Environmental Research and Consultancy Department

Flight path accuracy of the Gatwick Noise and Track Keeping System

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Summary

This report describes a study that was undertaken to assess the accuracy of the flight path information provided by the new Noise and Track Keeping (NTK) system ANOMS, installed at Gatwick Airport in April 2019, and its suitability for use in aircraft noise analysis.

Aircraft positional data recorded using Mode S/ADS-B receiving equipment were used for independent comparison against ANOMS outputs, which are based on Secondary Surveillance Radar data. For the flights analysed, the study has confirmed that flight tracks and aircraft heights in the system are being reported correctly with no obvious errors or significant bias in the data.

A comparison of the ANOMS NTK aircraft operations database with corresponding records from air traffic control runway logs has shown a very close agreement between the two data sources.

The analysis confirms that the system continues to provide reliable flight data for the types of studies carried out by the Environmental Research and Consultancy Department (ERCD) of the CAA.

Chapter 1

Introduction

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 Gatwick, Heathrow and Stansted airports. The NTK system at each airport matches air traffic control radar data (aircraft flight paths) to related noise measurements from noise monitors at prescribed ground positions. ERCD obtains data from the airports' systems via a link to the NTK remote servers.

In 2014, ERCD published the results of a study to assess the general accuracy of the flight path information collected by and held in the Gatwick NTK system[1]. For the sample of flights analysed, the results indicated that flight tracks in the Gatwick NTK system were being recorded and displayed correctly.

In April 2019, Gatwick Airport replaced its then current 'Casper Noise' NTK system with a new system called ANOMS. Although ANOMS continues to use Secondary Surveillance Radar (SSR) for its source of aircraft height and position information, additional checks have been undertaken by ERCD to ensure that the new system at Gatwick continues to provide reliable flight track data.

Chapter 2 of this report gives a technical assessment comparing horizontal position and height data from the ANOMS NTK system at Gatwick against an independent source. An assessment of the flight operations information is provided in Chapter 3. The study conclusions are summarised in Chapter 4.

[1] CAP 1246, *Accuracy of data in the Gatwick Noise and Track Keeping System*, Civil Aviation Authority, December 2014

Chapter 2

Flight track data

Methodology

The source of aircraft positional data collected by and held in the Gatwick NTK system is Secondary Surveillance Radar. The system's radar coverage is currently a circular area approximately 60 NM in radius (110 km), centred on the airfield, covering aircraft at heights of up to approximately 30,000 ft above airfield level. The radar feed into the Gatwick NTK system also provides altitude reporting in 25 ft intervals for Mode S equipped aircraft.

To assess the accuracy of the Gatwick radar data, it is necessary to perform direct checks of the NTK data against independently derived precision data. For this study, the NTK data have been checked against height and positional information supplied by Mode S/ADS-B broadcasts using a portable receiver that decodes transponder signals from aircraft. As noted above, aircraft equipped with Mode S transponders provide altitude reporting in 25 ft intervals, with ADS-B adding global navigation data typically obtained from the aircraft's GPS (Global Positioning System) receiver.

The aerial rotation period of the radar head at Gatwick Airport is approximately four seconds, therefore it provides aircraft positional information every four seconds. By comparison, Mode S/ADS-B position and ground speed messages are typically broadcast every half-second. In addition, since GPS can generally provide position data accurate to within a few metres[2], a Mode S/ADS-B receiver enables accurate determination of an aircraft's position at any given time for independent comparison against the output from ANOMS.

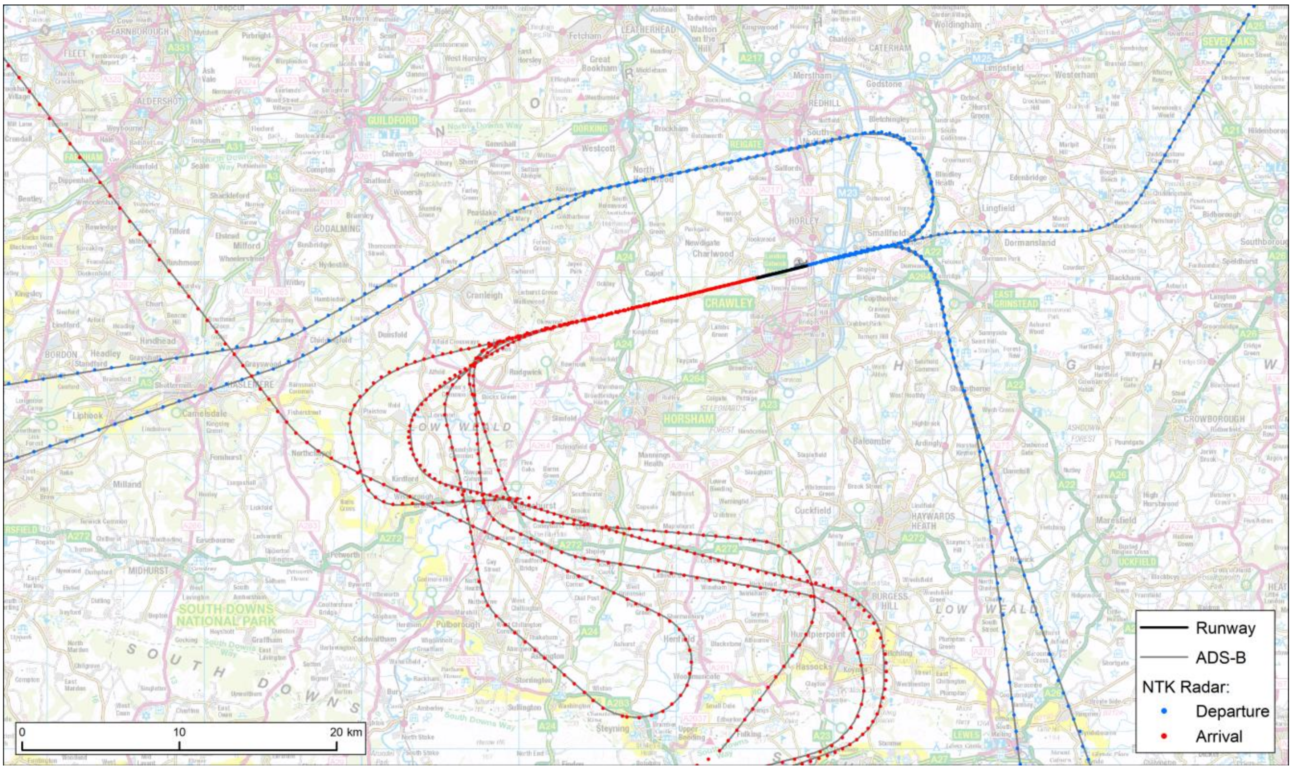
Mode S/ADS-B data were logged by ERCD for a sample of flights at Gatwick on 24 August 2019, using a receiver located close to the airfield. Because the Mode S/ADS-B receiver relies on a good line-of-sight to the aircraft, the signal can occasionally be interrupted by nearby buildings or other large obstructions. 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] Global Positioning System Standard Positioning Service Performance Standard, Assistant for GPS, Positioning and Navigation, 6000 Defense Pentagon, Washington DC, 4th Edition, September 2008.

