Environmental Research and Consultancy Department

Accuracy of data in the Gatwick Noise and Track Keeping System

CAP 1246

Published by the Civil Aviation Authority, 2014
CAA House, 45-59 Kingsway, London WC2B 6TE

The work reported herein was carried out under a Letter of Agreement placed on 6 June 2014 by the Department for Transport. Any views expressed are not necessarily those of the Secretary of State for Transport.

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Summary

This report describes a study that was undertaken to assess the accuracy of the flight path information provided by Casper Noise – the new Noise and Track Keeping (NTK) system installed at Gatwick airport in April 2013. Checks have been undertaken to ensure that the system continues to provide reliable data for the types of studies carried out by the Environmental Research and Consultancy Department (ERCD) of the CAA.

Aircraft positional data recorded using Mode S/ADS-B receiving equipment were used for independent comparison against Casper outputs, which are based on Secondary Surveillance Radar. 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 Casper NTK operations database with corresponding records from air traffic control runway logs has shown a very close agreement between the two data sources. The results also indicate a high correlation of noise events to radar tracks within the system.

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 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' systems via a link to the NTK remote servers.

In 2009, ERCD published the results of a study to assess the general accuracy of the flight path information contained in the ANOMS NTK system at each airport (Ref 1). For the sample of flights analysed, the results indicated that the accuracy of ANOMS NTK data was, on average, no worse than ±55 ft in aircraft height and no worse than 30 m in position across all three airports, which were within the expected tolerances of the radar data.

In April 2013 Gatwick Airport Limited replaced its ANOMS system with a new system called Casper Noise. Although Casper Noise continues to use 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 at Gatwick continues to provide reliable flight track data. Although the existing noise monitor hardware has not been replaced, an assessment of noise-to-track correlation in the new system has also been carried out.

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

Chapter 2

Flight track data

Methodology

The source of positional data in the Gatwick NTK system is Secondary Surveillance Radar. The area of radar coverage in the system is currently a circular area approximately 30 NM in radius (56 km), centred on the airfield, with heights covered up to approximately 20,000 ft above airfield level. As part of the NTK system replacement at Gatwick, the existing Mode C radar feed, which had a resolution of 100 ft, was upgraded to provide 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, whereas Mode S/ADS-B position and ground speed messages are broadcast twice every second on average. In addition, since GPS can generally provide position data accurate to within a few metres (Ref 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 Casper.

Mode S/ADS-B data for flights at Gatwick were logged by ERCD on 20 May 2014 using a receiver located close to the airfield. Figure 1 compares the NTK ground tracks with the recorded Mode S/ADS-B data for a sample of five arrivals. Figure 2 presents equivalent ground track data for a sample of five departures. Figures 3 to 12 illustrate the corresponding height profiles plotted against time. In each figure, the radar points are the raw values exported from the NTK system[1].

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.

[1] Flight tracks in the system are represented by 'best-fit' lines drawn through the individual raw radar points.

Position data

The ground track comparisons shown in Figures 1 and 2 show a close agreement between the NTK position data and the Mode S/ADS-B data. The measured positional differences have been quantified in further detail below. When considering these results it should be recognised that the Mode S/ADS-B position data against which NTK is compared are also subject to some uncertainty.

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

Table 1 Measured positional differences

Coverage radius	Mean difference, m	Std. Dev.
30 NM (56 km)	51	58
15 NM (28 km)	29	33

Whilst the results cover radar points up to the extent of the radar coverage area (a range of 30 NM in any direction), most of ERCD's analyses of flight track data tends to be limited to a smaller coverage area. Results are therefore provided separately for radar points within a range of 15 NM, which covers the extent of the departure Noise Preferential Routes and also the point at which most aircraft commence their final approach to land.

The results indicate that the average difference in ground track position, in any direction between the two data sources, is approximately 50 m, which is sufficiently accurate for the types of studies undertaken by ERCD. If the analysis is limited to radar points within a range of 15 NM from the airport, then the average difference in position is reduced to approximately 30 m. This is as expected since the radar azimuth (bearing) error increases with range.

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 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 position data are based on the range and azimuth 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 Casper are processed through a different coordinate system it is nevertheless reasonable to confirm that the system does not include a bias in one particular coordinate direction. The average X and Y differences of the individual radar data points (NTK *minus* Mode S/ADS-B) have therefore been calculated and are summarised in Table 2.

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

Coverage radius	Mean difference, m	
	X direction	Y direction
30 NM (56 km)	+8	+17
15 NM (28 km)	+9	+6

The average measured difference in each Cartesian axis direction between the two data sets is within ±20 m across the entire radar coverage area, thus confirming that there is no significant systematic bias in the NTK positional data. Slightly larger differences between the radar and Mode S/ADS-B positional data were however observed in the region to the south-west of the airport (see Figure 2), although the differences in the sample of flights analysed were not large enough to cause concern.

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). Because the radar height data in the Casper 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[2] at the time, and also correcting for the aerodrome’s elevation above mean sea level.

The height profile comparisons presented in Figures 3 to 12 indicate the agreement between the two sources of data is consistently good. The average measured height difference across all ten flights is +5 ft, with a standard deviation of 27 ft, see Table 3.

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[2] 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.

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

Mean difference, ft	Std. Dev.	5th / 95th percentile
+5	27	-42 / +36

To provide further indication of the range of measured height differences between the two data sources, the 5th and 95th percentile[3] values (of the differences) have also been calculated and are within ±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.

[3] The 95th percentile is the point below which 95 percent of all the measured differences fall, and the 5th percentile is the point below which 5 percent of the measured differences fall.

Chapter 3

Flight operations and noise data

Aircraft movements

An arrival or departure operation in the Casper NTK system is comprised of a radar track combined with an associated flight plan record. The flight plan record provides additional information 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 flights will be unaccounted for. However, if the plan data is missing for a particular flight then the operation will still be counted provided the radar track is present.

As a check of the overall completeness of the Casper operations database, the numbers of arrivals and departures reported by the system during June 2014 have been compared to the corresponding records from air traffic control runway logs provided by NATS, see Table 4.

In the majority of cases the agreement between the two data sources is very close, e.g. within ±1 operation. Whilst the possibility that the runway logs might themselves contain small errors or omissions cannot be ruled out entirely, the results indicate that in the worst instance, Casper is missing four departures on 22 June, accounting for just less than one percent of all departures that day.

