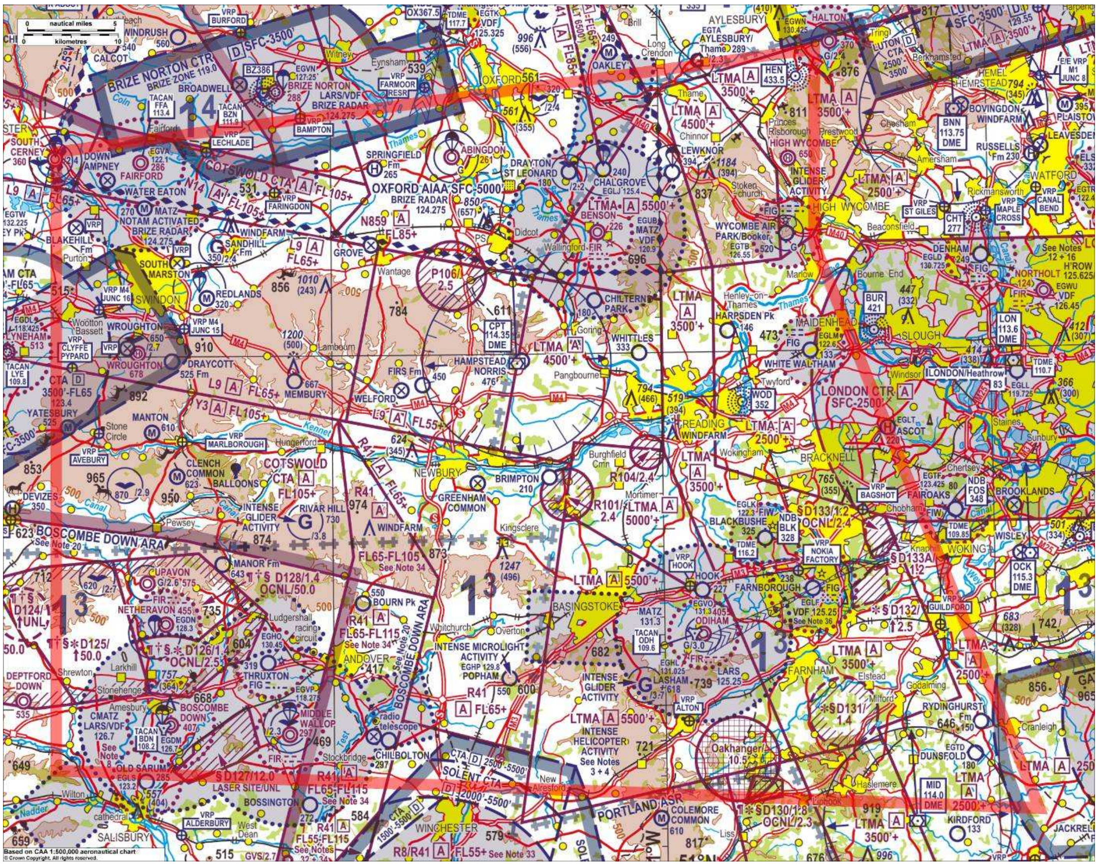
Class G Airspace Modelling (Feasibility Study)

Final Report

Executive Summary

This report provides a summary of the results obtained, and conclusions found by QinetiQ for the Class G Airspace Modelling (feasibility study) project. This study was limited to an area to the West of London (indicated by the red band in the extract from the CAA aeronautical chart below).



This feasibility study has shown that the activity that takes place within Class G airspace is sufficiently well understood and predictable in its nature, such that the level of activity at any time can be calculated (using computer modelling techniques) with a fair degree of accuracy. More significantly, modelling can quantify the expected level of use, and identify activity hot spots. Knowledge of such areas can serve to encourage extra vigilance on the part of pilots with regard to the application of ‘see and avoid’.

Validation has shown that the modelling techniques developed for this study are adaptable and expandable for modelling of much larger areas of airspace.

It is recognised that the accuracy of the results obtained could be improved with more accurate input data, particularly regarding movement and activity associated with the many small civil airfields and launch sites.

Abbreviations

AOPA	Aircraft Owners and Pilots Association
ASI	Airspace and Safety Initiative
ATZ	Aerodrome Traffic Zone
BGA	British Gliding Association
BHPA	British Hang Gliding and Paragliding Association
BMAA	British Microlight Aircraft Association
CAA	Civil Aviation Authority
GAT	General Air Traffic
GPS	Global Positioning System
LAA	Light Aircraft Association
MOD	Ministry of Defence
OF	Occupancy Factor
QFE	Height above aerodrome
QNH	Height (altitude) above mean sea level
OSGB	Ordnance Survey of Great Britain
SEP	Single Engine Piston
SLMG	Self Launched Motor Glider
TMA	Terminal Control Area
TMG	Touring Motor Glider
TRA	Temporary Restricted Airspace
UTC	Coordinated Universal Time
VGS	Volunteer Gliding Squadron

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1 Introduction

1.1 Purpose

The purpose of this report is to describe the results obtained and conclusions found by QinetiQ for the Class G Airspace Modelling (feasibility study) project.

The provision of data from users of Class G airspace formed a key input to the study. Moreover, it is recognised that the information supplied to the project provides a valuable insight into the behavioural patterns of airspace users. As this information is likely to be of interest to a wide audience including airspace users and safety regulators, detailed analysis of the data is provided in a separate (stand alone) report.

1.2 Project Overview

Part of the remit of the Airspace and Safety Initiative (ASI), chaired by the CAA, is to enhance the safety of airspace users operating outside controlled airspace. A particular problem in this respect is that, due to the lack of any general requirement to carry radios, transponders or file a flight plan, there are no accurate statistics detailing the number of flights that take place in Class G airspace. Furthermore, any changes to the size and shape of controlled airspace will result in an equal and opposite change to the size and shape of uncontrolled airspace. To properly assess such changes, the level of traffic in both controlled and uncontrolled (e.g. Class G) airspace needs to be understood.

