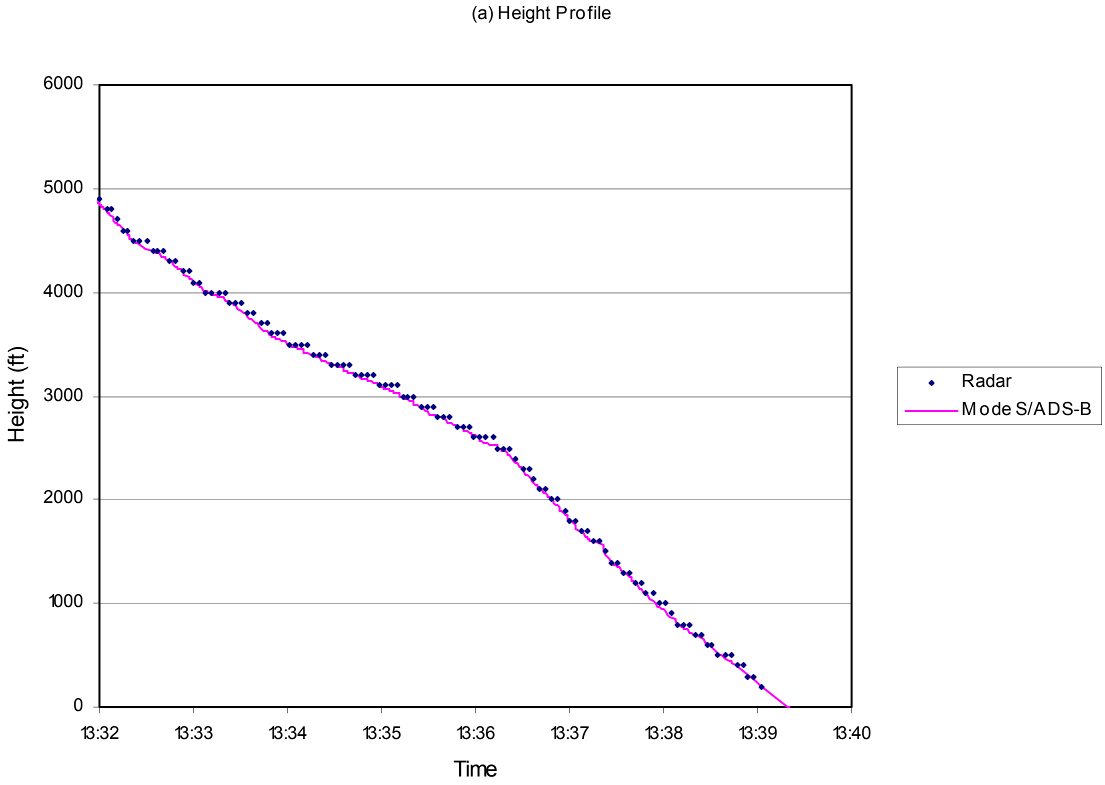


Figure 9 Gatwick arrival, 13:39 hrs



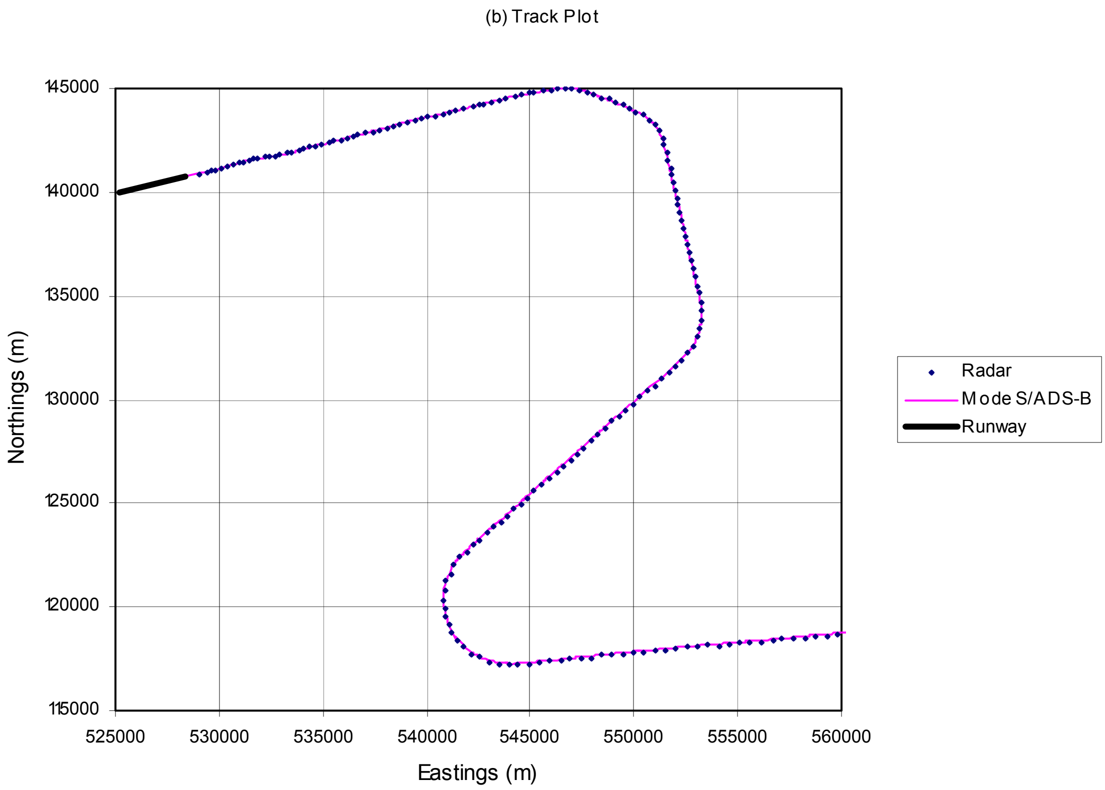
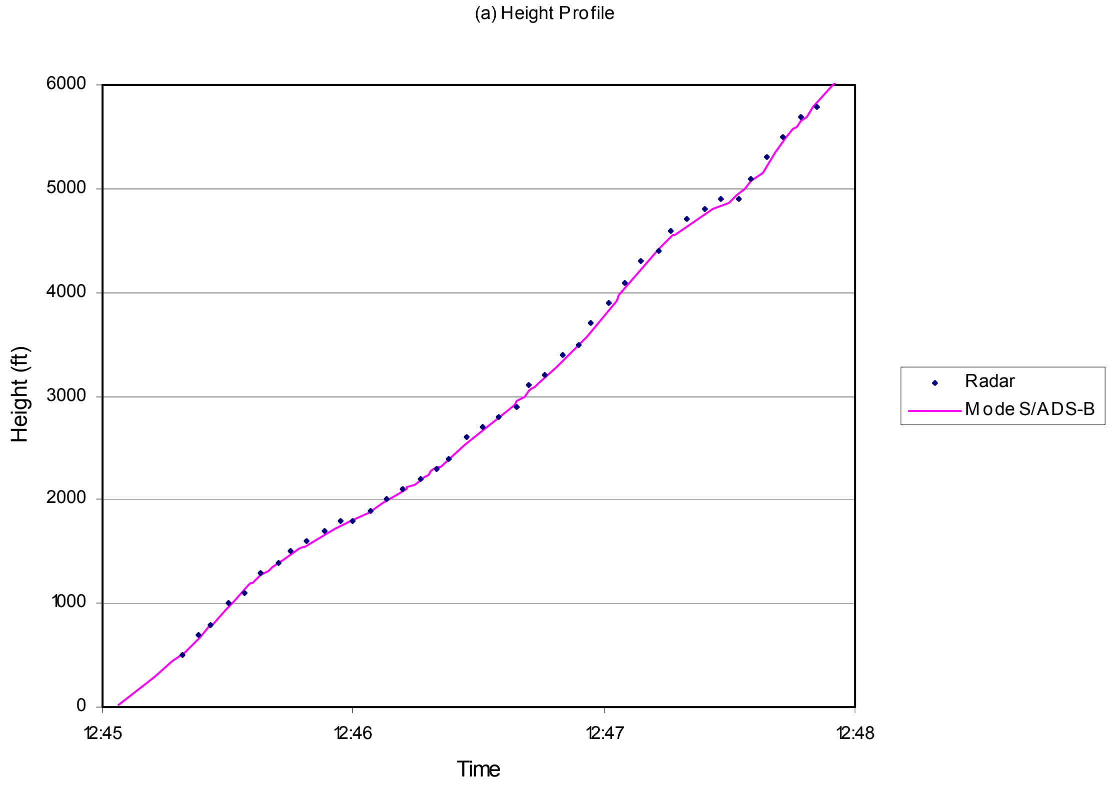