Horizontal position data

Figure 1 compares the horizontal component of the NTK radar points with the equivalent Mode S/ADS-B data for a sample of five arrivals and five departures recorded on 24 August 2019. For all the monitored flights, Mode S/ADS-B position values were logged out to a distance of at least 30 km from the airport, with height values up to 10,000 ft or higher in most cases. The radar points shown in Figure 1 are the raw values exported from the NTK system[3]. The corresponding height profiles for each flight are provided in Appendix A and discussed in the next section of this report.

Figure 1 Gatwick arrival and departure tracks



The ground track comparisons show a close agreement between the NTK position data and the ADS-B position data. The measured positional differences have been quantified in further detail below. When considering these results, it should be recognised that the ADS-B data against which NTK points are compared are also subject to some uncertainty.

Comparison of the position data at any given point in time can be strongly affected by small time synchronisation differences between the two data sets. For example, for an aircraft travelling at a ground 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 account for this as far as possible in this assessment, the Mode S/ADS-B

[3] To aid comparison with the radar points, the ADS-B tracks shown in Figure 1 are illustrated as continuous lines rather than discrete position values.

position points were interpolated to calculate the closest distance from the Mode S/ADS-B ground track to each radar point.

The average (mean) measured positional difference across all ten flights is summarised in Table 1 below.

Table 1 Measured positional difference

Mean difference, m	Standard Deviation, m
32	29

The results indicate that the average difference in ground track position between the two data sources is approximately 30 m, which is sufficiently accurate for the types of studies undertaken by ERCD.

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 indicates that the NTK radar and 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 position data are based on the range and azimuth of aircraft relative to a reference point, there is no reason to expect larger differences in one coordinate direction compared to the other (even after conversion to a geographic or Cartesian coordinate system) since position errors should generally be normally distributed. However, because the data in ANOMS are processed through a different coordinate system it is necessary to confirm that the system does not include a bias in one particular coordinate direction.

The average differences of the individual radar data points in the X and Y directions (NTK position *minus* Mode S/ADS-B position) have therefore been calculated and are summarised in Table 2.

Table 2 Measured differences in each axis direction, (NTK *minus* Mode S/ADS-B)

	Mean difference, m	Standard Deviation, m
X direction	-6	80
Y direction	-14	70

For the sample of flights analysed, the average measured difference in each Cartesian axis direction between the two data sets is within ±15 m (and the spread of the differences is similar in both directions), thus confirming that there is no significant systematic bias in the NTK positional data.

Height data

Mode S altitude data are referenced to the standard pressure of 1013.25 hPa (the pressure at mean sea level in a 'standard' atmosphere[4]). Because the radar height data in the ANOMS NTK system have been corrected for local atmospheric pressure and airfield elevation, it is necessary to correct the data from the Mode S/ADS-B receiver in the same way before comparing the two. This was done by taking into account the local atmospheric pressure[5] at the time that each flight occurred, and also correcting for the aerodrome's elevation above mean sea level.

The height profile comparisons presented in Appendix A indicate that the agreement between the two sources of data is consistently good. The average measured height difference calculated for the sample of flights analysed is -4 ft, which is negligible (Table 3).

Table 3 Measured height differences, (NTK *minus* Mode S/ADS-B)

Mean difference, ft	Standard Deviation, ft	5^{th} / 95^{th} percentile, ft
-4	32	-52 / +36

To provide a further indication of the range of measured height differences between the two data sources, the 5^{th} and 95^{th} percentile[6] values (of the differences) have also been calculated and are within approximately ±50 ft. The results therefore confirm that there is no significant error or bias in the NTK height data when compared to data that have been acquired and processed independently using a Mode S/ADS-B receiver.