The QinetiQ solution to this problem is to develop computer modelling techniques to indicate the expected level of activity by the various categories of airspace user across an area of interest. Furthermore, with knowledge about aircraft basing, patterns of use and the impact certain weather conditions have on each type of flying activity, it is possible to determine the combined level of activity at any given location.

There are four key stages to the project:

1. Data gathering
2. Model development
3. Run scenarios through model to produce results
4. Validation of results

The Mid Project Report published in July 2010 described the approach being used to obtain data from airspace users through a combination of surveys and questionnaires. It also described the output capability of the model, and proposed a method for validating results.

This report will focus on the results that have been produced and the validation exercises performed. It will make observations on the results, and provide conclusions as to the viability and accuracy of the approach used.

1.3 Area of Interest

From the outset, it was recognised that any attempt to model Class G airspace activity across the whole of the United Kingdom would be a major undertaking, and with significant potential for risk for both customer and supplier. In order to assess the value of airspace modelling with minimal cost and risk, it was agreed that a 6-month long ‘Pilot’ study should be performed.

The agreed area of interest for the ‘Pilot’ study is marked with a red band on the 1:500 000 aeronautical chart excerpt (Figure 1-1). This area was chosen as it is a busy area for general aviation, and includes a wide variety of airspace users. As well as being heavily used, the Class G airspace in this area is inter-dispersed with controlled airspace (as well as Danger Areas, Prohibited and Restricted airspace) which have the potential to create choke points and hot spots.

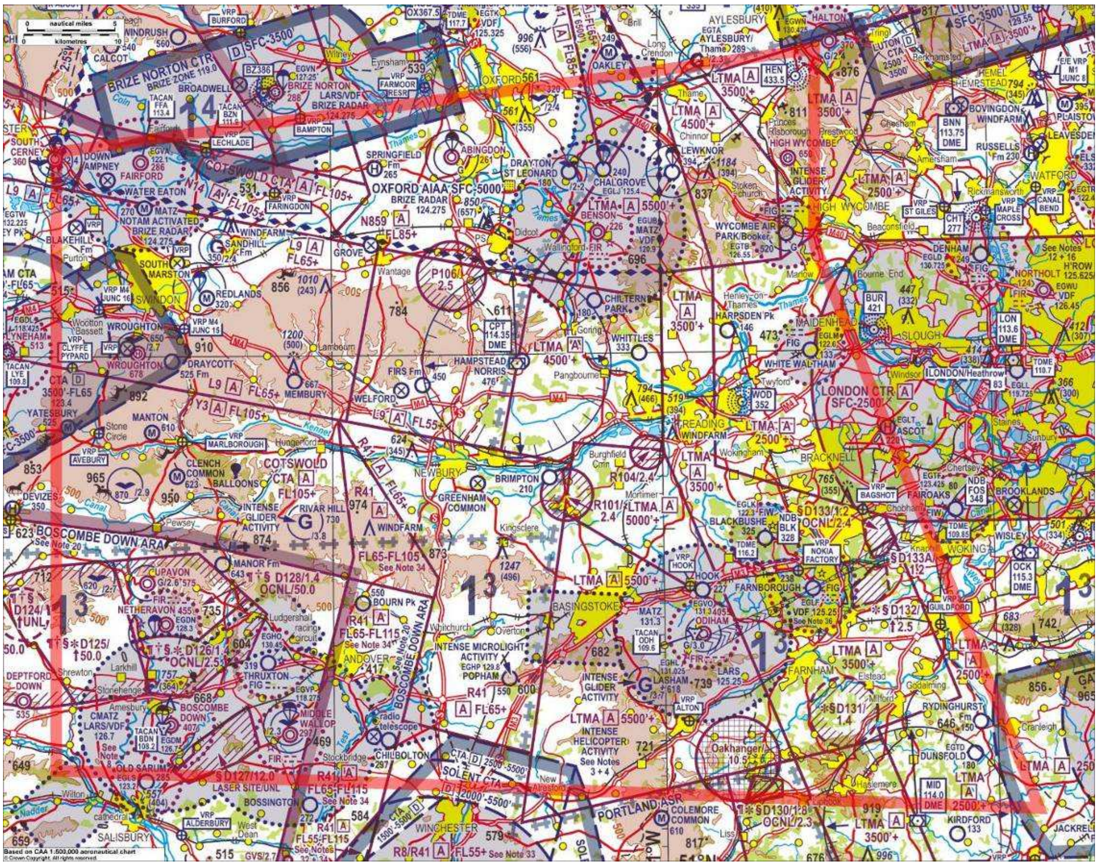


Figure 1-1: Area of Interest for ‘Pilot’ study

1.4 Types of Activity

The following generic types of aircraft are known to operate from fixed sites within the area of interest, and are taken into account by the model.

- Glider
- Glider Tug
- Gyrocopter (Rotorcraft)
- Hang Glider

- Helicopter (single engine)
- Helicopter (twin engine)
- Microlight (flex wing)
- Microlight (3-axis ‘Ultralight’ <450 kg)
- Military (elementary fixed wing trainer)
- Military (basic trainer)
- Military (fast jets – based at Boscombe Down)
- Military (helicopter)
- Military (multi-engine transport)
- Motor Paraglider (foot launched)
- Parachute Dropping Aircraft (civil or military)
- Paraglider
- Self Launched Motor Glider (SLMG) or Touring Motor Glider (TMG)
- Single Engine Light Aircraft (450 – 5,700 kg)
- Multi-engine Light Aircraft (light twin <5,700 kg)
- Multi-engine Heavy Aircraft (>5,700 kg)
- Vintage/Bi-plane

The following generic aircraft are not known to operate from fixed sites within the area of interest, and are not modelled in this pilot study.