Figure 10 Gatwick departure, 12:45 hrs



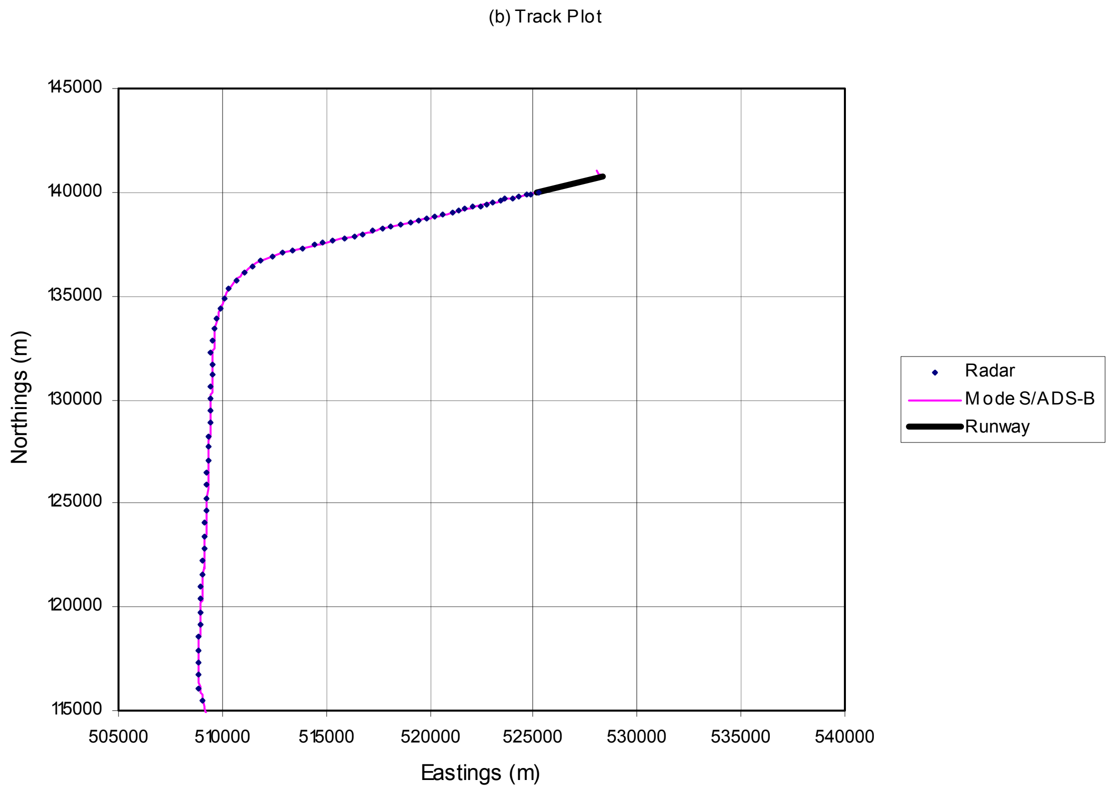
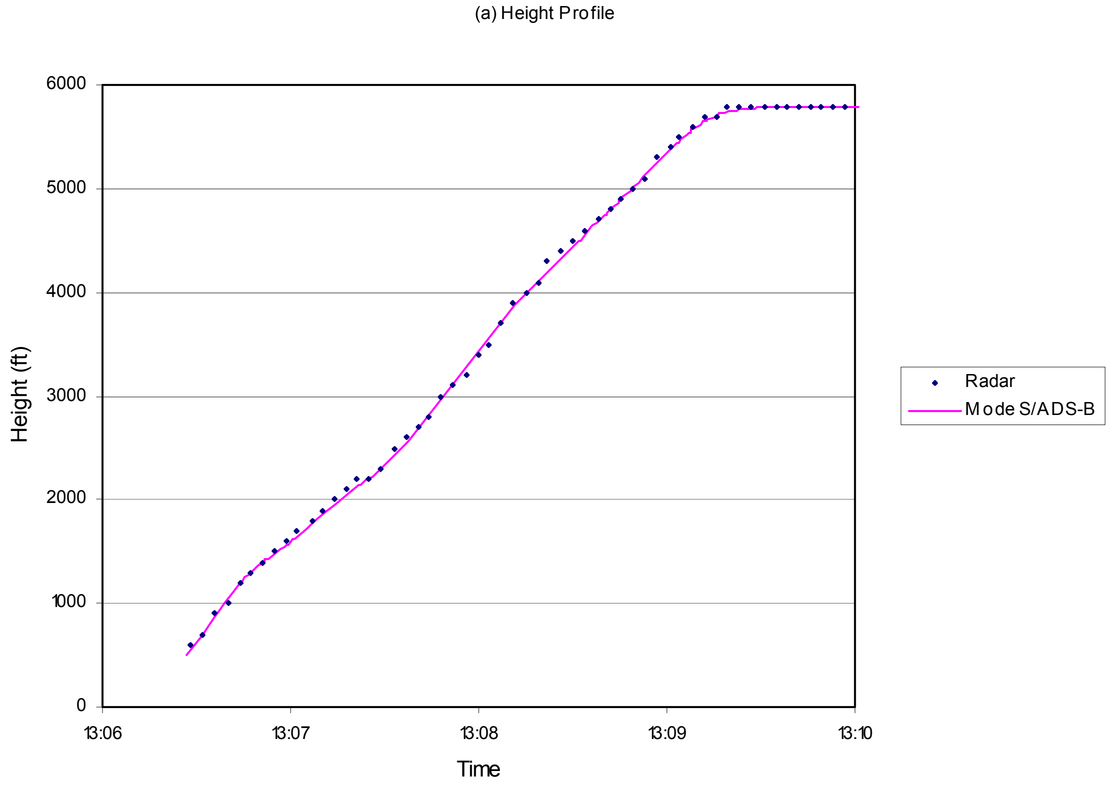


Figure 11 Gatwick departure, 13:06 hrs



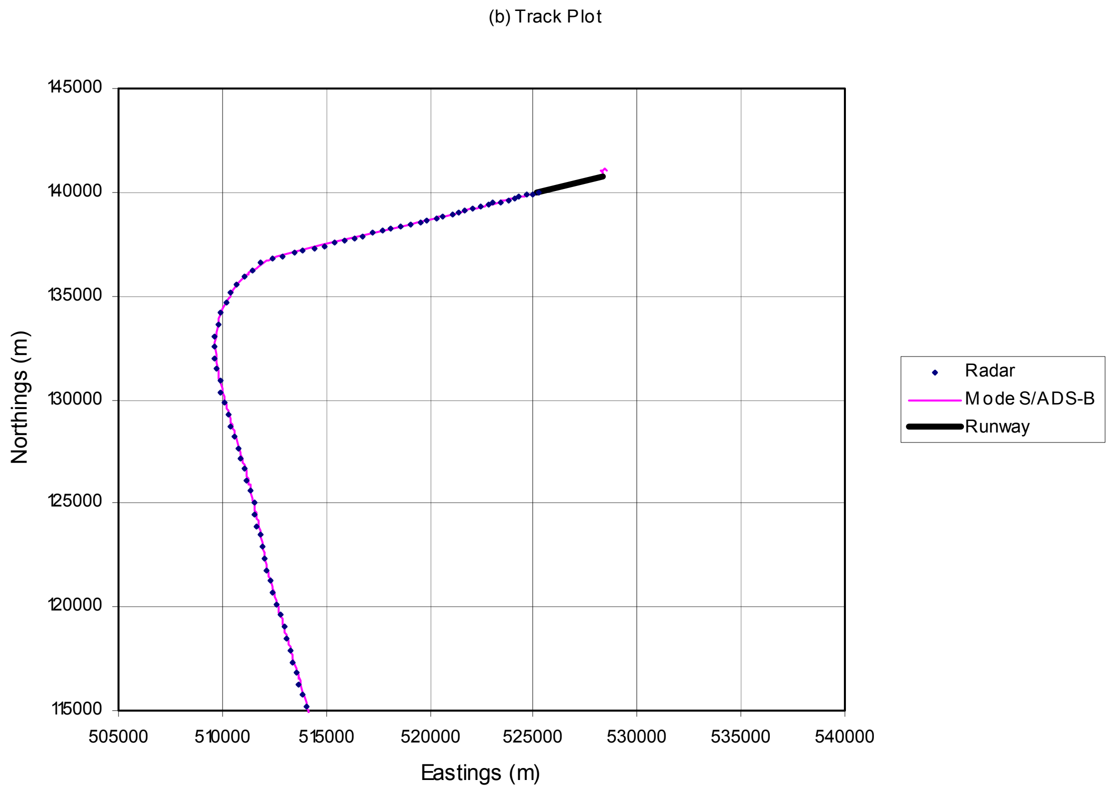
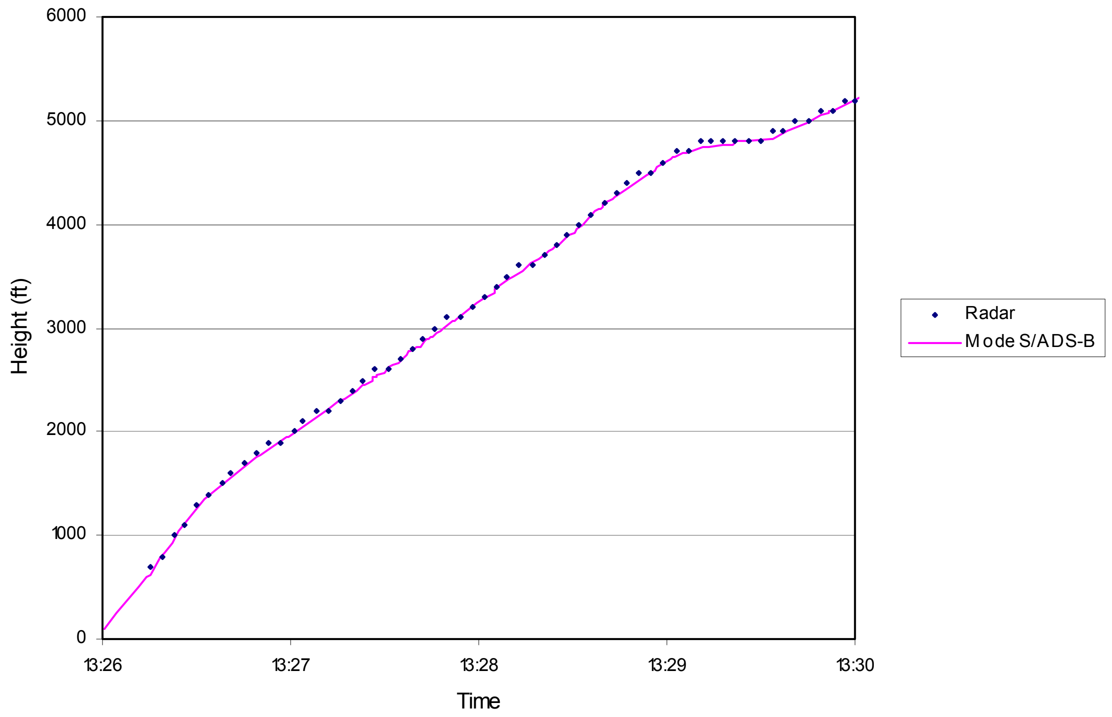