4 International Organization for Standardization, Standard Atmosphere, ISO 2533:1975, 1975.

5 It should be noted that this local pressure correction is also subject to some uncertainty. For example, a pressure adjustment error of 1 hPa would correspond to a height difference of approximately 27 ft. In addition, the Mode S transmissions of pressure altimeter readings from the aircraft are also subject to some uncertainty (which would be present in both the ANOMS and Mode S/ADS-B data sets).

6 The 95^{th} percentile is the point below which 95 percent of all the measured differences fall, and the 5^{th} percentile is the point below which 5 percent of the measured differences fall.

Chapter 3
Aircraft movements

An arrival or departure operation in the ANOMS NTK system is comprised of a radar track that is ordinarily combined with an associated flight plan record. The flight plan record provides additional information about the aircraft movement such as scheduled time of arrival/departure, airport of origin/destination and also aircraft registration, which is cross-referenced with aircraft fleet data to obtain exact aircraft type and engine details. If the radar feed into the system is temporarily interrupted, there is a risk that a proportion of movements will be unaccounted for.

To check the overall completeness of the ANOMS operations database, the numbers of arrivals and departures (excluding any helicopter operations) reported by the system during July and August 2019 have been compared to the corresponding records from runway logs provided by air traffic control at Gatwick Airport (Tables 4 and 5).

Noting the possibility that the runway logs might also contain small errors or omissions, the results nonetheless show that the agreement between the two data sources is very close and typically within ±1 aircraft movement per day (approximately ±0.1% of daily movements). In some cases the differences are larger than this. For example, the results in Table 5 indicate that there were 10 movements unaccounted for in the NTK system between 29 and 31 August 2019. However, a more detailed analysis of the NTK database for this period revealed that eight of those movements were classified by the Gatwick system as 'touch-and-go' operations.

Very occasionally a flight might return to the airport almost immediately after departing and can be classified as a touch-and-go operation in the NTK system (rather than a separate departure and arrival). However, the same flight would normally be counted as two separate movements in the runway logs, which partly explains why the logs reported a slightly greater number of movements in this case.

Whilst a detailed analysis of some of the other smaller differences that exist between the two data sources has not been undertaken for this study, they could be explained by the following:

- missing or incomplete radar tracks in the NTK system[7], or
- for movements occurring very close to midnight, an NTK operation may be wrongly included in the following day or in the previous day[8].

In summary, the overall differences shown in Tables 4 and 5 are not significant enough to affect the outcome of ERCD's noise modelling work.

[7] An incomplete radar track could result in an aircraft movement being undetected by the NTK system.

[8] Departure and arrival times in the NTK system correspond to the times of the first and last radar points respectively, rather than the actual lift-off and touchdown times recorded by ATC.

Table 4 Daily counts of ANOMS NTK operations, 1-31 July 2019

Date	NTK data		Runway log data		Difference between NTK and runway logs	
	Arr.	Dep.	Arr.	Dep.	Arr.	Dep.
01 July 2019	444	443	444	443	0	0
02 July 2019	453	440	453	440	0	0
03 July 2019	432	441	432	441	0	0
04 July 2019	452	453	453	453	-1	0
05 July 2019	446	452	446	452	0	0
06 July 2019	421	426	421	426	0	0
07 July 2019	455	451	455	451	0	0
08 July 2019	452	445	452	445	0	0
09 July 2019	447	434	447	434	0	0
10 July 2019	379	384	380	384	-1	0
11 July 2019	465	473	465	473	0	0
12 July 2019	454	458	455	459	-1	-1
13 July 2019	421	429	420	429	+1	0
14 July 2019	466	450	466	451	0	-1
15 July 2019	449	450	449	450	0	0
16 July 2019	449	437	449	437	0	0
17 July 2019	442	452	442	452	0	0
18 July 2019	450	459	450	459	0	0
19 July 2019	455	457	455	457	0	0
20 July 2019	420	441	421	442	-1	-1
21 July 2019	498	463	499	463	-1	0
22 July 2019	466	461	465	461	1	0
23 July 2019	435	447	435	447	0	0
24 July 2019	460	453	460	453	0	0
25 July 2019	411	415	411	415	0	0
26 July 2019	419	439	420	439	-1	0
27 July 2019	419	416	418	417	+1	-1
28 July 2019	470	457	470	457	0	0
29 July 2019	458	454	458	454	0	0
30 July 2019	438	435	438	435	0	0
31 July 2019	457	459	457	459	0	0

Table 5 Daily counts of ANOMS NTK operations, 1-31 August 2019

Date	NTK data		Runway log data		Difference between NTK and runway logs	
	Arr.	Dep.	Arr.	Dep.	Arr.	Dep.
01 August 2019	462	465	462	465	0	0
02 August 2019	456	467	456	467	0	0
03 August 2019	434	438	434	438	0	0
04 August 2019	470	456	470	456	0	0
05 August 2019	461	461	461	461	0	0
06 August 2019	464	453	464	453	0	0
07 August 2019	433	452	434	452	-1	0
08 August 2019	470	462	470	463	0	-1
09 August 2019	428	447	428	447	0	0
10 August 2019	438	446	438	446	0	0
11 August 2019	481	458	481	458	0	0
12 August 2019	442	444	441	444	+1	0
13 August 2019	464	447	465	447	-1	0
14 August 2019	450	451	450	451	0	0
15 August 2019	460	463	460	467	0	-4
16 August 2019	464	462	463	462	+1	0
17 August 2019	434	446	435	446	-1	0
18 August 2019	456	453	456	453	0	0
19 August 2019	456	452	455	452	+1	0
20 August 2019	460	449	460	449	0	0
21 August 2019	451	452	451	452	0	0
22 August 2019	457	462	457	462	0	0
23 August 2019	472	470	472	470	0	0
24 August 2019	425	440	425	440	0	0
25 August 2019	459	454	459	454	0	0
26 August 2019	472	455	472	455	0	0
27 August 2019	443	442	443	442	0	0
28 August 2019	457	462	457	462	0	0
29 August 2019	461	462	462	464	-1	-2
30 August 2019	469	464	470	467	-1	-3
31 August 2019	418	445	420	446	-2	-1