A more detailed comparison of the two data sources for 22 June indicates that the missing flights occurred as a result of temporary interruptions to the radar feed[4]. Relatively small amounts of data loss such as this from time to time would not significantly affect the outcome of ERCD's noise modelling work.

[4] This was verified by the Casper system status log for that day, which reported that four flight plan records could not be matched to radar tracks.

Many of the smaller differences may also be explained by one of the following:

- A departure that returns to the airport shortly after take-off for technical reasons is counted as both a departure and an arrival in the runway logs but is counted separately as a 'Terrain' flight in Casper. For example, Terrain flights were recorded in Casper on 23, 24, 26 and 30 June. The runway logs on the other hand recorded each of these flights as one departure and one arrival on those days.
- For movements occurring very close to midnight, NTK operations can be included in the following day or in the previous day compared to the runway logs. For example, an arrival was recorded in Casper landing on 25 June just before midnight, whereas the runway logs recorded the arrival on the next day, just after midnight on 26 June.

Table 4 Daily counts of Casper NTK operations, June 2014

Date	NTK data		Runway log data		Difference between NTK and runway logs	
	Arr.	Dep.	Arr.	Dep.	Arr.	Dep.
01 Jun-14	421	415	421	416	0	-1
02 Jun-14	418	405	418	406	0	-1
03 Jun-14	389	384	389	386	0	-2
04 Jun-14	392	389	392	390	0	-1
05 Jun-14	394	398	394	398	0	0
06 Jun-14	411	417	411	417	0	0
07 Jun-14	367	378	367	380	0	-2
08 Jun-14	427	409	428	410	-1	-1
09 Jun-14	413	411	413	412	0	-1
10 Jun-14	384	386	385	386	-1	0
11 Jun-14	391	386	391	387	0	-1
12 Jun-14	398	401	398	402	0	-1
13 Jun-14	409	417	409	417	0	0
14 Jun-14	372	378	371	378	+1	0
15 Jun-14	414	413	415	414	-1	-1
16 Jun-14	423	405	423	405	0	0
17 Jun-14	389	396	388	395	+1	+1
18 Jun-14	399	393	400	393	-1	0
19 Jun-14	393	398	393	400	0	-2
20 Jun-14	418	416	417	418	+1	-2
21 Jun-14	368	379	368	380	0	-1
22 Jun-14	421	410	421	414	0	-4
23 Jun-14	420	409	420	410	0	-1
24 Jun-14	343	356	344	358	-1	-2
25 Jun-14	371	378	370	378	+1	0
26 Jun-14	410	402	412	403	-2	-1
27 Jun-14	416	417	416	418	0	-1
28 Jun-14	379	381	379	381	0	0
29 Jun-14	424	418	424	418	0	0
30 Jun-14	428	416	428	417	0	-1

Aircraft registrations

Although runway logs are generally considered to be a definitive record of aircraft movements, they are not currently used by ERCD to generate summaries of traffic fleets for noise modelling purposes because aircraft registrations, which are used to determine the exact aircraft variants, are not always provided for every movement (typically around one or two percent of registrations are missing). Nonetheless, individual registrations in the Casper NTK system would still be expected to match the corresponding records in the runway logs where available.

A detailed comparison of both data sets revealed that less than 0.5 percent of registrations did not match during June 2014. In every instance however, the aircraft type for each unmatched registration was identical, which would mean that its contribution to the noise environment would be correctly accounted for in any analysis undertaken by ERCD. Although further investigation of the cause of the differences was not undertaken, they are likely to be due to last minute changes of aircraft (for technical or operational reasons) not being reflected in one of the data sources.

Correlation of noise events

As mentioned in Chapter 1, the NTK system matches air traffic control radar data to related noise measurements from noise monitors at prescribed ground positions. The Gatwick system currently comprises five fixed (permanent) noise monitor sites located at approximately 6.5 km from start-of-roll, as well as a number of mobile (temporary) noise monitors that can be deployed anywhere inside the NTK radar coverage area.
Figure 13 reproduced from CAP 1149 (Ref 3) shows the locations of the monitor positions used at Gatwick in recent years (the numerical identifier for each noise monitor is also shown).

Noise events at each monitor are detected automatically by means of a user-specified threshold level and minimum event duration. An event occurs when the measured noise level exceeds the threshold level for longer than the minimum duration. For each measured noise event, the NTK system software then determines whether an aircraft passed within a defined zone around the noise monitor close to the time of L_{max} (the maximum sound level measured during the event). If an aircraft is found then the software correlates the noise event with that particular flight, otherwise the event is classed as community noise (non-aircraft).

If the threshold level is set too low, then the system can become overloaded with non-aircraft events which could make the identification of genuine aircraft events more difficult (e.g. if the aircraft event and non-aircraft event occur within a few seconds of each other). On the other hand, if the threshold is set too high then genuine quieter aircraft events could be missed. It should also be accepted that there will always be some quiet aircraft types that cannot be measured reliably because of the level of the background sound.

Table 5 summarises the percentage of arrival and departures in each runway direction ('08' easterly or '26' westerly) that registered a noise event at the fixed sites during

June 2014. The results indicate a high correlation of noise events to flight tracks at each site, with only a very small percentage of flights having no associated noise data. Relatively small amounts of data loss in a continuous and unattended noise monitoring system such as the one at Gatwick airport are to be expected and, in practice, would not affect the measurement and modelling of long term aircraft noise exposure.

Table 5 Percentage of operations with noise events at fixed monitors, June 2014

Fixed noise monitor[5]	Percentage of operations with noise events (by runway direction)	
	Arrival	Departure
1 - Russ Hill	99.8 (08)	99.3 (26)
3 - Orltons	99.9 (08)	99.2 (26)
5 - Oaklands Park Farm	99.5 (08)	97.5 (26)
6 - Bellwood	99.7 (26)	98.6 (08)

As mentioned in Chapter 1, the existing noise monitor hardware was not replaced when Casper Noise was installed in April 2013. Since that time, Gatwick airport has continued to adopt a good working practice for the acoustical calibration of its noise instrumentation. On-site acoustical calibration checks of each noise monitor are carried out on a quarterly basis. All noise measuring equipment is also removed from service and periodically verified by an approved calibration agency. This calibration is traceable to UK National Standards.

[5] Gatwick fixed monitor 4 (Moat House) was not operational during the study period.