Figure 12 Gatwick departure, 13:26 hrs

(a) Height Profile



(b) Track Plot

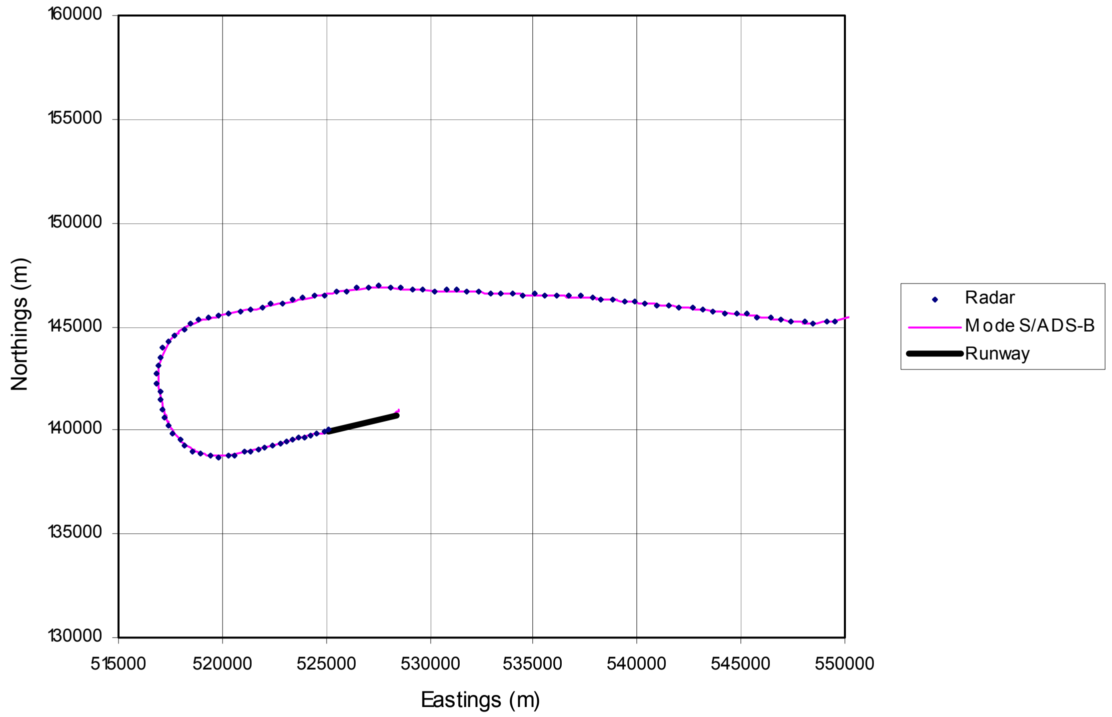
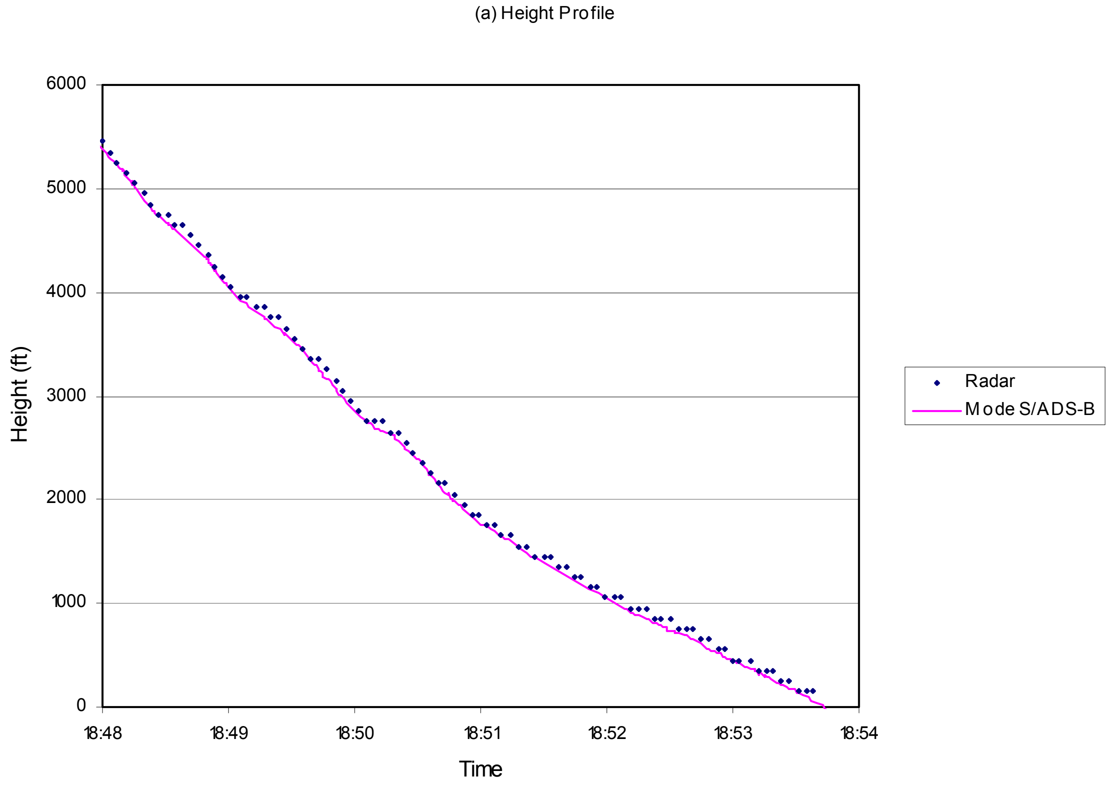