Chapter 4

Conclusions

A technical assessment comparing aircraft horizontal position and height data from the ANOMS NTK system at Gatwick Airport against an independent source has been carried out for a sample of 10 flights within a range of at least 30 km from the airport. The average difference in ground track position, in any direction between the two data sources, is approximately 30 m. For the flights analysed, the study has confirmed that flight tracks in the system are being recorded and displayed correctly with no obvious errors or significant bias in the data.

A comparison of the ANOMS NTK operations database with corresponding records from air traffic control runway logs has shown a very close agreement between the two data sources, typically within ±1 movement per day, which is not significant enough to affect the outcome of ERCD's noise modelling work.

APPENDIX A

Flight profile comparisons

Figures A1 to A5 compare the NTK height profiles with the Mode S/ADS-B data for the sample of five Gatwick arrivals analysed for this study. Figures A6 to A10 present similar results for the sample of five departures.

In each figure the aircraft height relative to the Gatwick runway is plotted against time. The points marked ‘Radar’ are the raw height values exported from the NTK system. To aid comparison with the radar points, the ADS-B tracks are illustrated as continuous lines rather than discrete height values. Although the Mode S/ADS-B dataset contained height values up to 10,000 ft or higher in most cases, for presentational purposes aircraft heights are only shown below 7,000 ft.