Chapter 4
Conclusions

A technical assessment comparing height and position data from the Casper NTK system against an independent source has been carried out for a sample of 10 flights at Gatwick within a range of 30 NM from the airport. The average difference in ground track position, in any direction between the two data sources, is approximately 50 m, reducing to approximately 30 m when limited to radar points within a range of 15 NM from the airport. 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 Casper 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 operation per day, which is not significant enough to affect the outcome of ERCD’s noise modelling work.

The results also indicate a high correlation of noise events to radar tracks within the system. A small percentage of flights were found to have no associated noise data at the fixed monitor sites which, in practice, is to be expected and would not affect the measurement and modelling of long term aircraft noise exposure.

APPENDIX A

References

1. ERCD Report 0906, Accuracy of Data in the Noise and Track Keeping System at the London Airports, Civil Aviation Authority, September 2009.
2. Global Positioning System Standard Positioning Service Performance Standard, Assistant for GPS, Positioning and Navigation, 6000 Defense Pentagon, Washington DC, 4th Edition, September 2008.
3. CAP 1149, Noise monitor positions at Heathrow, Gatwick and Stansted Airports, Civil Aviation Authority, March 2014.

APPENDIX B

Figures

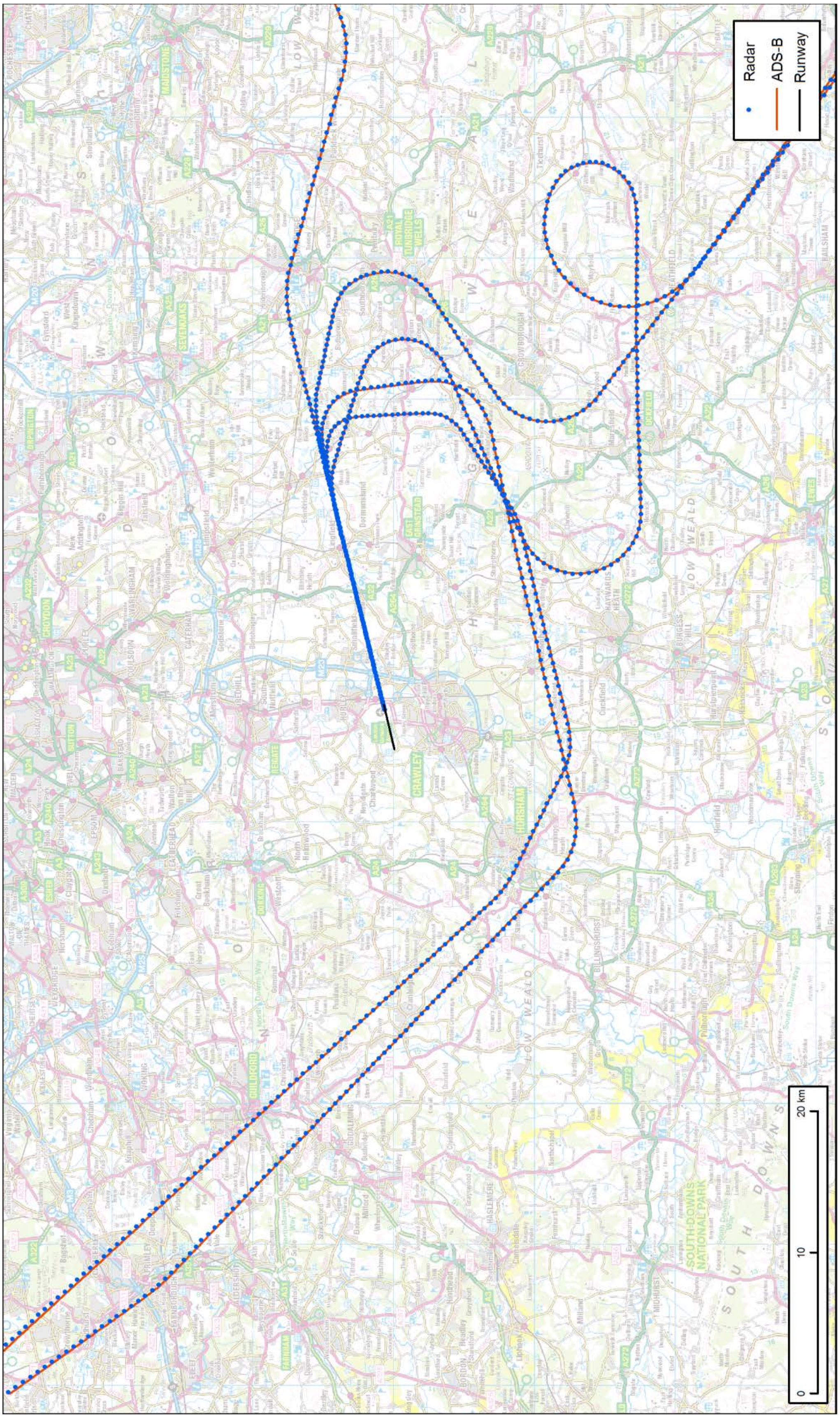


Figure 1 Gatwick arrival tracks

Figure 2 Gatwick departure tracks

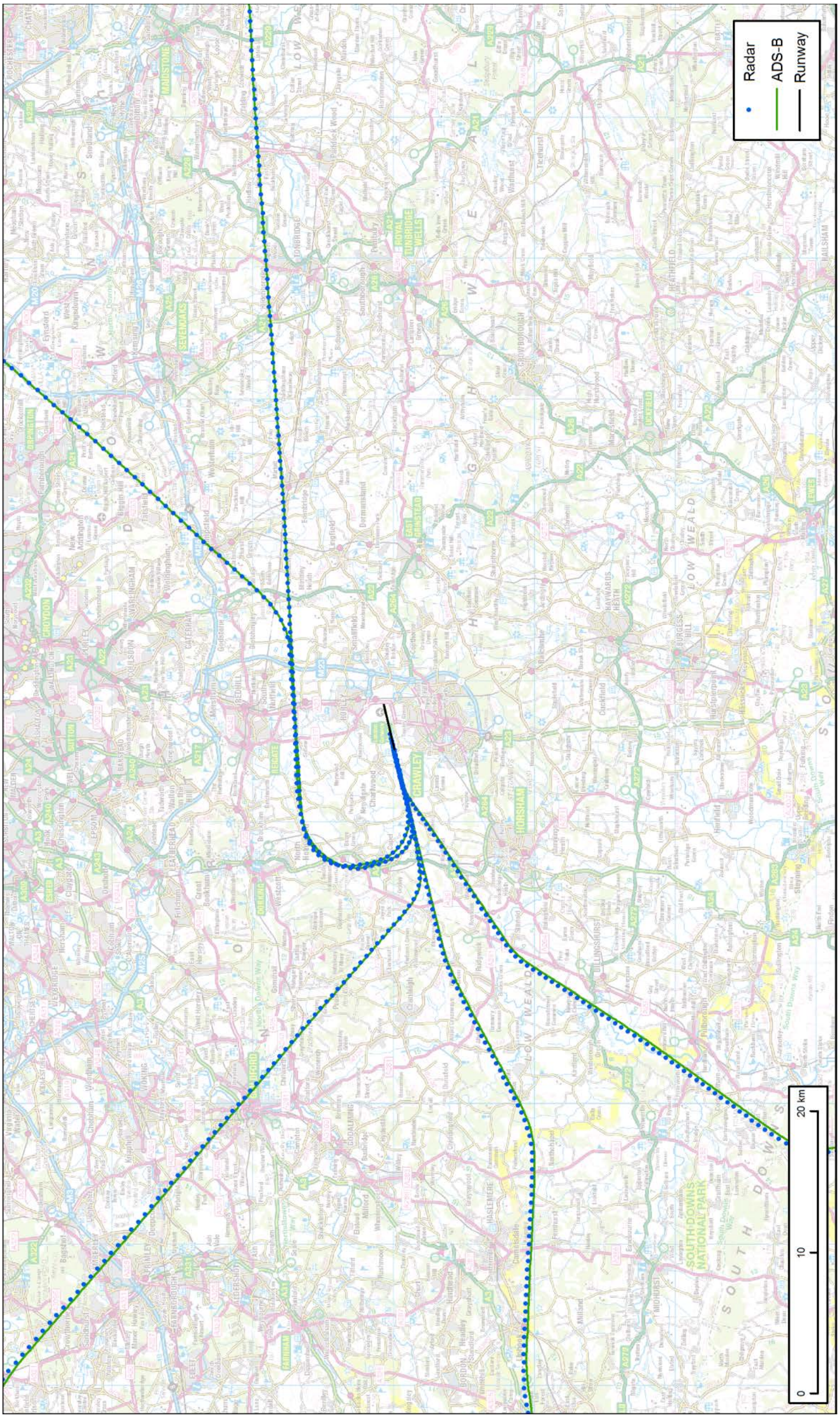


Figure 3 Gatwick 14:28 arrival

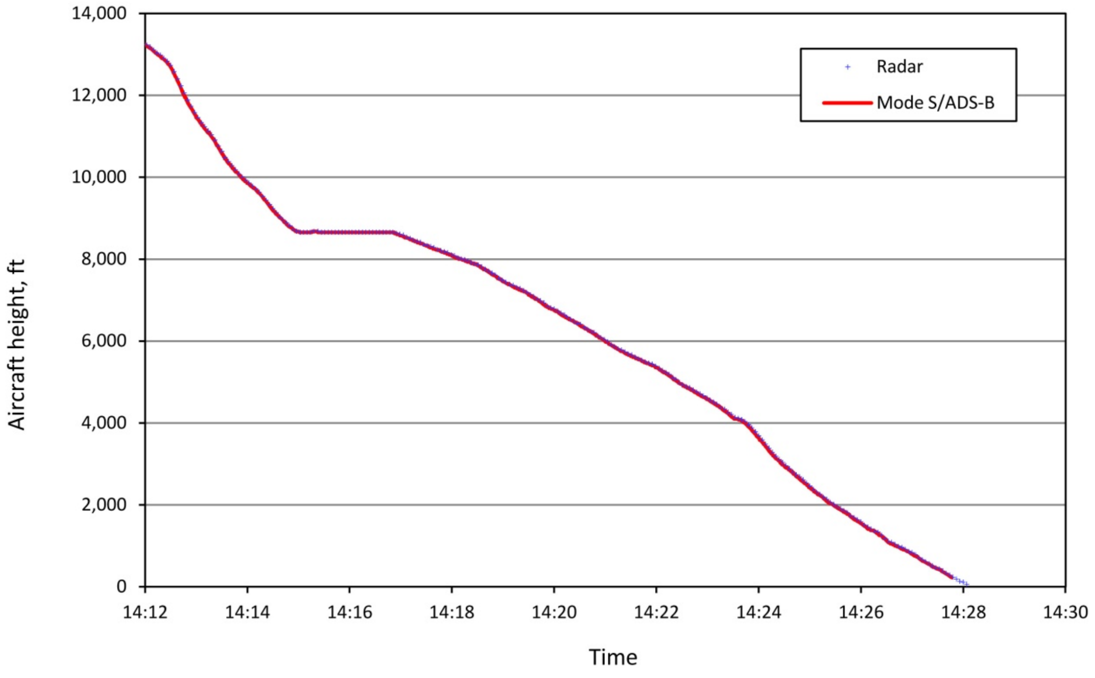


Figure 4 Gatwick 14:49 arrival

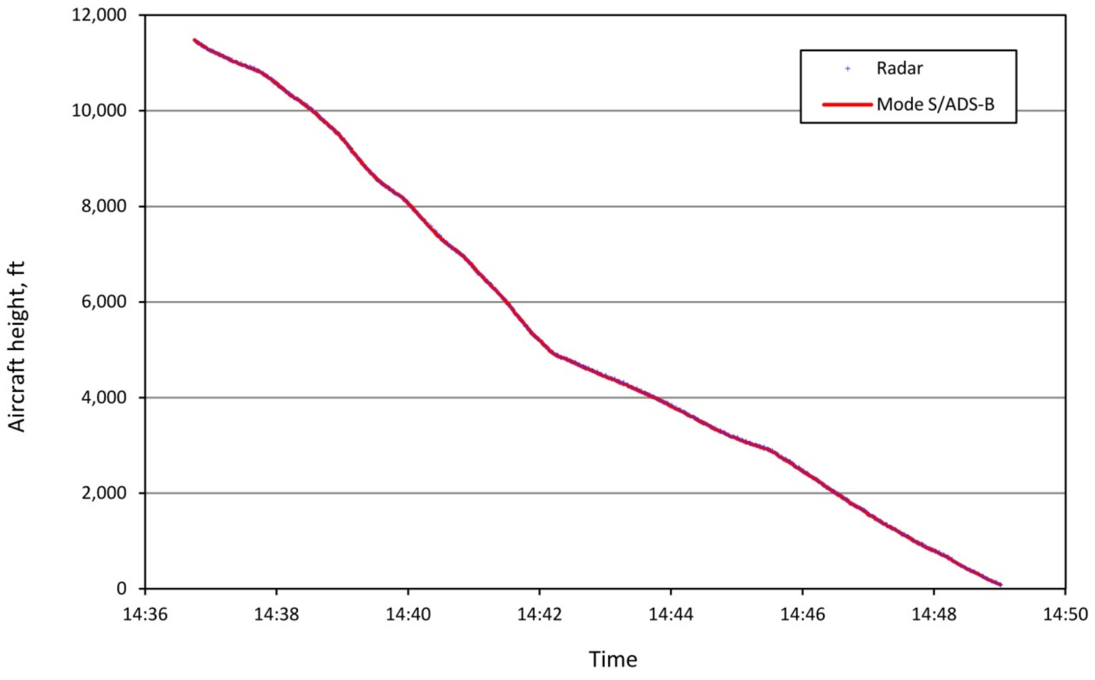


Figure 5 Gatwick 15:26 arrival

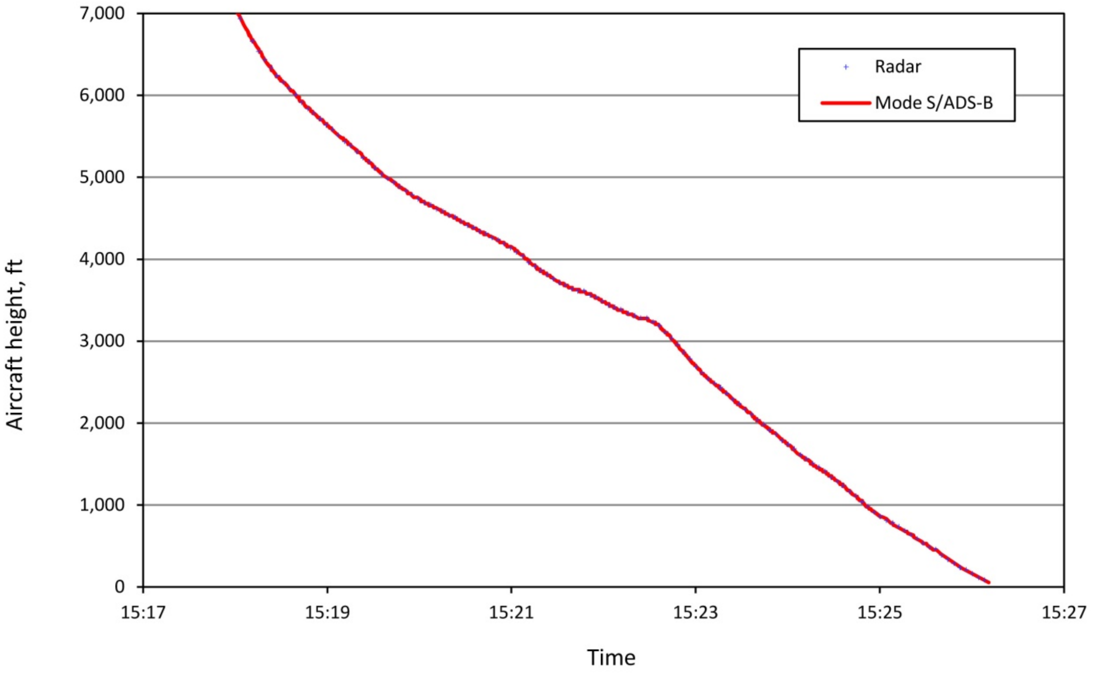