Figure 13 Stansted arrival, 18:53 hrs



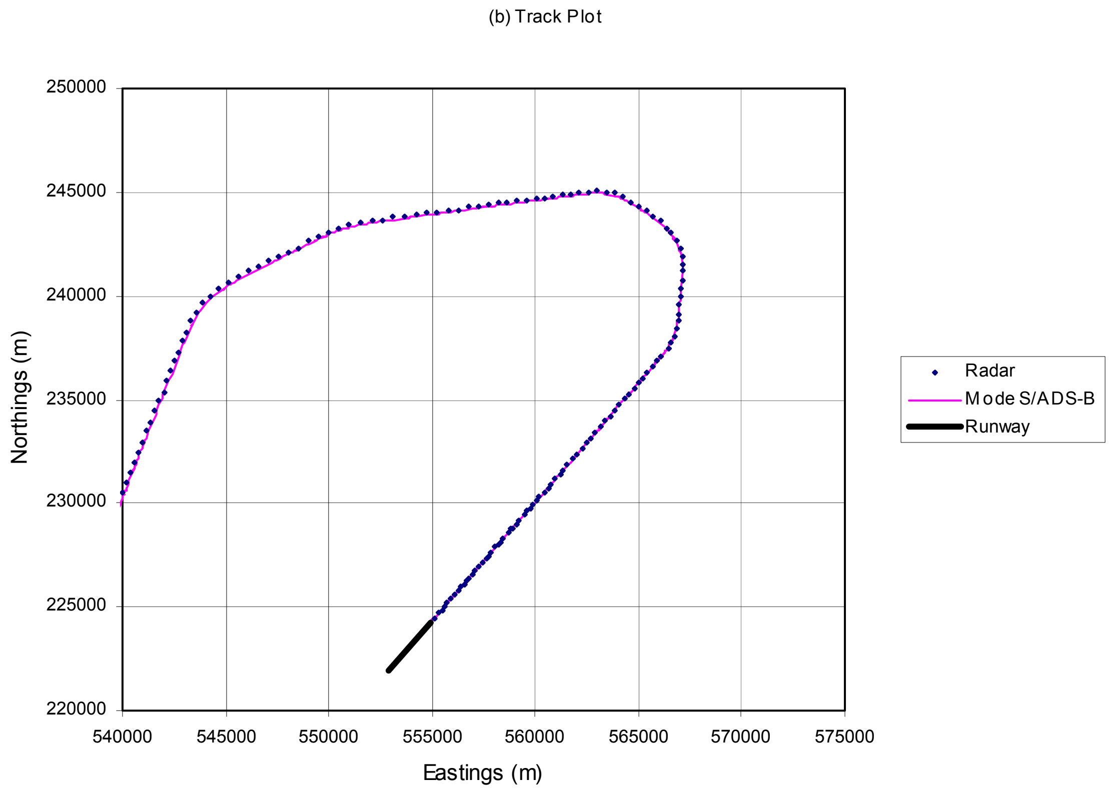
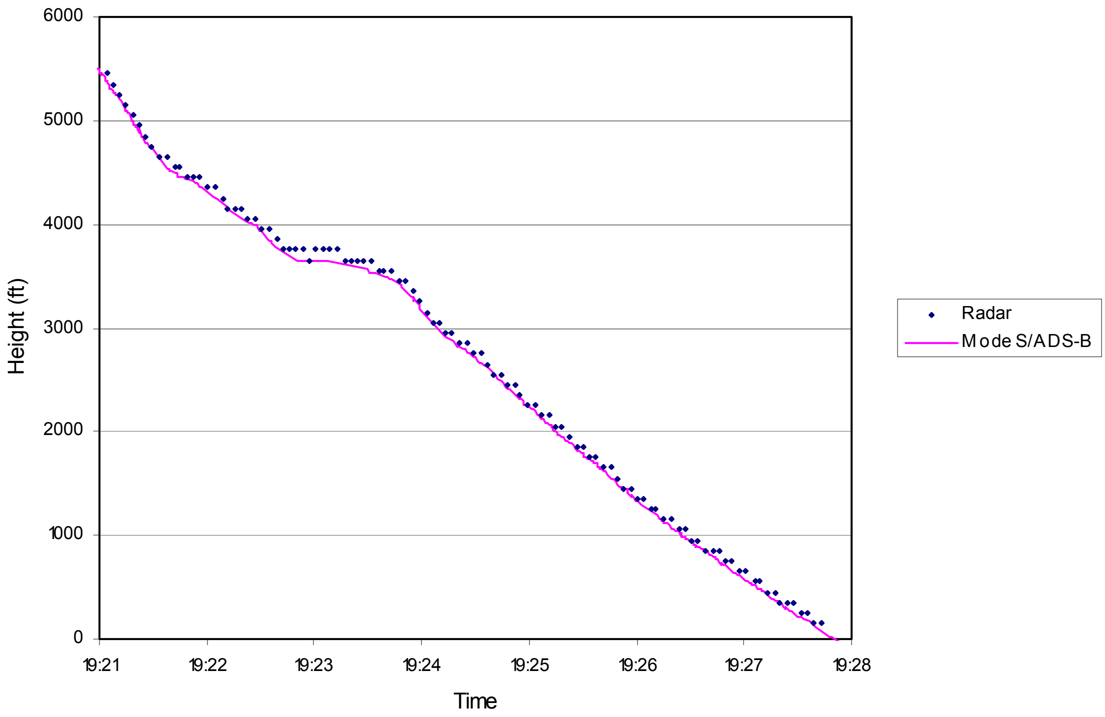


Figure 14 Stansted arrival, 19:28 hrs

(a) Height Profile



(b) Track Plot

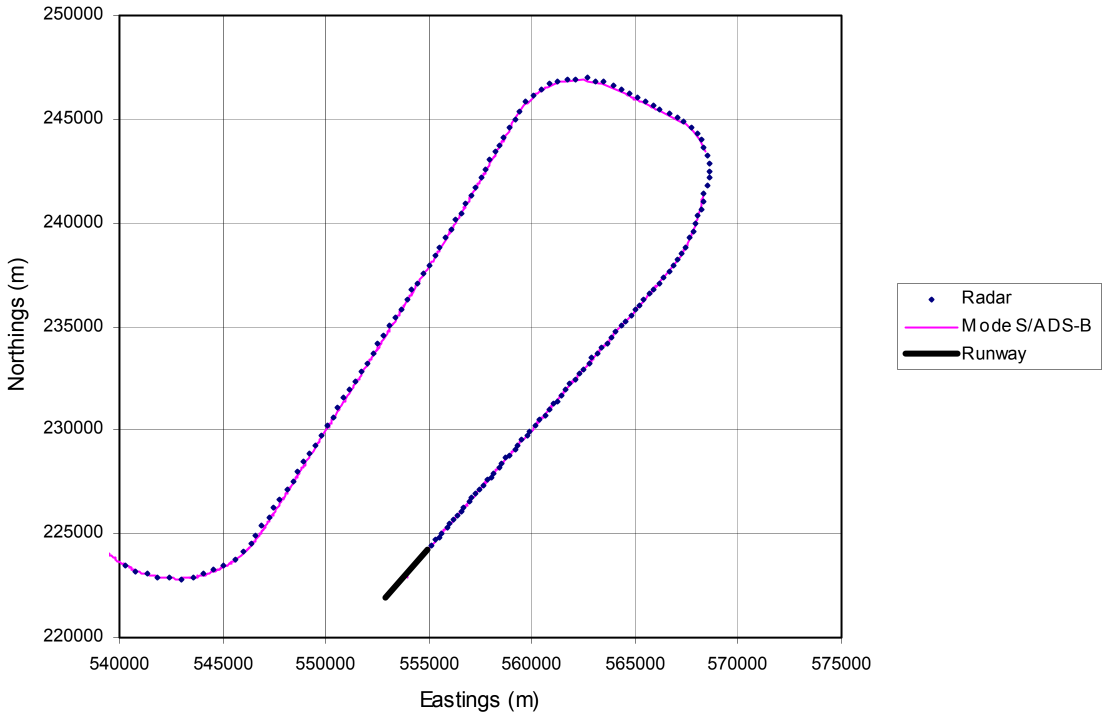
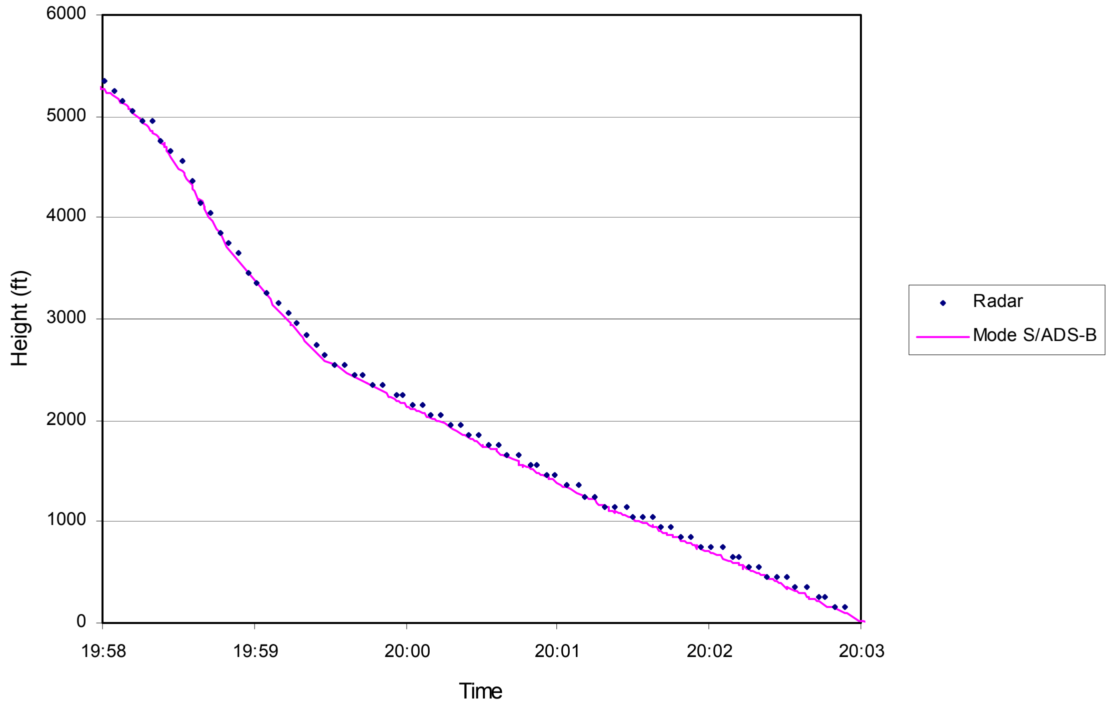