- Airships
- Hot Air Balloons
- Military (fast jets – operational units)

1.5 Structure of this Report

The following sections in this report summarise progress made in the following areas:

Section 2 – Input Data

Section 3 – Results

Section 4 – Validation

Section 5 – Observations

Section 6 – Conclusions

Annexes

1.6 Acknowledgements

The modelling performed in this ‘Pilot’ study was only possible with the cooperation of the many organisations and individuals that supplied valuable input data. Whilst it is not possible to mention each and every person that contributed, QinetiQ would like to specifically acknowledge the contribution made by the following organisations:

- Abingdon (612 Sqn VGS)
- Aircraft Owners and Pilots Association (AOPA)
- Army Aviation Centre, Middle Wallop
- Black Mountains Gliding Club
- Bustard Flying Club
- British Gliding Association (BGA)
- British Hang Gliding & Paragliding Association (BHPA)
- British Microlight Aircraft Association (BMAA)
- Cabair Helicopters Ltd
- Cheshire Helicopters
- Chilbolton Flying Club
- Civil Aviation Authority
- DAATM
- Devon & Somerset Gliding Club
- Empire Test Pilots School, Boscombe Down
- Farnborough Airport (TAG Aviation)
- Flying TV Ltd
- GS Aviation (Clench Common)
- Kestrel Gliding Club
- Light Aircraft Association (LAA)
- London Gliding Club
- London Oxford Airport
- Oakley Flying Club
- NATS Ltd
- PDG Helicopters
- Pennine Helicopters Ltd
- RAF Benson
- RAF Boscombe Down
- RAF Brize Norton
- RAF Odiham
- RAF Lyneham
- Redlands Airfield
- Scottish Gliding Association
- Skydive London
- Southern Sailplanes
- Southampton University Air Squadron
- Starspeed Ltd
- Thruxton Airfield
- West London Aero Club
- Western Power Distribution

2 Input Data

2.1 Data Gathering

In order to conduct the modelling it was necessary to gather a wealth of input data.

The following sources of data were used:

- **On-line Survey:** Responses from 1600 pilots detailing how often, when and where they fly has enabled typical behavioural profiles to be created. (This information is summarised in a separate report.)
- **Civil Site Survey Responses:** Civil airfields within the area of interest were asked to provide details relating to air traffic movements, aircraft basing, types of activity and hours of operation.
- **Military Site Survey Responses:** Military airfields within the area of interest were asked to provide details relating to air traffic movements, aircraft basing, types of activity and hours of operation at each site.
- **Long Answer Questionnaires:** Certain ASI and NATMAC members provided detailed information about their respective aviation activities. This information provided greater (expert) insight as to when activities are likely to take place, particularly with respect to pilot privileges and weather limitations.
- **Air Britain 2010 Quick Reference Handbook:** Lists the aircraft based at civil airfields within the area of interest, and numbers of military aircraft by type.

2.2 Sites

The 65 sites identified within the area of interest and used in the modelling are listed at Annex A. Coordinates for each site, in OSGB X,Y format are also provided.

Due to the nature of balloon operations (i.e. occasional use from a large number of pre-selected unprepared sites) it has not been possible to include such sites in this ‘Pilot’ study. As a consequence, and due to the need for activity to be associated with a site, it has not been possible to model hot air balloon activity in this feasibility study.[1]

2.3 Aircraft Use Categories

Aircraft use categories are assigned to characterise the way in which aircraft are operated. For example, a privately owned single engine piston (SEP) aircraft will generally be used less intensively than one that is owned by a flight training organisation. Similarly, an aircraft that is owned by a syndicate is likely to be used more often than a privately owned aircraft.

[1] However, with the provision of suitable data, it would be possible to include such activity in any future version of the model.

The list of aircraft use categories used in this study is provided at Annex B. It should be noted that this is not a definitive list, and it is possible to add, amend or remove categories should the need arise.

2.4 Aircraft Basing

Aircraft based at each site are assigned an aircraft use category, based on specific information from site survey responses, or other published data (G-INFO, Air Britain etc).

Annex C lists the aircraft use categories for the aircraft known to be based at each of the 65 sites within the area of interest. This excludes visiting aircraft.

2.5 Weather Limitations

All aircraft are affected by weather to a greater or lesser extent. Details about the weather limitations that generally apply to different aviation activities were provided by experienced pilots through the ‘long answer’ survey questionnaires. This information has been coded into the model, to enable an appropriate level of activity for each category of use.

The following tables provide an example of how this information has been captured, and the values that are applied for a selection of aircraft use categories. (The percentage value represents the percentage of the total activity that *would* take place if there were no weather limitations).

Visibility

Category of Use	<3 km	3-5 km	5-10 km	>10 km
Private Glider (G1)	0%	10%	50%	100%
Private Helicopter (HS1)	0%	50%	80%	100%
Private SEP Aircraft (LS1)	0%	10%	50%	100%

Table 2-1: Visibility assumptions for a selection of categories

Wind Speed

Category of Use	0-5 kt	6-10 kt	11-15 kt	16-20 kt	21-25 kt	>25 kt
Private Glider (G1)	50%	80%	100%	100%	80%	0%
Private Helicopter (HS1)	100%	100%	100%	100%	100%	50%
Private SEP Aircraft (LS1)	100%	100%	90%	50%	10%	0%

Table 2-2: Wind speed assumptions for a selection of categories

Cloud Base

Category of Use	0 ft	500 ft	1000 ft	2000 ft	3000 ft	4000 ft	CAVOK
Private Glider (G1)	0%	0%	0%	50%	80%	100%	100%
Private Helicopter (HS1)	0%	0%	30%	100%	100%	100%	100%
Private SEP Aircraft (LS1)	0%	0%	10%	50%	100%	100%	100%

Table 2-3: Cloud base assumptions for a selection of categories

2.6 Airspace Limitations

Airspace classifications and restrictions will influence the distribution of each category of use.