Figure A1 Gatwick 09:31 arrival

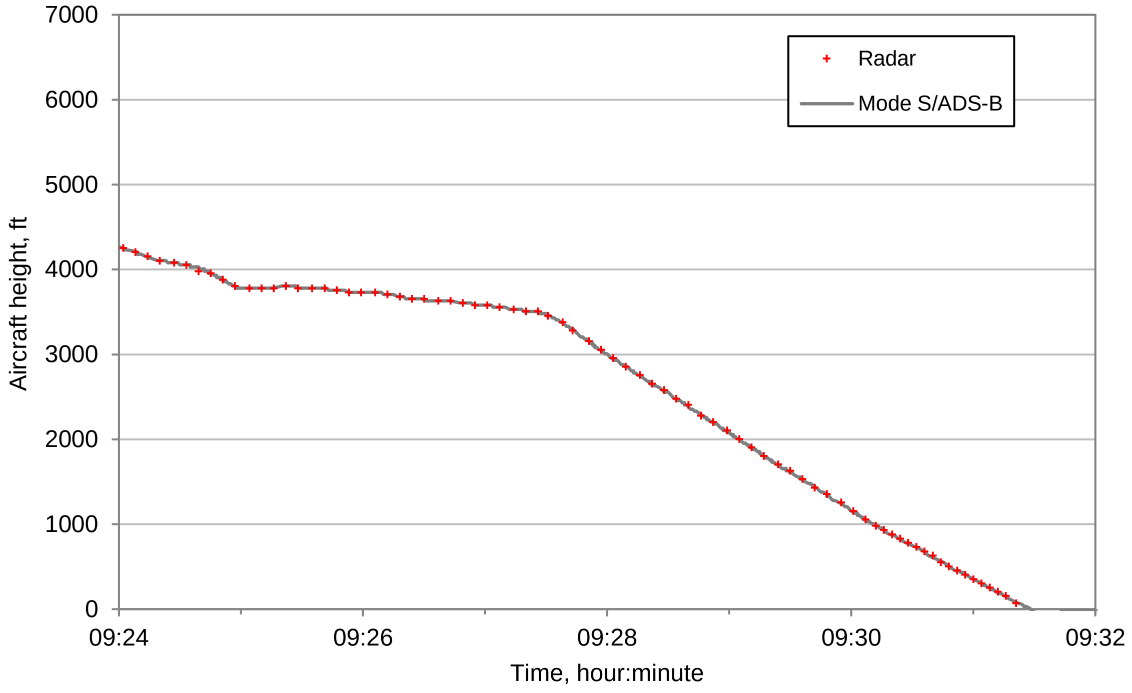


Figure A2 Gatwick 09:33 arrival

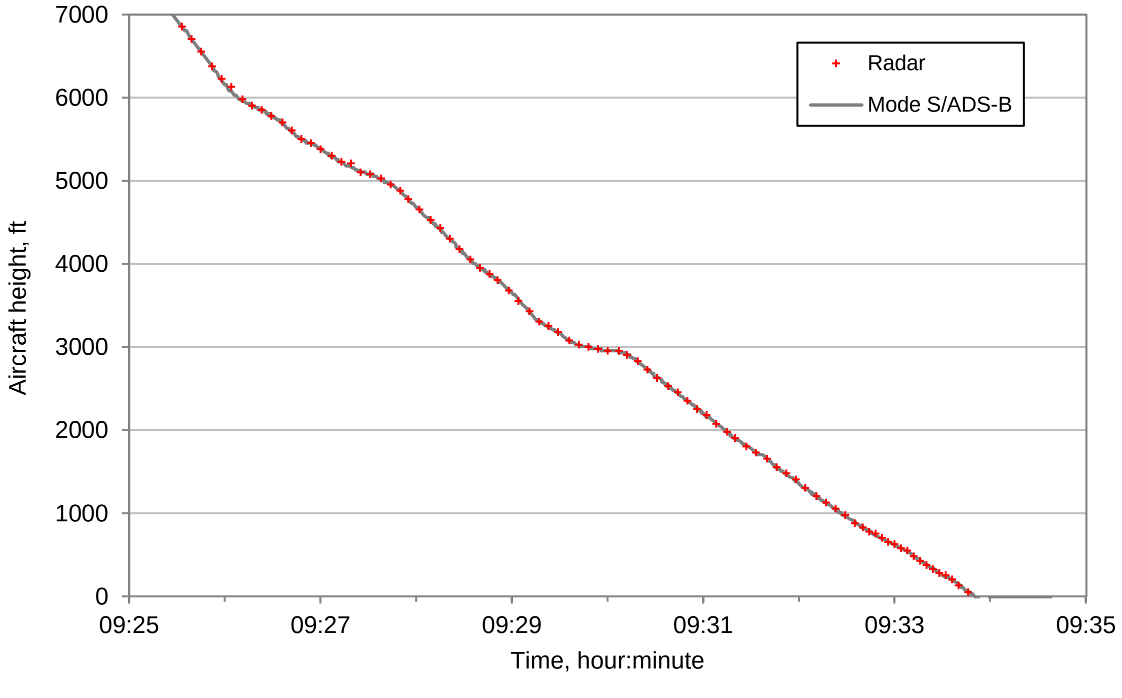


Figure A3 Gatwick 09:37 arrival

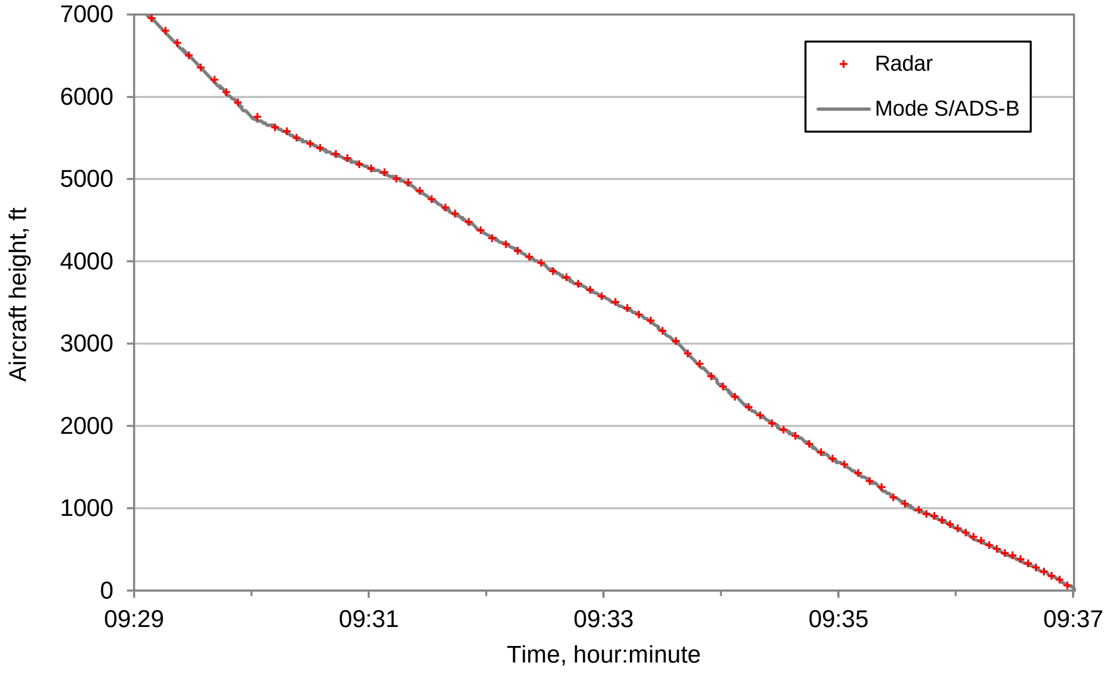


Figure A4 Gatwick 09:40 arrival

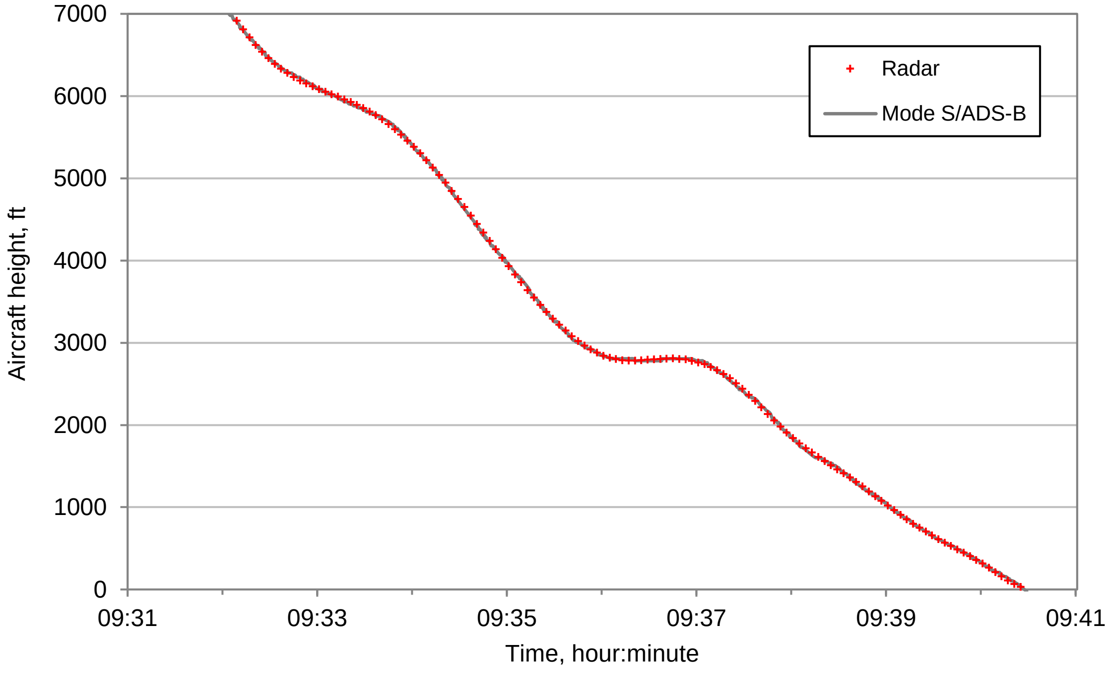