Figure 6 Gatwick 15:29 arrival

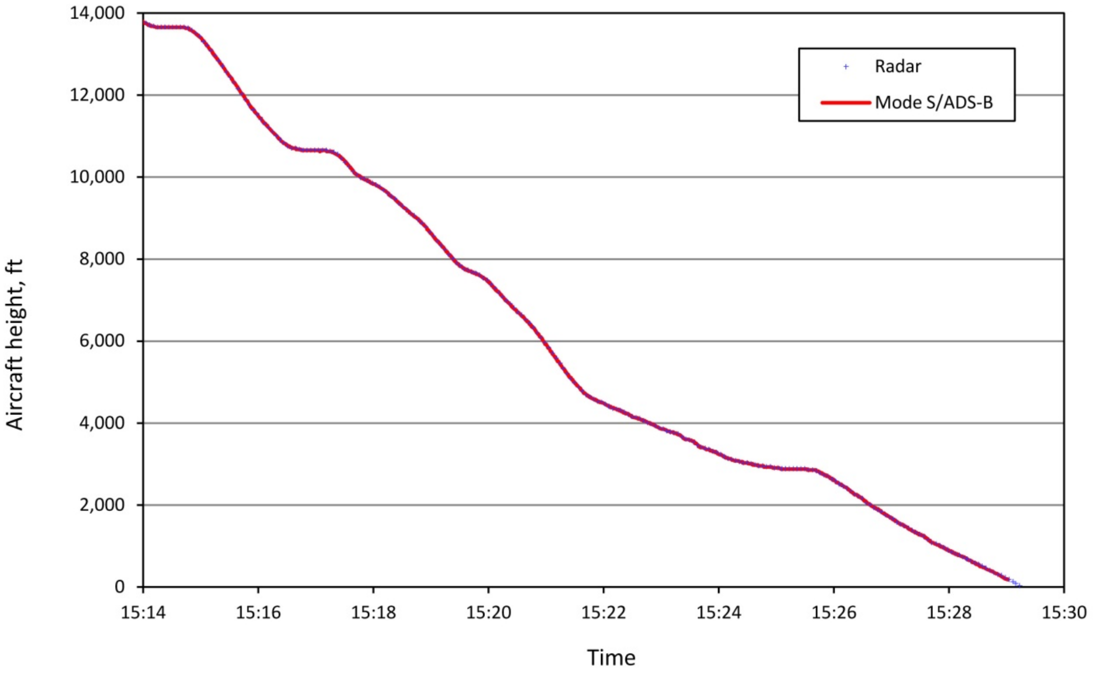


Figure 7 Gatwick 15:32 arrival

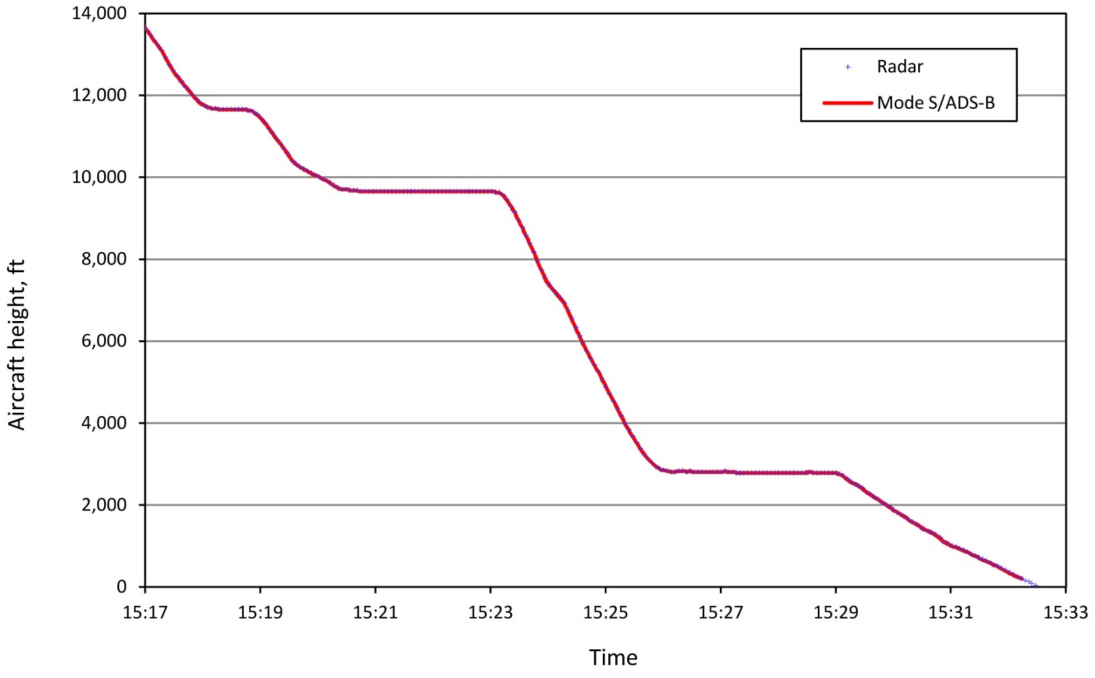


Figure 8 Gatwick 14:11 departure

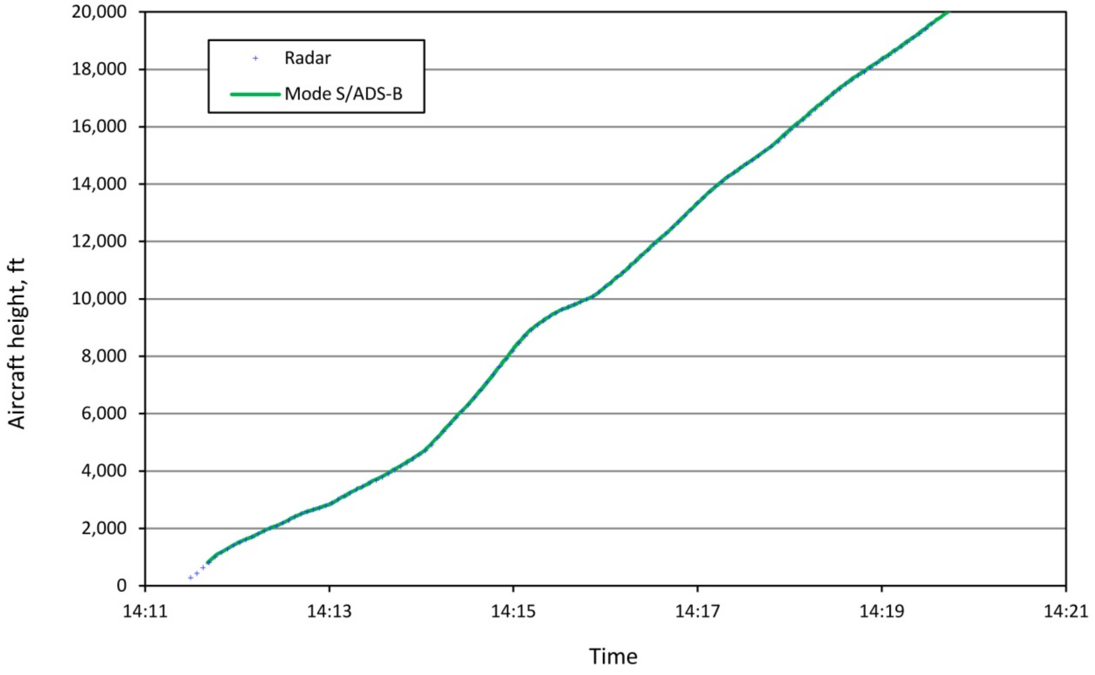


Figure 9 Gatwick 14:13 departure

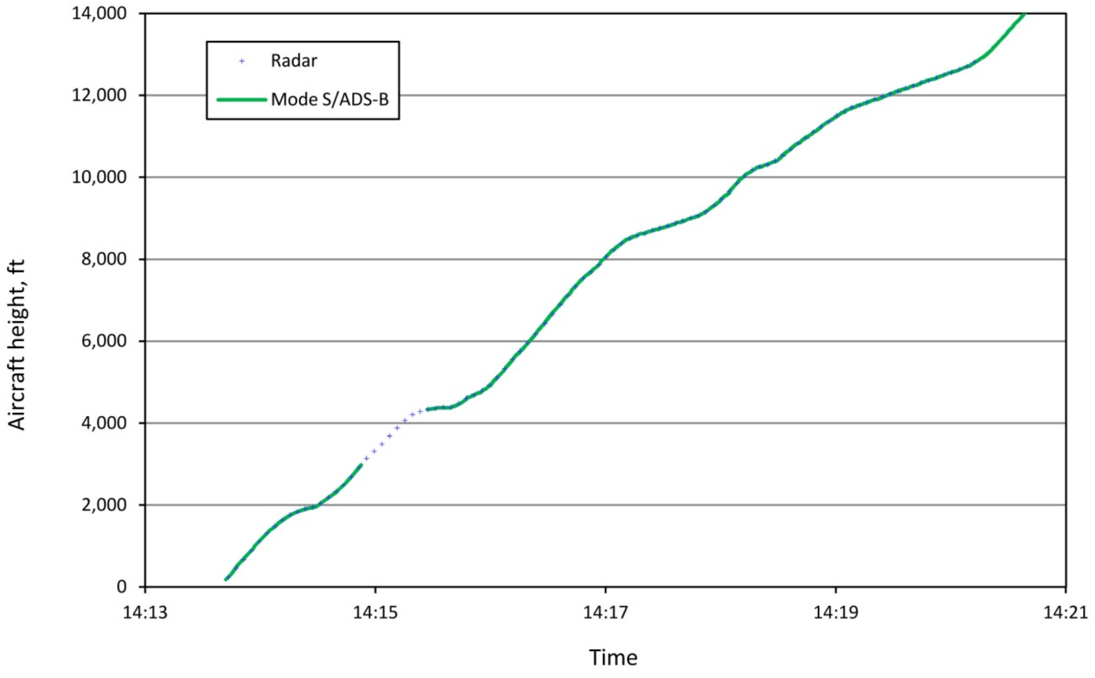


Figure 10 Gatwick 14:25 departure

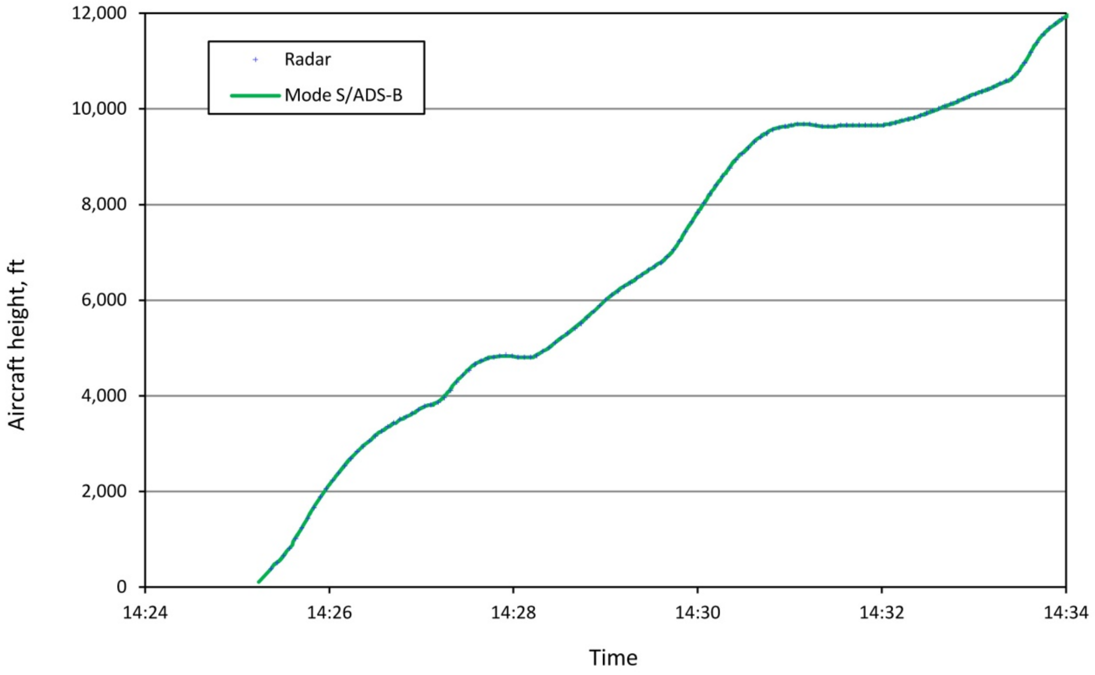


Figure 11 Gatwick 15:25 departure

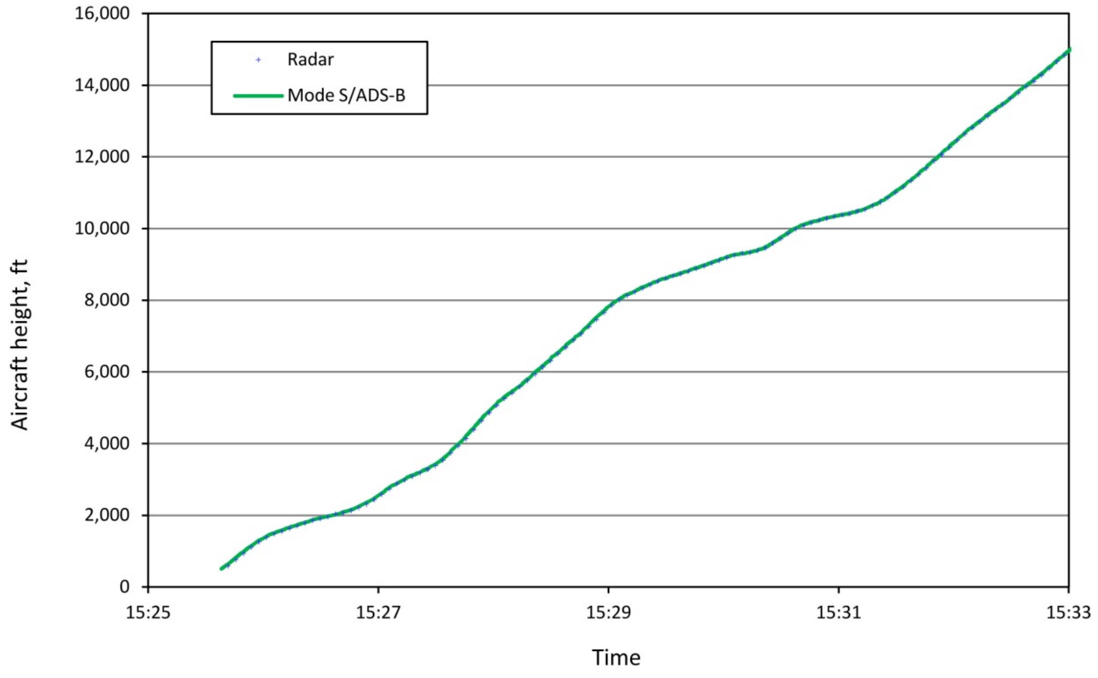


Figure 12 Gatwick 15:43 departure