For the purpose of this study, the airspace was characterised using a 1 × 1 km grid (aligned with the Ordnance Survey national grid, i.e. the 1km grid squares shown on 1:50,000 Landranger™ maps). Overlay masks in 500-ft altitude bands were created to represent the following classes of airspace within the area of interest:

- Class A
- Class D
- Danger Areas
- Prohibited Airspace
- Restricted Airspace

For each category of user, a composite airspace mask was created by applying a set of assumptions to characterise the degree to which each user will access the various classes of airspace. Table 2-4 lists the assumptions that have been made for a selection of categories.

Category of User	Assumptions				
	Class A	Class D	Danger Area	Prohibited	Restricted[2]
Balloon	Will avoid	10%	Will avoid	Will avoid	Will avoid
Microlight (Flex Wing)	Will avoid	10%	Will avoid	Will avoid	50%
Microlight (3-Axis)	Will avoid	20%	Will avoid	Will avoid	50%
Gliders	Will avoid	Will avoid	Will avoid	Will avoid	50%
Helicopters (Single Engine)	Will avoid	75%	Will avoid	Will avoid	Will avoid
Helicopters (Twin Engine)	100%	100%	Will avoid	Will avoid	Will avoid
Light Single (450-5700 kg)	5%	30%	Will avoid	Will avoid	50%
Light Twin	100%	100%	Will avoid	Will avoid	50%
Military (Elementary)	Will avoid	Will avoid	Will avoid	Will avoid	Will avoid
Military (Helicopter)	100%	100%	100%	Will avoid	Will avoid
Hang Gliders	Will avoid	Will avoid	Will avoid	Will avoid	Will avoid
Paragliders	Will avoid	Will avoid	Will avoid	Will avoid	Will avoid

Table 2-4: Assumptions regarding airspace access

It is worth noting that the above assumptions have been made by considering aircraft equipage, pilot qualifications and knowledge about operating preferences in the round. Modification or further refinement of these assumptions is possible, should additional information become available.

[2] The majority of permanent Restricted Airspace exists around HM Prisons and only applies to rotary wing aircraft. As a consequence, it is assumed that 50% of fixed wing aircraft will legitimately penetrate Restricted Airspace. The other 50% are assumed to avoid the airspace.

3 Results

3.1 Individual Categories of Use

A selection of graphical outputs from the model, showing individual categories of use, is provided here to illustrate the effect of different input data conditions. The diagrams are maps indicating the occupancy factor (OF) as a function of geographical position within the area of interest. The term ‘Occupancy Factor’ (OF) has been coined for this purpose, representing the number of seconds in every hour that aircraft will occupy each 1 × 1 km square (within a specific altitude range).

> *Example 1:* A hot air balloon that is airborne for 1 hour and remains within a single 1 × 1 km square will result in an OF of 3,600 being assigned to that square.
>
> *Example 2:* Two hot air balloons that are each airborne for 1 hour and remain within the same 1 × 1 km square will result in an OF of 7,200 being assigned to that square.
>
> *Example 3:* A light aircraft performing circuits for 1 hour continuously follows a route that covers eighteen 1 × 1 km squares. This would result in an OF of 200 being assigned to each of the squares.

The OF is colour coded as a ‘heat map’ where warm colours (red end of the spectrum) indicate high values and cool colours (blue end of the spectrum) indicate low values. It should be noted that various scale ranges are used in these diagrams. Also, in order to provide suitable discrimination of activity away from busy airfields, some busy areas (i.e. those coloured dark red) may have values that are off the scale.

3.1.1 Gliding Activity

Figure 3-1 shows the predicted gliding activity between surface and 10,000 ft for the following input conditions:

Month	Day	Time	Surface Temp	Dew Point	Cloud Cover	Cloud Base	Visibility	Wind
August	Sat	1400	25°C	15°C	1/8	5,000 ft	>10 km	240/1 2

This is considered to represent 'better than average' gliding conditions.