Figure 15 Stansted arrival, 20:03 hrs

(a) Height Profile



(b) Track Plot

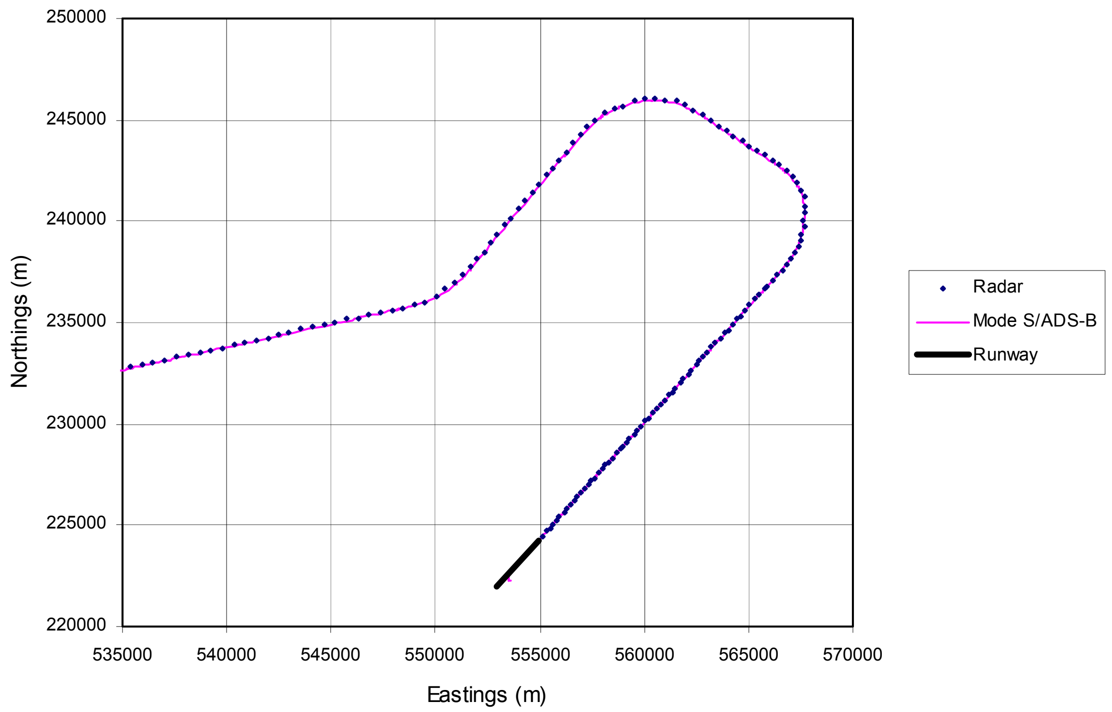
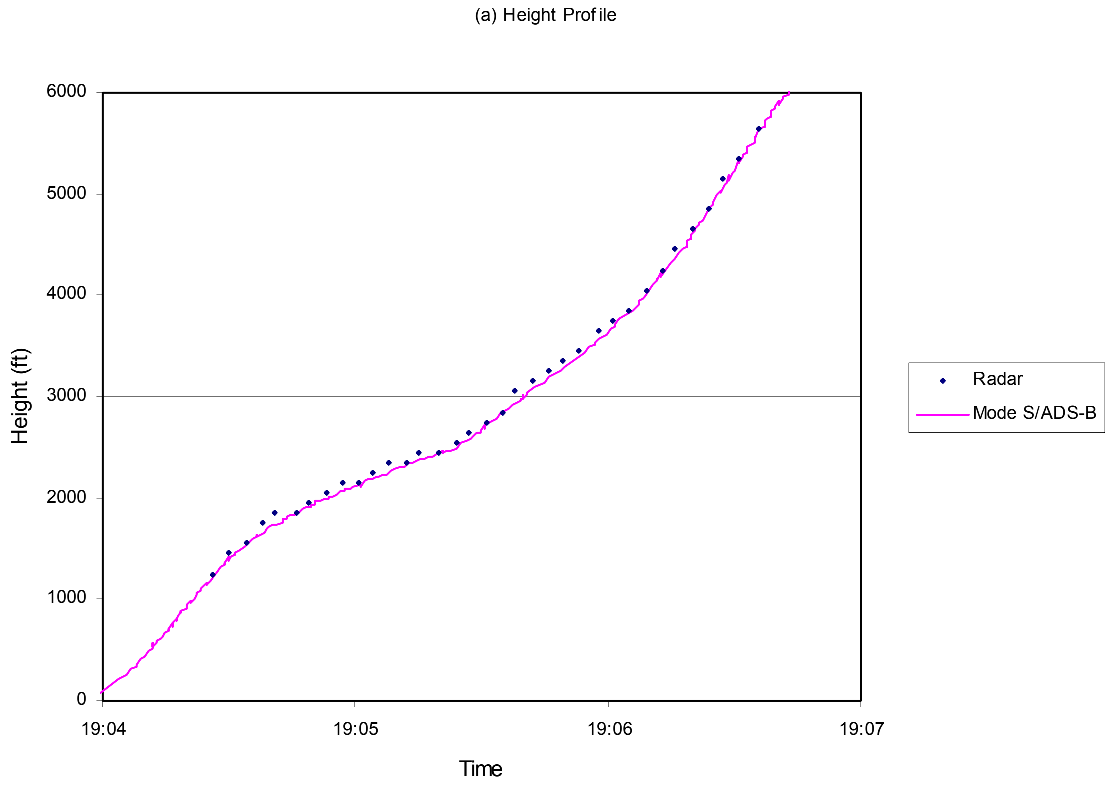


Figure 16 Stansted departure, 19:04 hrs



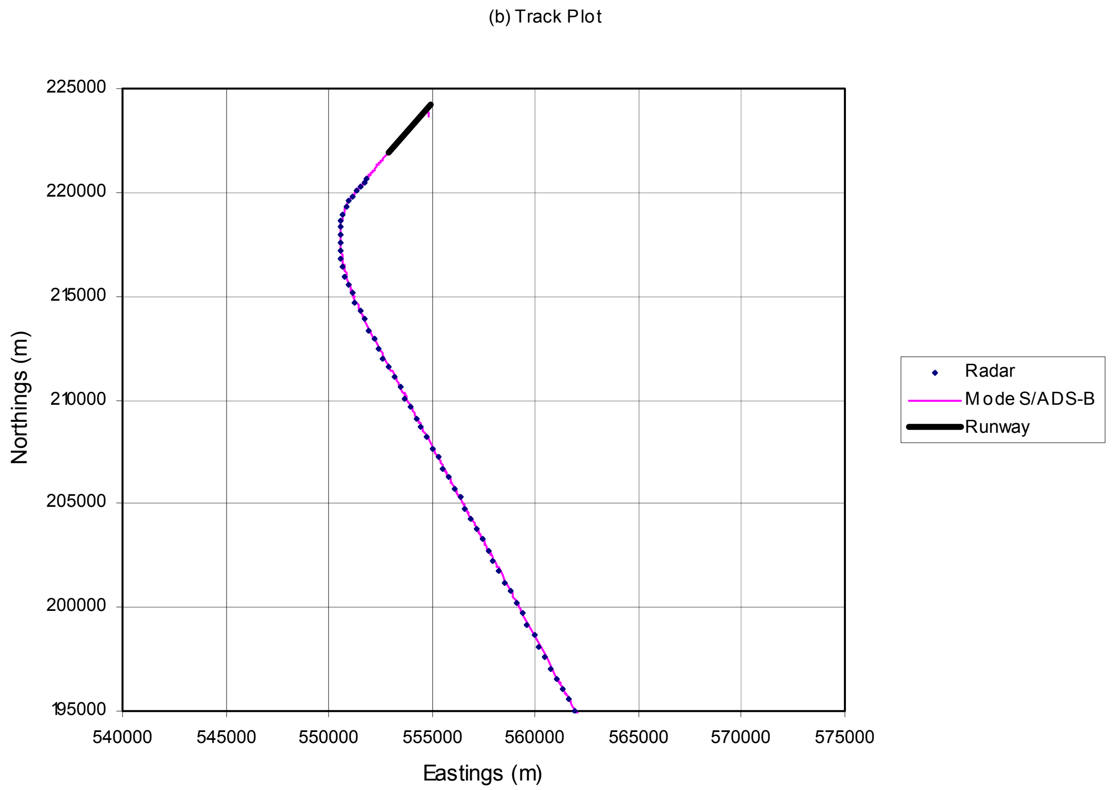
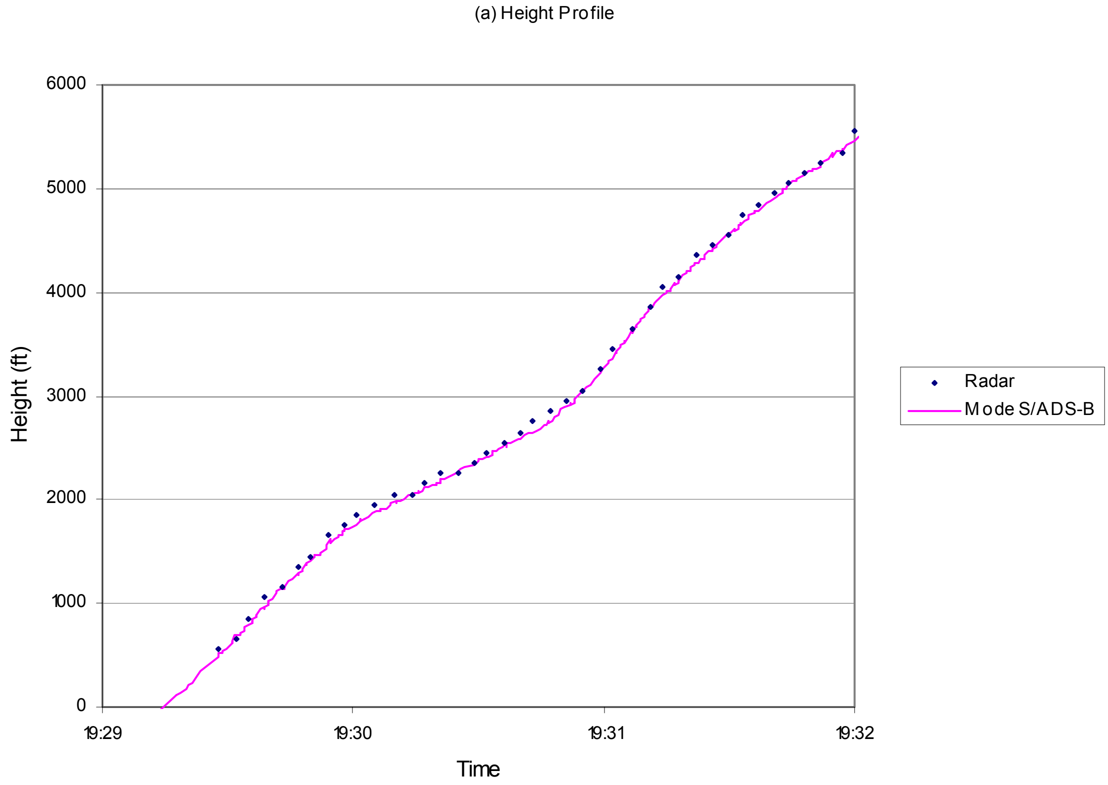