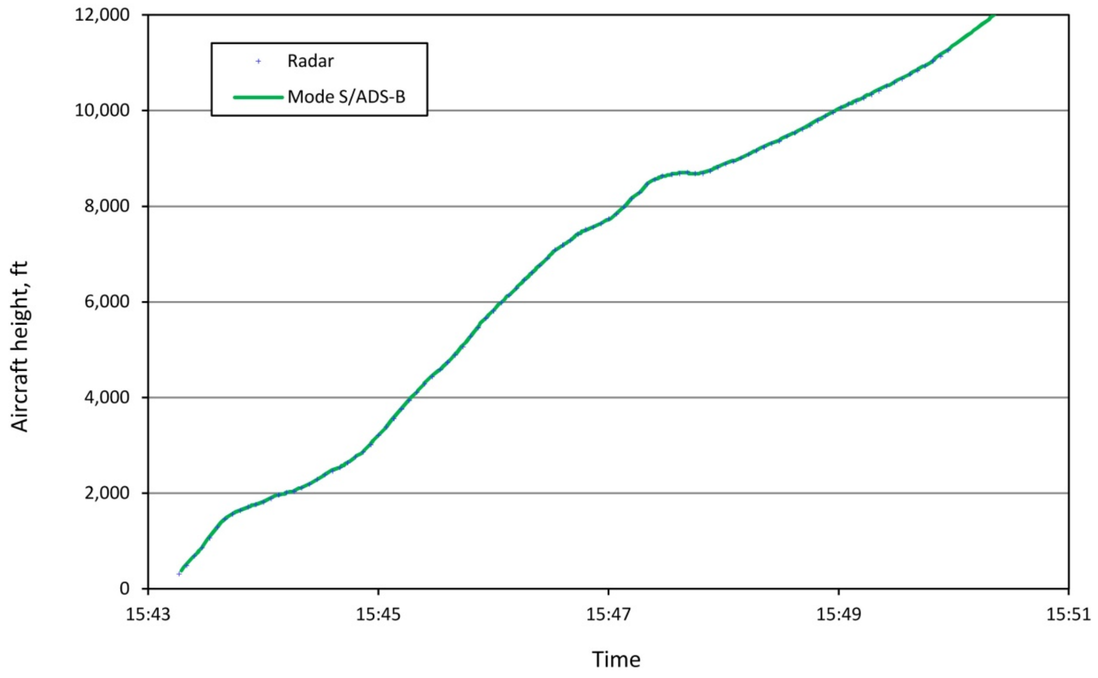
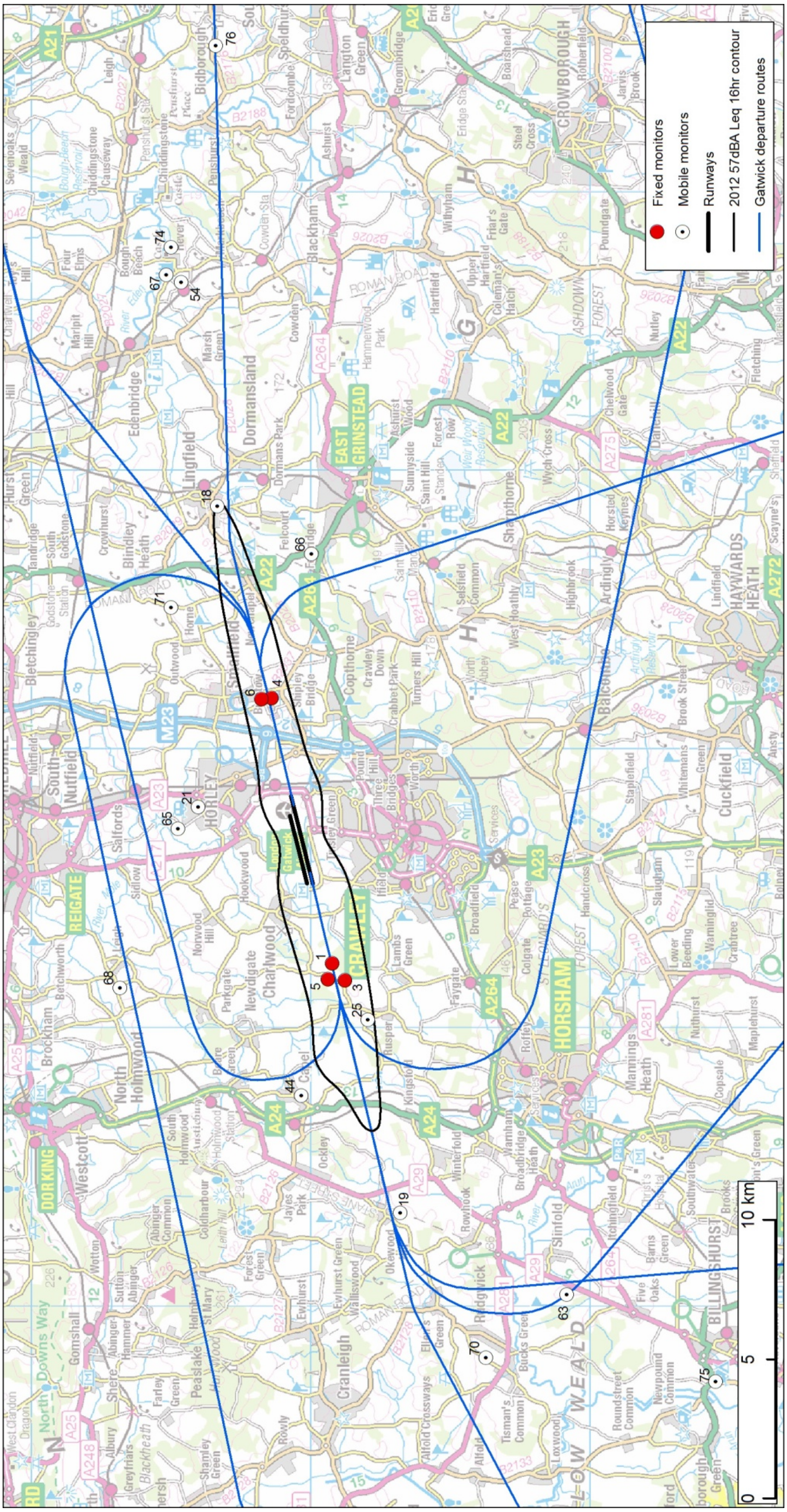


Figure13 Noise monitor positions at Gatwick



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.
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.
NATS	Previously known as National Air Traffic Services Ltd. NATS provides air traffic control services at several UK airports.
NM	Nautical mile. A length equal to 1,852 metres.
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.