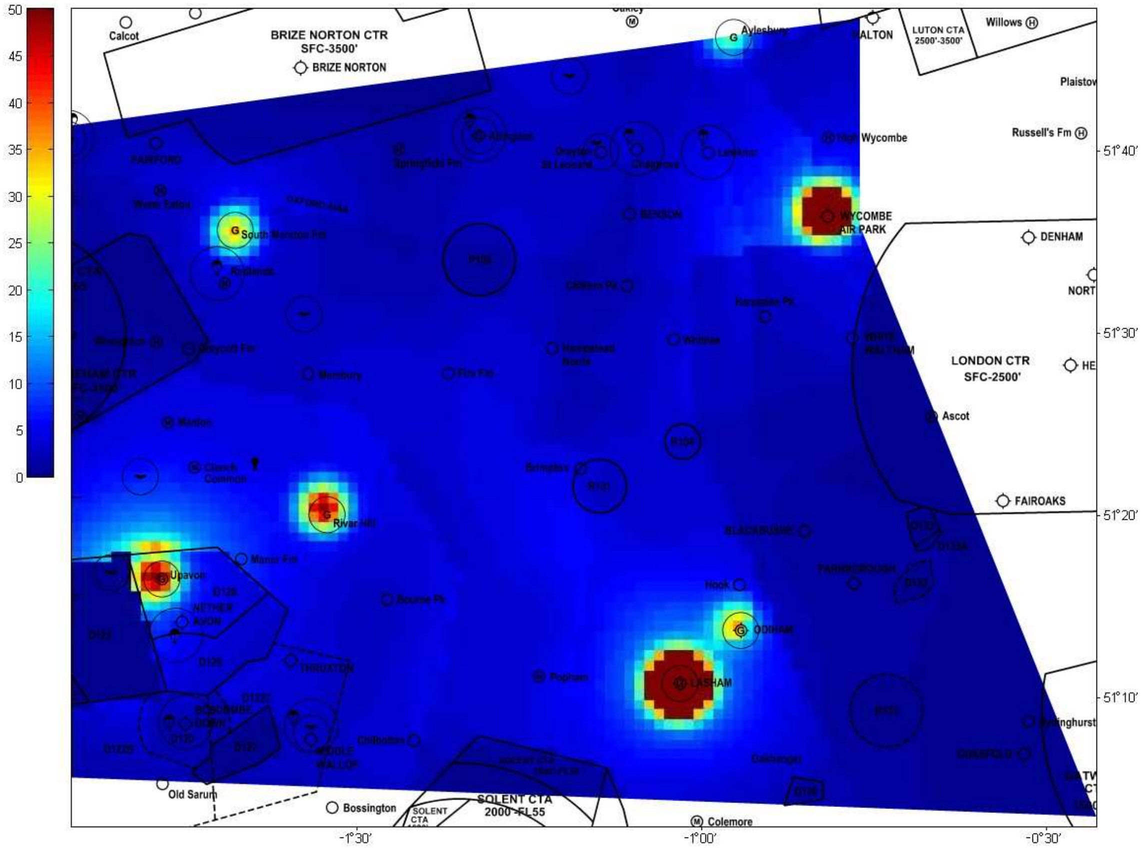


Figure 3-1: 'Better than average' gliding conditions

Figure 3-2 shows the predicted gliding activity between surface and 10,000 ft for the following input conditions:

Month	Day	Time	Surface Temp	Dew Point	Cloud Cover	Cloud Base	Visibility	Wind
May	Sun	1400	15°C	6°C	8/8	3,000 ft	>10 km	020/05

This is considered to represent 'average' gliding conditions.

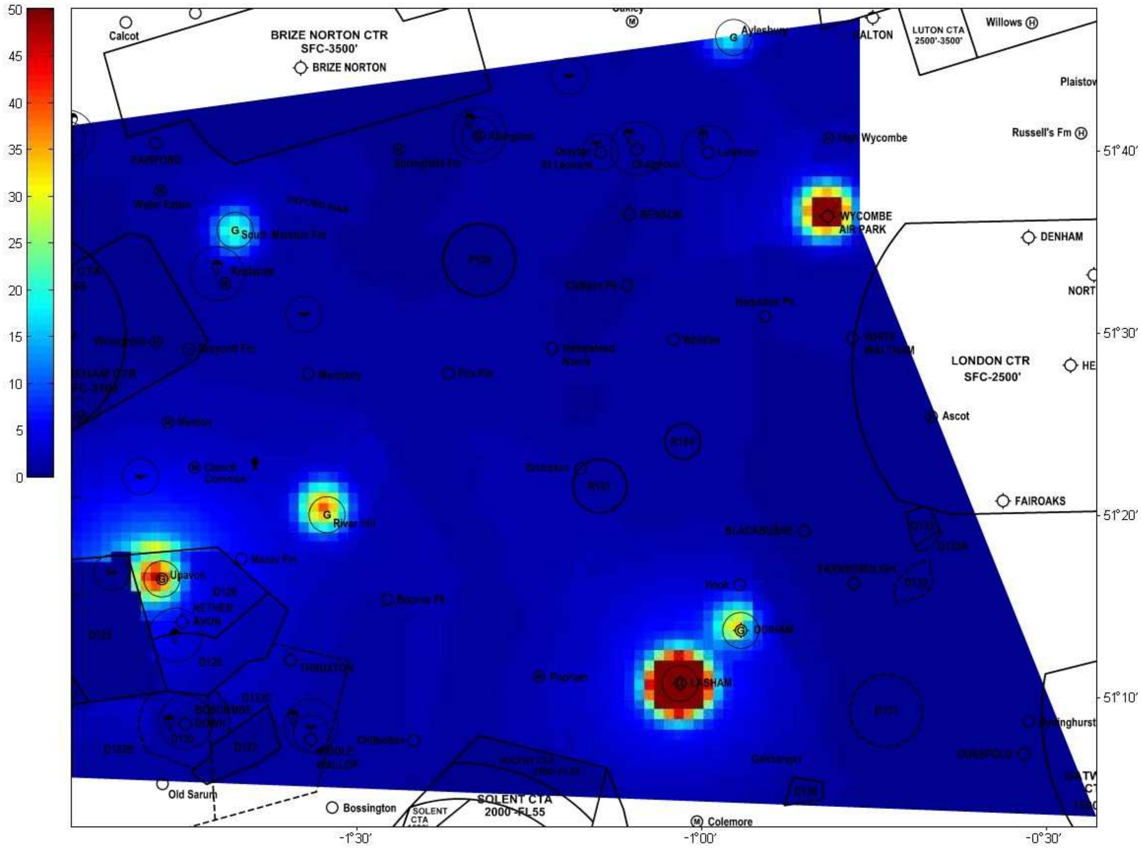


Figure 3-2: 'Average' gliding conditions

Figure 3-3 shows the predicted gliding activity between surface and 10,000 ft for the following conditions:

Month	Day	Time	Surface Temp	Dew Point	Cloud Cover	Cloud Base	Visibility	Wind
April	Sat	1400	12℃	8℃	8/8	2,000 ft	5 km	060/01

This is considered to represent 'poor' gliding conditions, where only short duration local flights would be made in the vicinity of the glider sites modelled.