Figure 17 Stansted departure, 19:29 hrs



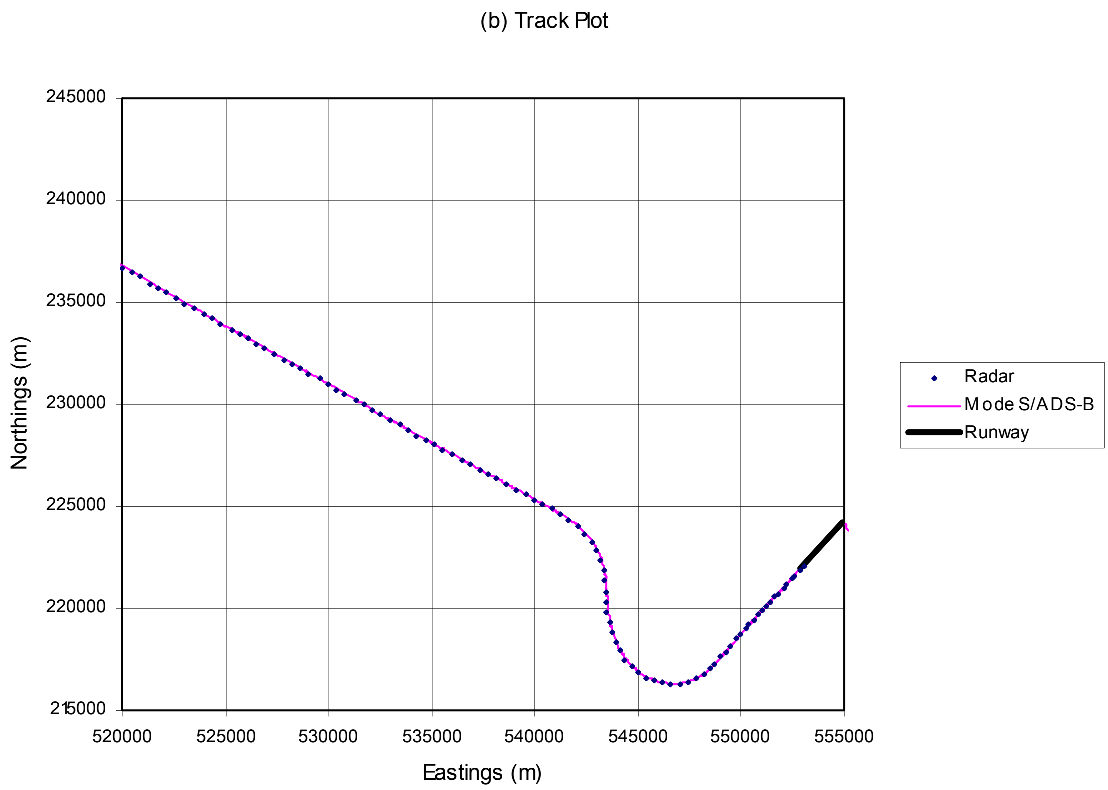
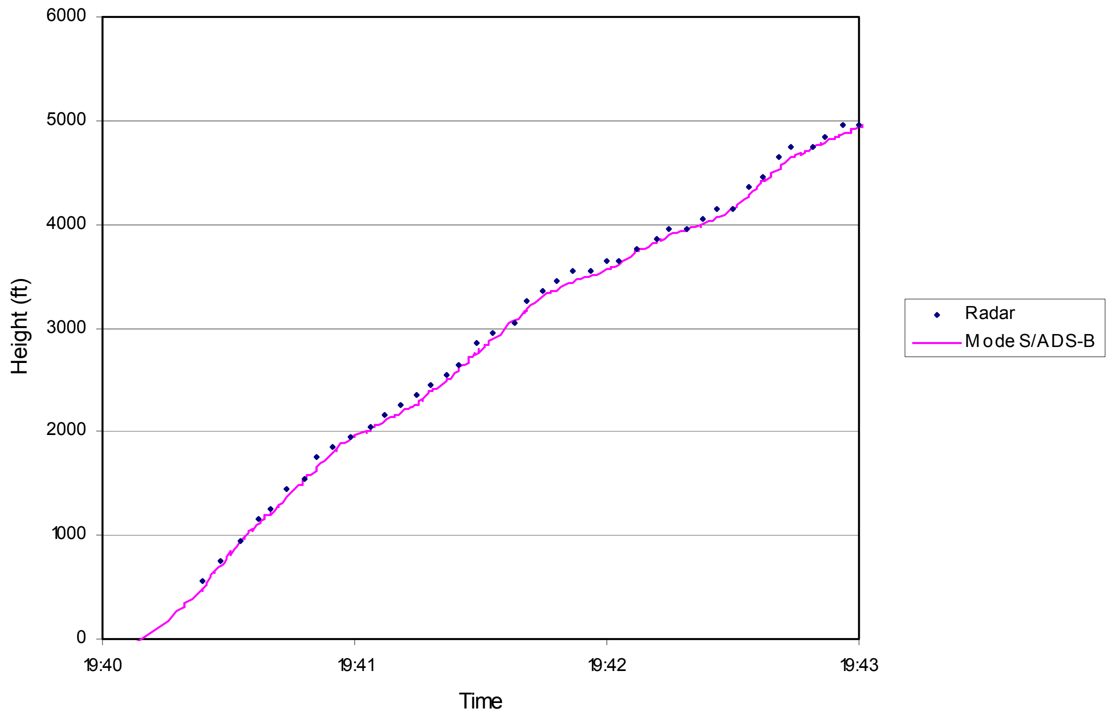
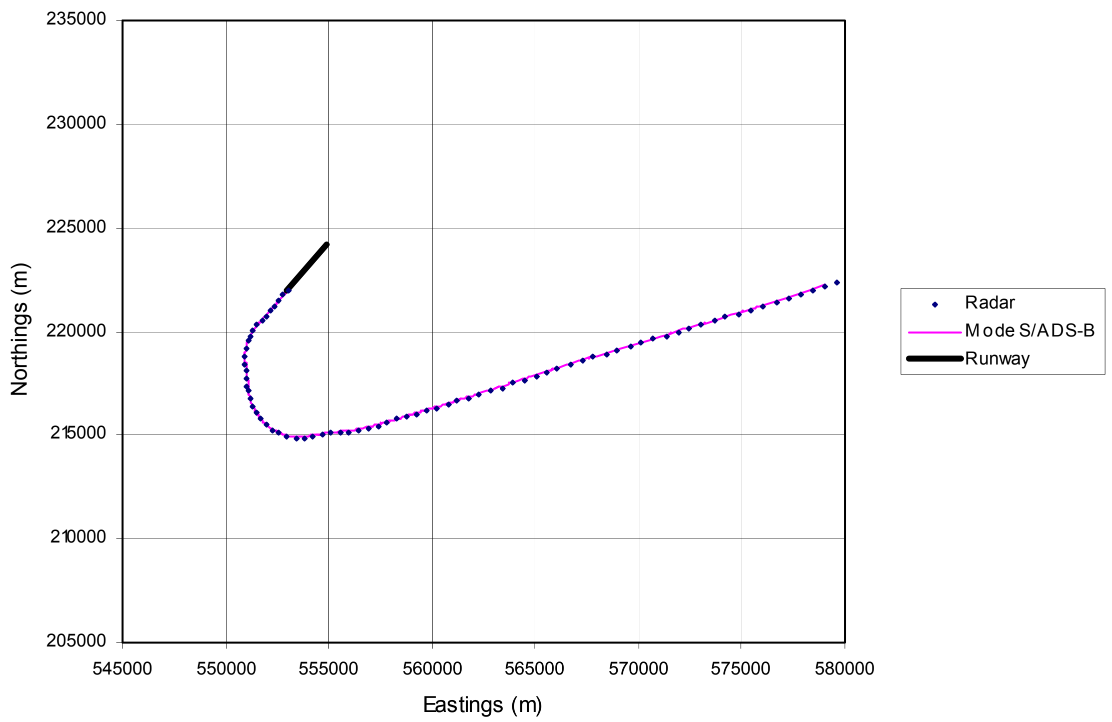


Figure 18 Stansted departure, 19:40 hrs

(a) Height Profile



(b) Track Plot



Appendix A Overview of the NTK System

A1 What an NTK system does

A1.1 A Noise and Track Keeping (NTK) system provides information on:

- which aircraft are flying in the vicinity of an airport;
- where they fly to and from;
- where they are in the air;
- how high and how fast they are;
- which runways and routes they are using;
- how much noise they make on the ground; and
- the corresponding weather conditions.