Figure A5 Gatwick 09:48 arrival

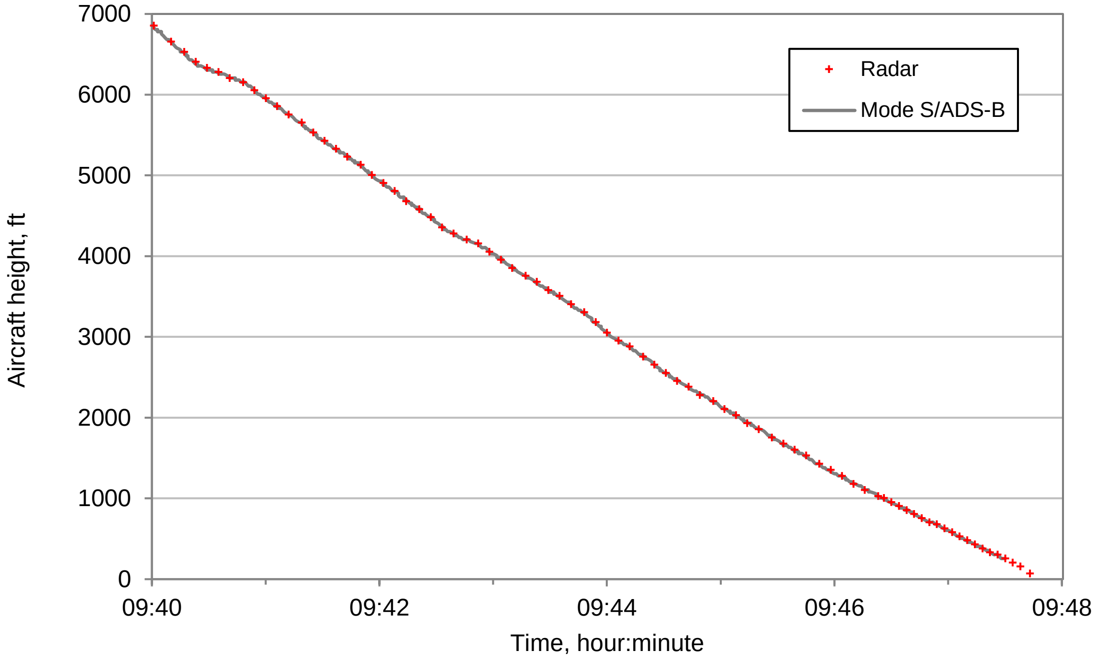


Figure A6 Gatwick 09:27 departure

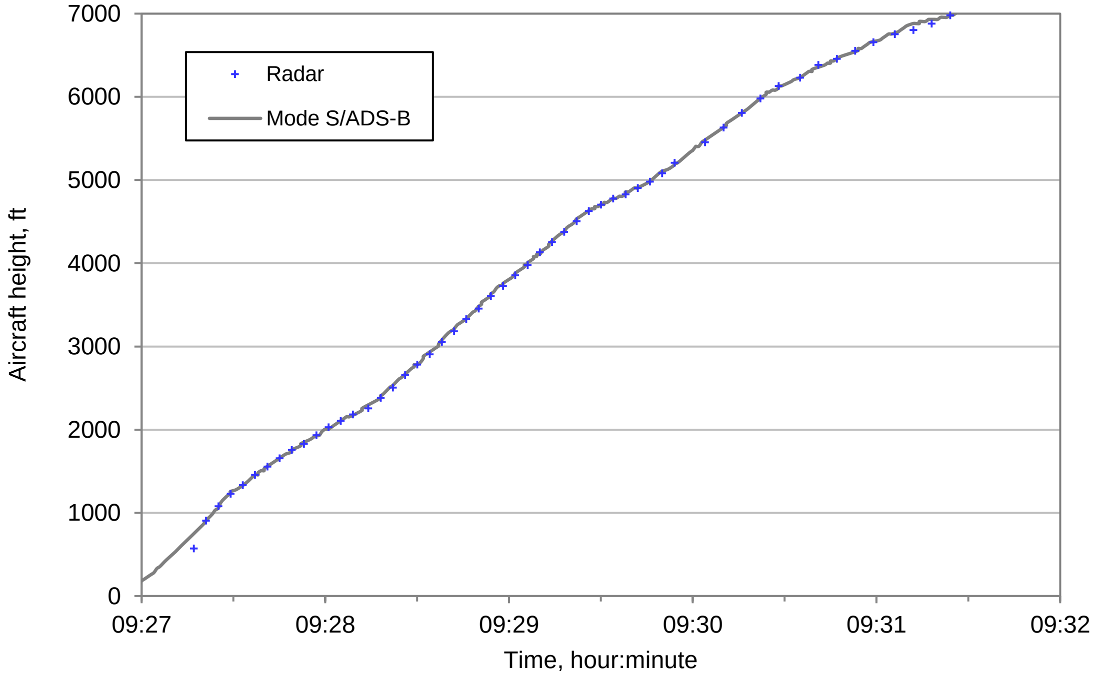


Figure A7 Gatwick 09:28 departure

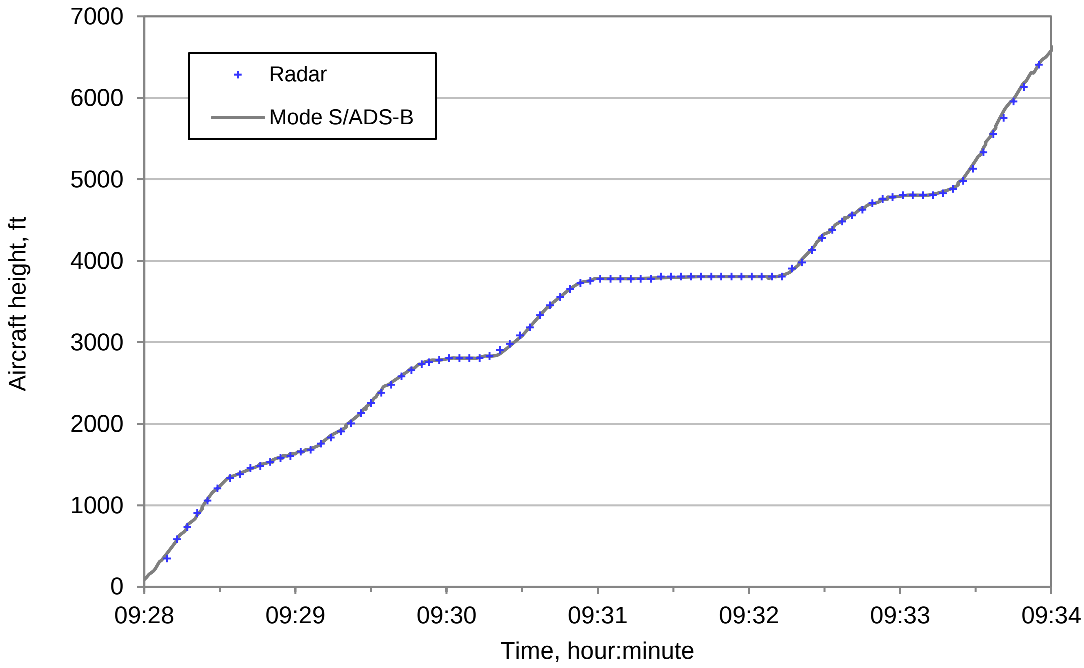


Figure A8 Gatwick 09:31 departure

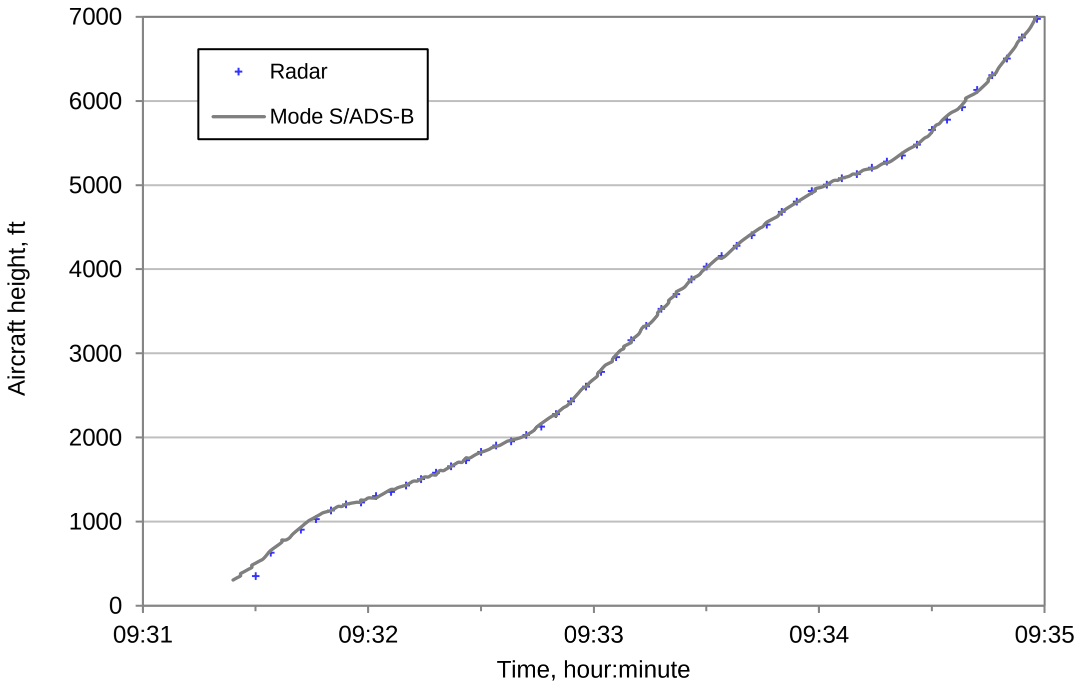