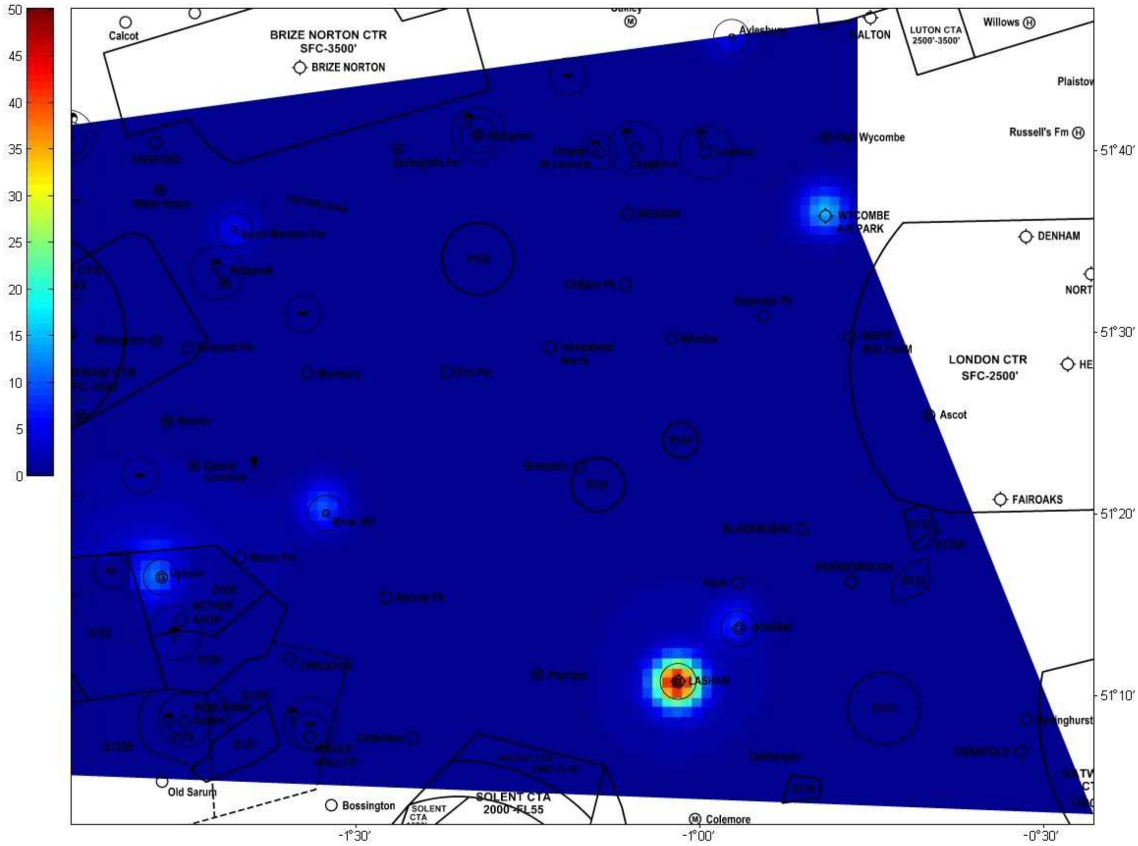


Figure 3-3: 'Poor' gliding conditions

3.1.2 Single Engine Fixed Wing (450 - 5,700 kg)

Figure 3-4 shows the predicted activity between surface and 10,000 ft for the following conditions:

Month	Day	Time	Surface Temp	Dew Point	Cloud Cover	Cloud Base	Visibility	Wind
July	Sat	1100	25℃	10℃	Nil	N/A	>10 km	Calm

Such weather conditions are considered to be ideal for single engine light aircraft.

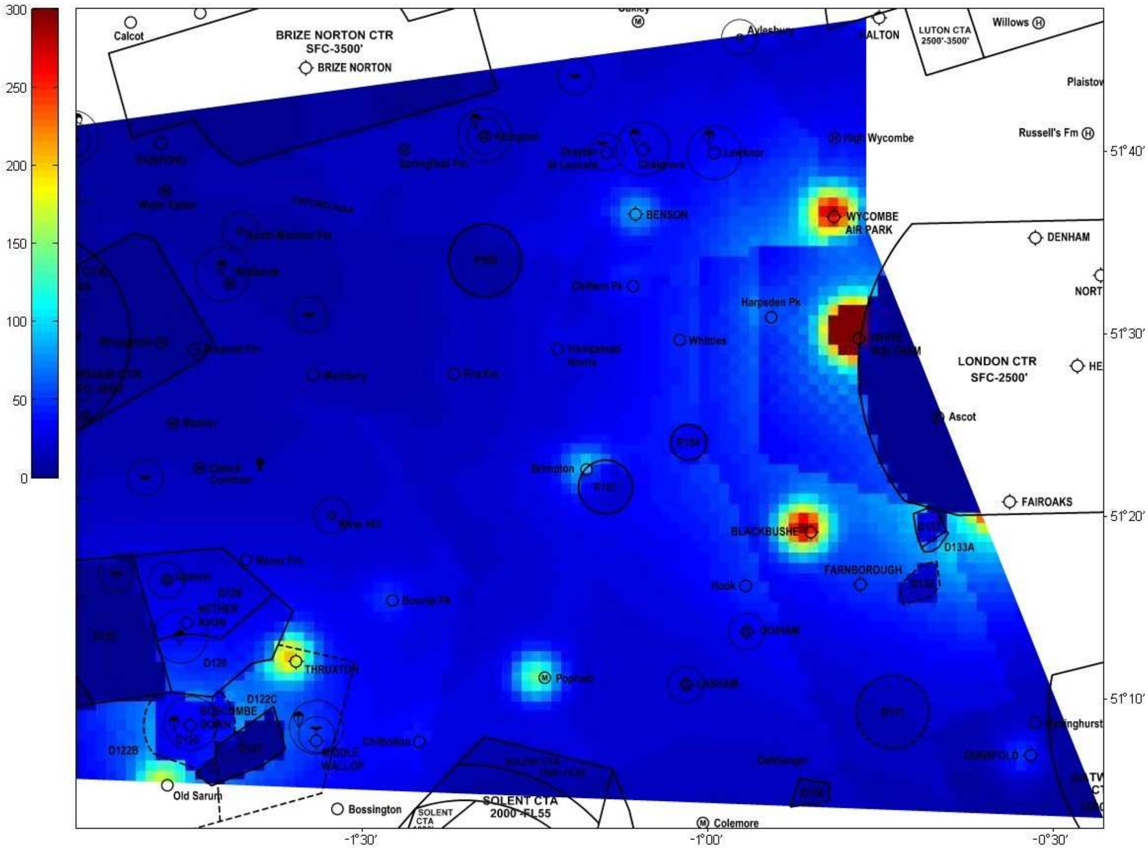


Figure 3-4: Good conditions for single engine light aircraft

Figure 3-5 shows the predicted activity between surface and 10,000 ft for the following conditions:

Month	Day	Time	Surface Temp	Dew Point	Cloud Cover	Cloud Base	Visibility	Wind
Mar	Sun	1400	7℃	4℃	8/8	1,500 ft	6 km	220/20

Such weather conditions are considered to be marginal for the majority of single engine light aircraft. Figure 3-5 is therefore representative of the activity that might be expected to occur under 'poor' flying conditions.