A1.2 ERCD currently uses a system called ANOMS 8, which is supplied by an Australian company, Lochard, one of the world's major suppliers of such systems. The NTK system at CAA House is linked by a high-speed internet service to servers for each airport that are maintained by Lochard. Similar systems are operated by BAA at Heathrow, Gatwick and Stansted airports, with whom ERCD staff work closely. Data for all three airports are accessible from the ERCD system.

A2 Uses of NTK data

A2.1 Typical uses of NTK data in ERCD are:

- annual noise exposure contour input data for Heathrow, Gatwick and Stansted (e.g. ground tracks, height/speed profiles, noise levels and route/traffic analyses);
- studies on behalf of ANMAC[1], e.g. departure limits review, arrivals noise study, Quota Count validation study;
- descent profile monitoring; and
- ad hoc studies (e.g. flight path movement charts and track density plots).

A2.2 BAA uses the NTK systems mainly to monitor:

- aircraft exceeding the departure noise limits;
- night flight restrictions;
- departure track deviations from the Noise Preferential Routes (NPRs); and
- achievement of the Continuous Descent Approach (CDA) technique.

A2.3 The NTK system at each airport also provides input to the BAA complaint and enquiry handling teams and for BAA to undertake a variety of local studies of aircraft noise, procedures, track keeping, etc. Data from the NTK systems are also fed into an online public flight-tracking tool called WebTrak[2], which mirrors the aircraft flight track, height and aircraft type information in ANOMS.

[1] Aircraft Noise Monitoring Advisory Committee. The committee is chaired by the Department for Transport and comprises representatives of the airlines, Heathrow, Gatwick and Stansted airports and airport consultative committees.

[2] http://lhr.webtrak-lochard.com/ for Heathrow
http://lgw.webtrak-lochard.com/ for Gatwick
http://stn.webtrak-lochard.com/ for Stansted

A3 Sources of data for the NTK system

A3.1 **Figure A1** shows the sources of data feeding into the NTK system. At each airport, radar data are used from a default radar head, with a standby head available in each case in the event of failure or planned maintenance. Radar head locations and characteristics for Heathrow, Gatwick and Stansted airports are summarised in **Table A1**. Only these radar heads would provide the required low-level coverage at the relevant airport.

Table A1 Radar Heads at Heathrow, Gatwick and Stansted

Airport	Radar	Type	OS coordinate X	OS coordinate Y	Nominal aerial rotation period (seconds)
Heathrow	Main	23 cm	507496	176027	4
	Alternate	10 cm Watchman	508504	174650	4
Gatwick	Main	10 cm Watchman	526713	139999	4
	Alternate	23 cm (Pease Pottage)	525166	133083	6
Stansted	Main	10 cm Watchman	553093	222708	4
	Alternate	23 cm (Debden)	555540	234841	6

A3.2 The radar data are transferred to the London airports via a network. Code-to-Callsign processing (CCDS) at the London Area Control Centre in Swanwick provides the callsign corresponding to the SSR code in use to remote systems on request. The radar and CCDS data are then returned to a NATS Radar Data Filtering and Processing System (RDFPS) at each airport where they are combined. This allows:

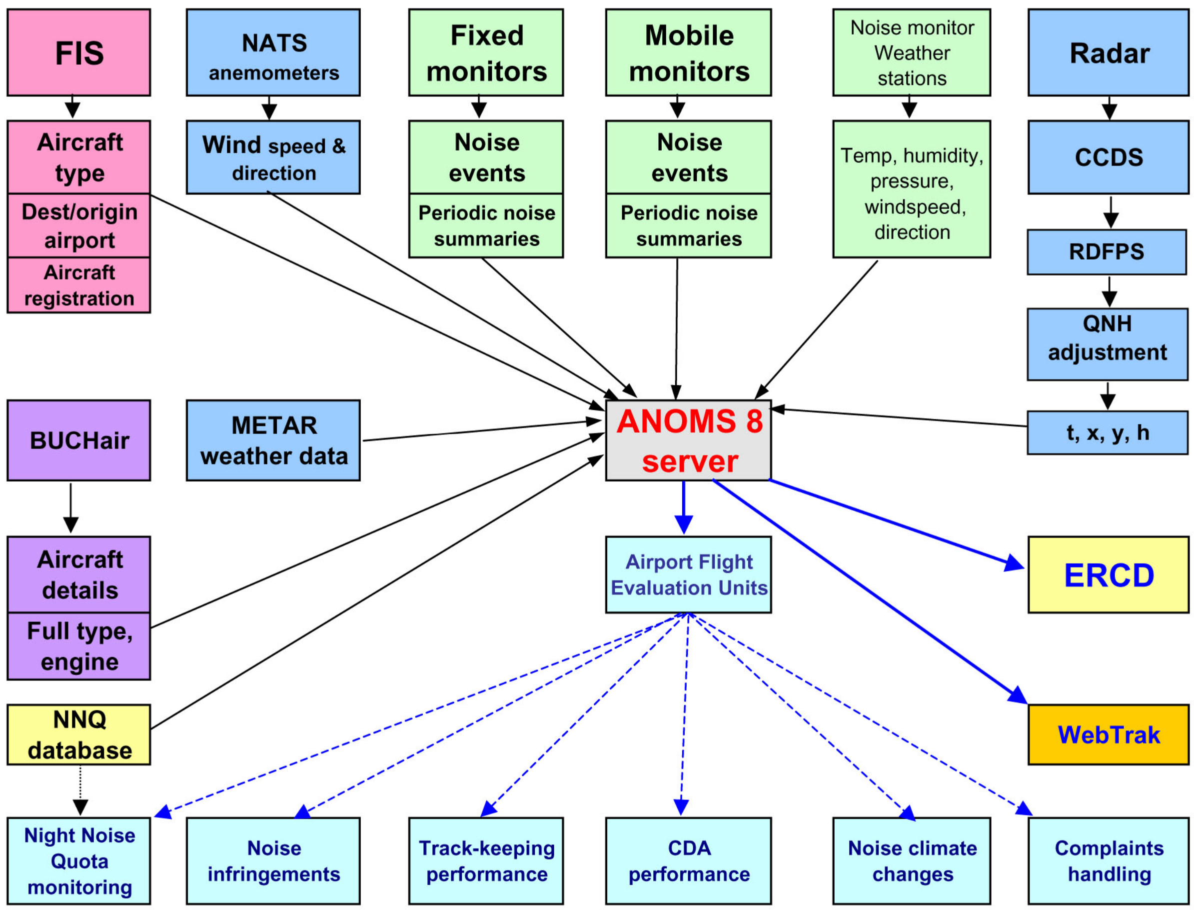
- Customised filtering for each radar head (e.g. to eliminate known areas where reflections or radar distortion is a problem).
- Filtering of data outside a given rectangular radar coverage area.
- Filtering of data outside a specified altitude range.
- Filtering of tracks not departing from or landing at the airport in question.
- QNH adjustment, by which the Flight Levels (below FL060) are converted to altitude above mean sea level.
- Conversion of range and azimuth values to Cartesian coordinates relative to a reference point on the airfield (taking into account the 'slant range effect' because the radar range is in 3-dimensions, not a distance on the ground).

The RDFPS output is then transferred to BAA via BAA's Virtual Private Network (VPN).

A3.3 The NTK interfaces at each airport are the Communications Servers ("Rovers"). These are essentially stand-alone PCs that store all the incoming radar and noise data. ANOMS 8 uses the airfield elevation to adjust altitudes above mean sea level to heights above airfield, and allows the radar tracks to be overlaid and viewed on a variety of different Ordnance Survey maps using a GIS-style interface within the NTK system.

A3.4 Aircraft registration data from the airports' Flight Information Systems (FIS) are also fed into the NTK system, which ANOMS 8 can cross reference with BUCHair, an aircraft fleet database, to obtain exact aircraft type and engine details.