Figure A9 Gatwick 09:33 departure

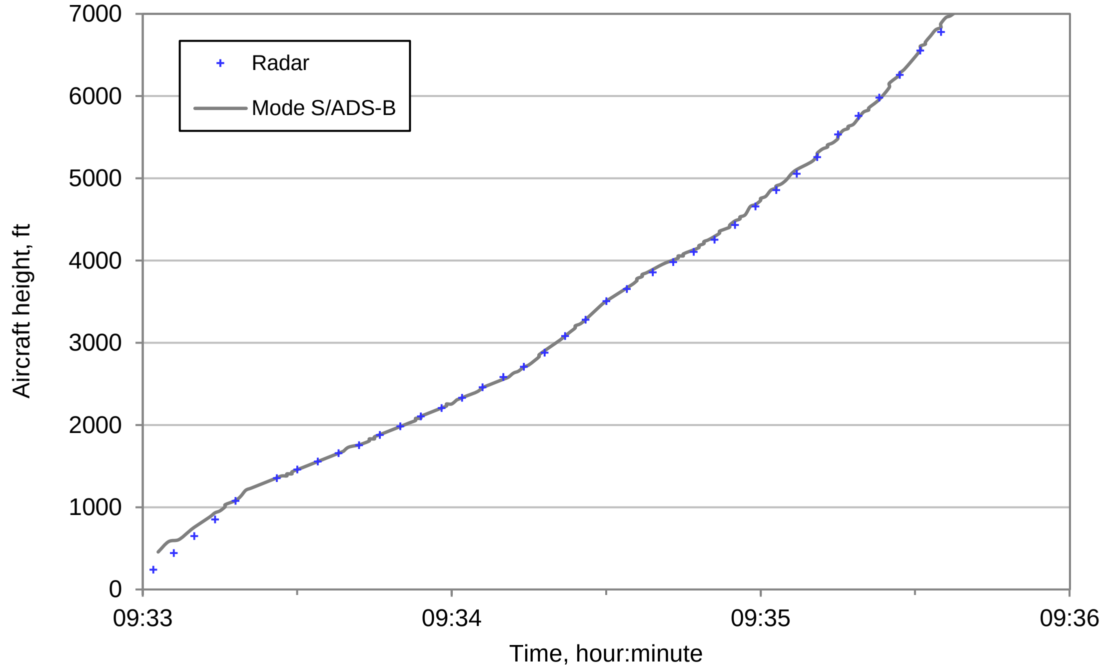
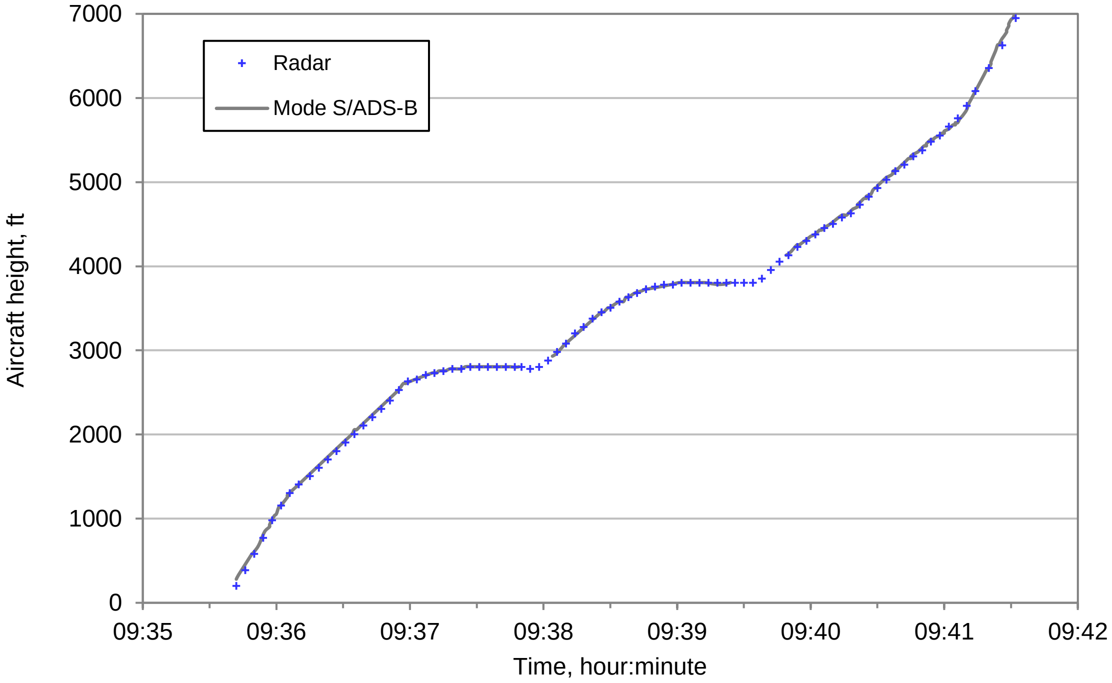


Figure A10 Gatwick 09:35 departure



Glossary

Glossary	
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.
Aircraft movement	An aircraft take-off or landing at an airport.
hPa	hectoPascal. The international unit for the measurement of atmospheric pressure. The unit is equal to the millibar (mb).
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.
NM	Nautical mile. A length equal to 1,852 m.
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 air traffic controllers' radar displays.