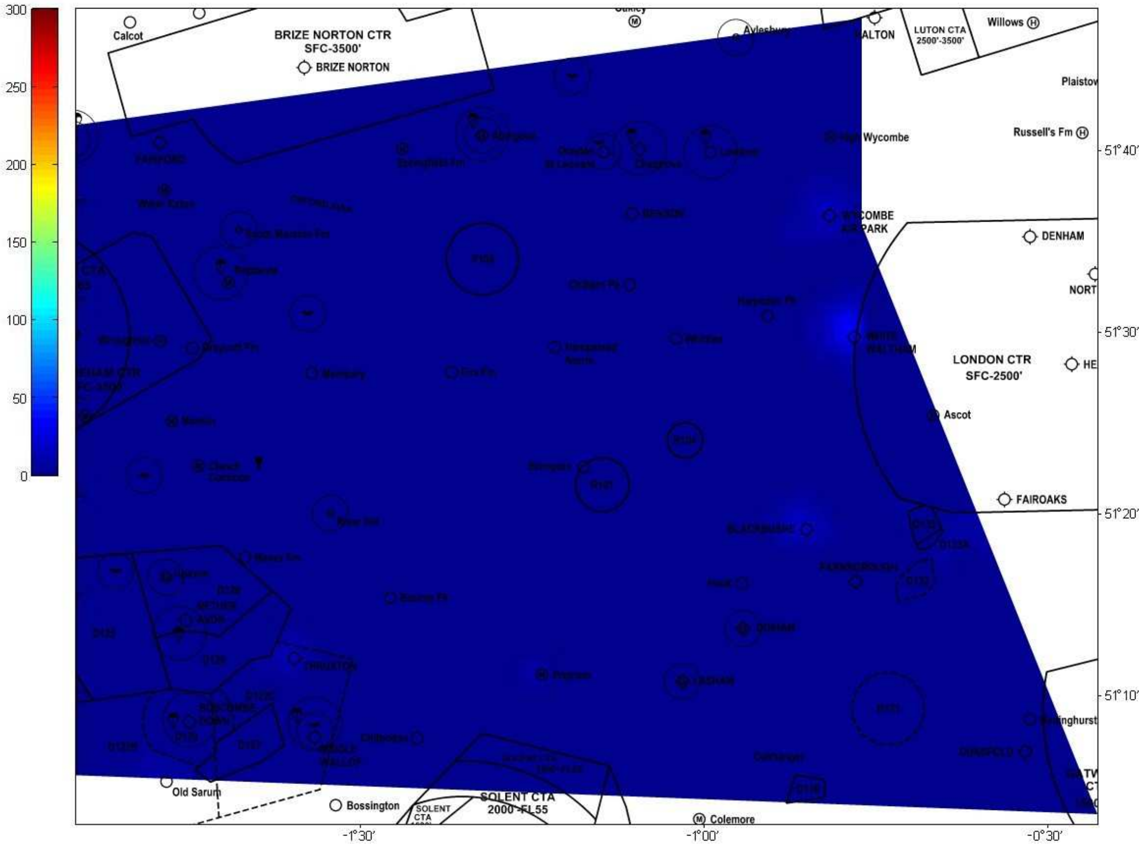


Figure 3-5: Poor conditions for single engine light aircraft

3.1.3 Military Users

Figure 3-6 shows the predicted activity between surface and 10,000 ft for the following conditions:

Month	Day	Time	Surface Temp	Dew Point	Cloud Cover	Cloud Base	Visibility	Wind
July	Thu	1100	25℃	10℃	Nil	N/A	>10 km	Calm

Such weather conditions are considered to be within limits for all types of military flying known to take place within the area of interest.