Figure A1 Data Inputs to and Typical Outputs from the NTK System



Appendix B Sources of Uncertainty in NTK Data

B1 Radar data

B1.1 The ANOMS 8 NTK system was specified to use Secondary Surveillance Radar (SSR) data for its source of height and position information, and it is largely the uncertainty of this that is discussed here.

B1.2 The height data output by the NTK system are derived from SSR Mode C transmissions of pressure altimeter readings from the aircraft. The resolution of these Flight Level data (which are referenced to a reference atmospheric pressure of 1013.25 hPa) is 100 ft.

B1.3 Below Flight Level 060 (corresponding to an altitude of approximately 6,000 ft), the Flight Level is adjusted by the NATS radar data processing system to QNH, i.e. the altitude relative to mean sea level at the London Area local atmospheric pressure. The radar data are then transferred to the airports' NTK systems, which apply the appropriate airfield elevation adjustment, so the data stored in the NTK represent the aircraft heights above aerodrome level (aal) at a nominal reference point. Sources of uncertainty for any individual data point include:

- SSR Mode C Correspondence error. As the Mode C transponder reports the Flight Level, which has a resolution of 100 ft, the uncertainty introduced from this resolution is a maximum of ±50 ft (on the basis that Flight Level data are rounded to the nearest 100 ft).
- Altimetry System error. The altimeter barometric pressure is subject to on-board measurement accuracy and local pressure variations. The magnitude of these errors is not usually known unless there is some external reference to the aircraft height, but in this context it is considered to be of the order of ±50 ft at most.
- Conversion errors. Examples are errors introduced by pressure corrections, the time base of the radar, and co-ordinate transformations. These factors may contribute a further possible height uncertainty of the order of ±25 ft at most.

B1.4 The uncertainty values given above are broadly-based estimates from NATS. The sum of the uncertainty values, ±125 ft, is of course indicative of a 'worst case' and in no way represents typical or routine inaccuracy of the system. A more realistic estimate of the probable overall uncertainty, assuming the individual uncertainties are independent of each other, would be ±75 ft[1]. Also note that these individual height readings (values typically every four seconds) are 'splined' (smoothed) by the NTK system for each flight, so much of the impact of the coarse resolution is removed before height data are used for any study, as illustrated in **Figure B1**.

B1.5 The accuracy in aircraft position (i.e. its ground track) as indicated by the NTK system is dependent on the aircraft's location relative to the radar head[2]. The range data (distance between the radar head and the aircraft) have a resolution of 1/16 nm (116 m). Thus, resolution uncertainty in this direction could be of the order of ±60 m. At 90° to this direction, the accuracy decreases with distance from the radar head, as it depends on the resolution of the azimuth angle, 0.088°. At locations close to

[1] Estimated by taking the square root of the sum of the squared uncertainty values.

[2] The primary radar heads at the three London airports are all located within the airport boundaries.

the vicinity of the NTK fixed monitors (approximately 6.5 km from the radar head at each airport), resolution in this direction is approximately 10 m.

B1.6 Because of the relatively short aerial rotation period (typically four seconds) of the main NATS radar head at each London airport, aircraft flight paths in the NTK system can be resolved to a greater accuracy than systems based on longer rotation periods, such as six or eight seconds. As with the height data, when these individual position readings are splined, much of the uncertainty associated with the coarse resolution is removed and the overall accuracy of the data is better than the worst case - see **Figure B2**.

B2 Noise data

B2.1 The NTK noise monitors are Type 1 precision sound level meters that conform to the appropriate IEC 60651 and IEC 60804 international standards[3] (Refs B1, B2). The sound calibrators that are used to verify the accuracy of the sound level meters before and after each series of noise measurements all conform to the Class 1 requirements of IEC 60942[4] (Ref B3). The IEC standards specify the performance requirements of the noise instrumentation in a number of areas.

B2.2 Each NTK monitor currently comprises the following instrumentation:

- Larson Davis Model 870 integrating sound level meter
- Larson Davis Model 875 1/3-octave band real time analyser[5]
- Larson Davis Model 2541 free-field microphone

B2.3 In order to ensure that the NTK noise monitors continue to operate in conformance to the manufacturing standards, all items are removed from service and calibrated by an approved calibration agency once a year. This periodic verification is traceable to UK National Standards. The UK's National Physical Laboratory has indicated that the standard uncertainty for a Type 1 sound level meter is ±0.4 dBA (Ref B4).

B2.4 Although a periodic verification test ensures that each NTK sound level meter continues to operate in conformance to the manufacturing standards, it should be remembered it is not an absolute guarantee that the meter will perform as intended for the following 12 months – merely, it is a statement of the instrumentation's performance at the time of the test. Regular on-site checks using traceable sound calibrators also add extra confidence to the validity of the NTK noise measurements, but again it should be remembered that such checks are normally only carried out at a specific sound pressure level and frequency.

B2.5 Of course, possible sources of uncertainty for aircraft noise measurements include not only the noise instrumentation itself, but also variations in the noise source and propagation path, meteorological variations, the local environment at the

[3] In May 2002, IEC 60651 and IEC 60804 were replaced by IEC 61672-1 (the current international standard for sound level meters), which specifies two performance categories, Class 1 and Class 2. The new Class 1 standard is broadly equivalent to the previous Type 1 grade of IEC 60651/60804.

[4] In January 2003 the latest edition of IEC 60942 was published. However, the NTK sound calibrators were all manufactured to a previous edition of the standard.

[5] The Model 875 analyser is only installed at particular sites when there is a need to monitor Effective Perceived Noise Level (EPNL). This involves analyses of the frequency spectra of noise events as well as the duration of the sound.

measurement site, and also any variance due to data sampling. All of these individual uncertainty components can influence the quality of the final measured result. This is discussed in more detail in ERCD Report 0506 (Ref B5). It is recommended that this report be read in conjunction with ERCD Report 0406 (Ref B6), which describes the best practice monitoring techniques used by ERCD when carrying out aircraft noise studies.

References

B1 IEC 60651:1979, *Sound level meters*, International Electrotechnical Commission (IEC)

B2 IEC 60804:1985, *Integrating-averaging sound level meters*, International Electrotechnical Commission (IEC)

B3 IEC 60942:2003, *Sound calibrators*, International Electrotechnical Commission (IEC)

B4 Payne R, *Uncertainties associated with the use of a sound level meter*, NPL Report DQL-AC 002, National Physical Laboratory, April 2004

B5 White S, *Precision of Aircraft Noise Measurements at the London Airports*, ERCD Report 0506, Civil Aviation Authority, November 2005

B6 White S, *Techniques used by ERCD for the Measurement and Analysis of Aircraft Noise and Radar Data*, ERCD Report 0406, Civil Aviation Authority, January 2005

Figure B1 Illustration of splined height data

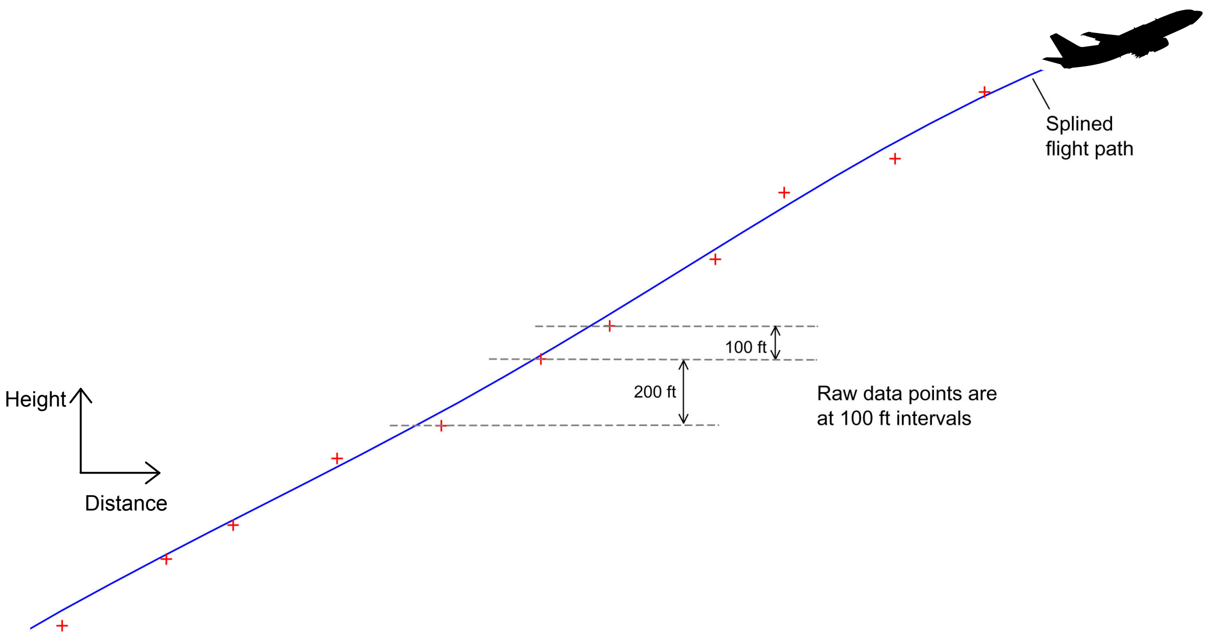


Figure B2 Illustration of splined position data