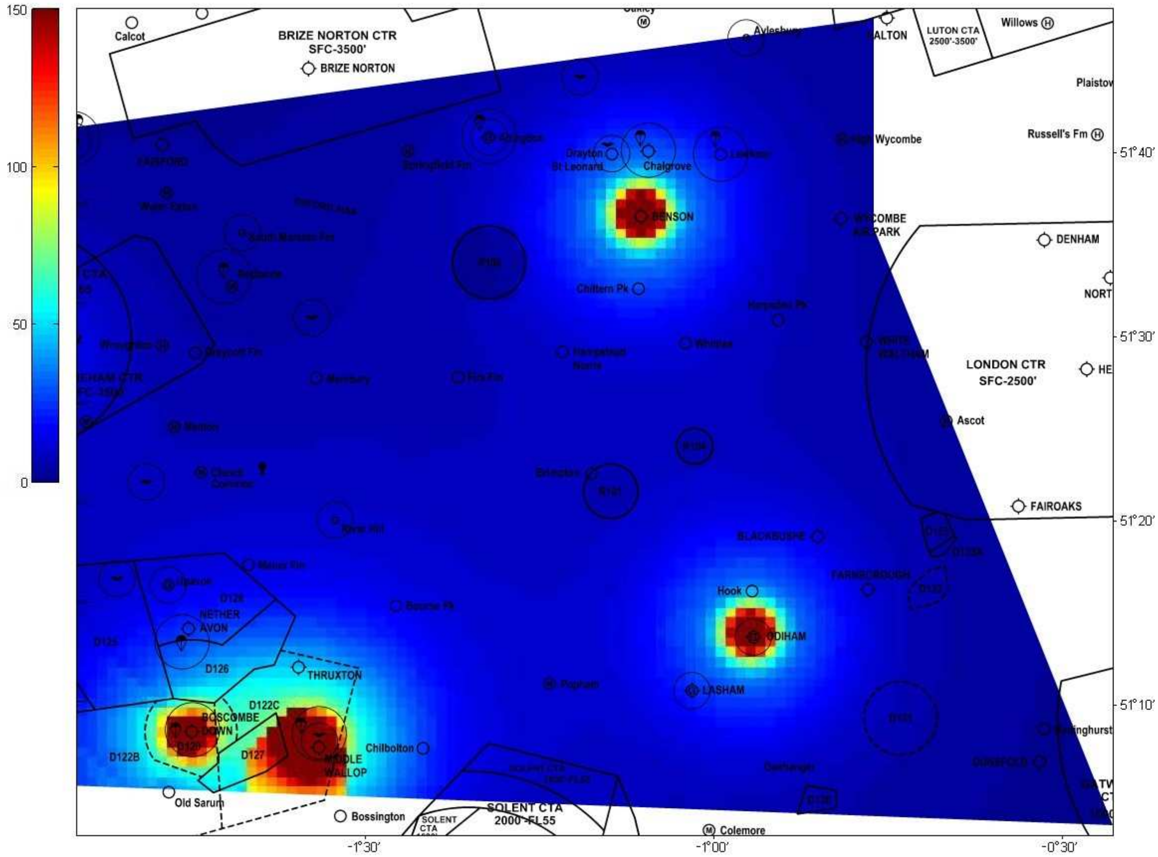


Figure 3-6: Typical weekday military activity

Figure 3-7 shows the predicted activity between surface and 10,000 ft for the following conditions:

Month	Day	Time	Surface Temp	Dew Point	Cloud Cover	Cloud Base	Visibility	Wind
Sep	Sat	1400	20℃	12℃	Nil	N/A	>10 km	Calm

This set of conditions has been chosen to show the elementary flight training activity (i.e. VGS and UAS squadrons) that takes place at weekends.

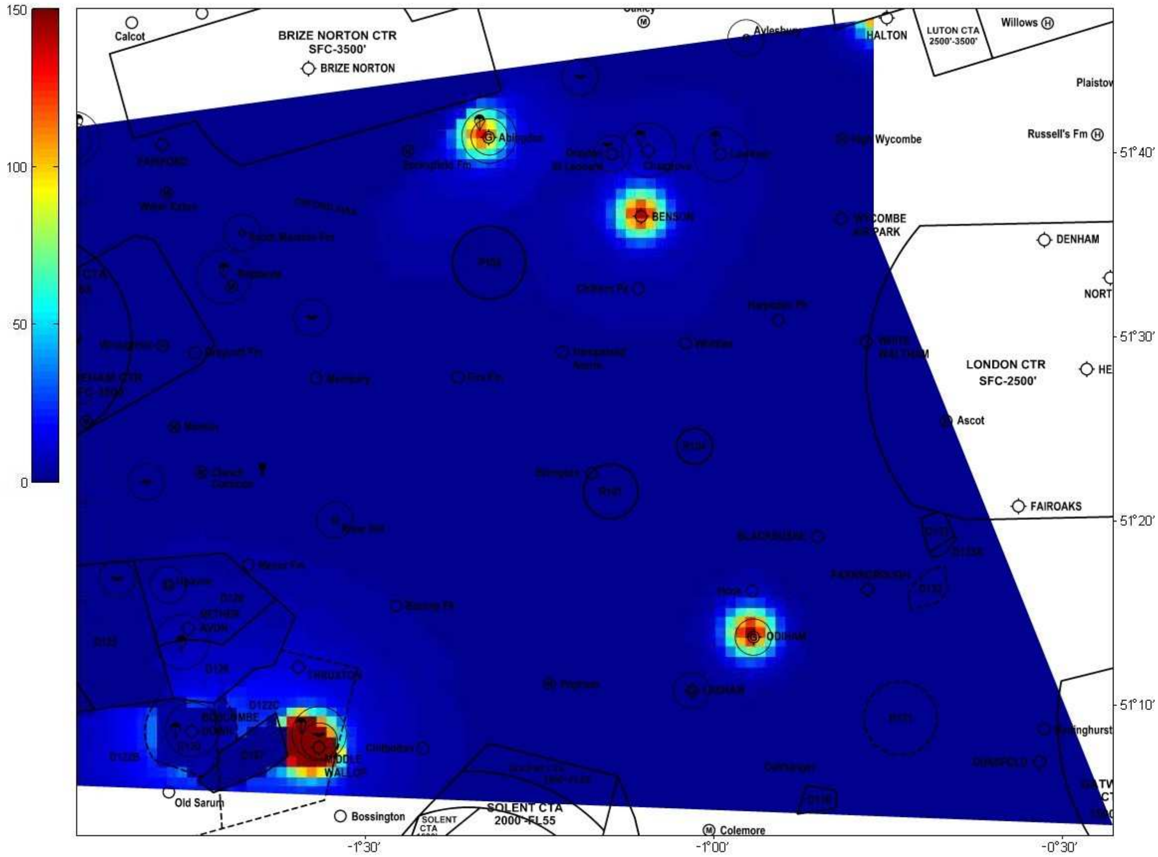


Figure 3-7: Typical weekend/bank holiday military activity

3.1.4 Flex Wing Microlight Activity

Figure 3-8 shows the predicted activity between surface and 10,000 ft for the following conditions:

Month	Day	Time	Surface Temp	Dew Point	Cloud Cover	Cloud Base	Visibility	Wind
Jul	Sat	1300	25℃	10℃	Nil	N/A	>10 km	Calm

This set of conditions has been chosen to illustrate the level of flex wing microlight activity taking place at weekends/bank holidays under ‘perfect’ weather conditions.

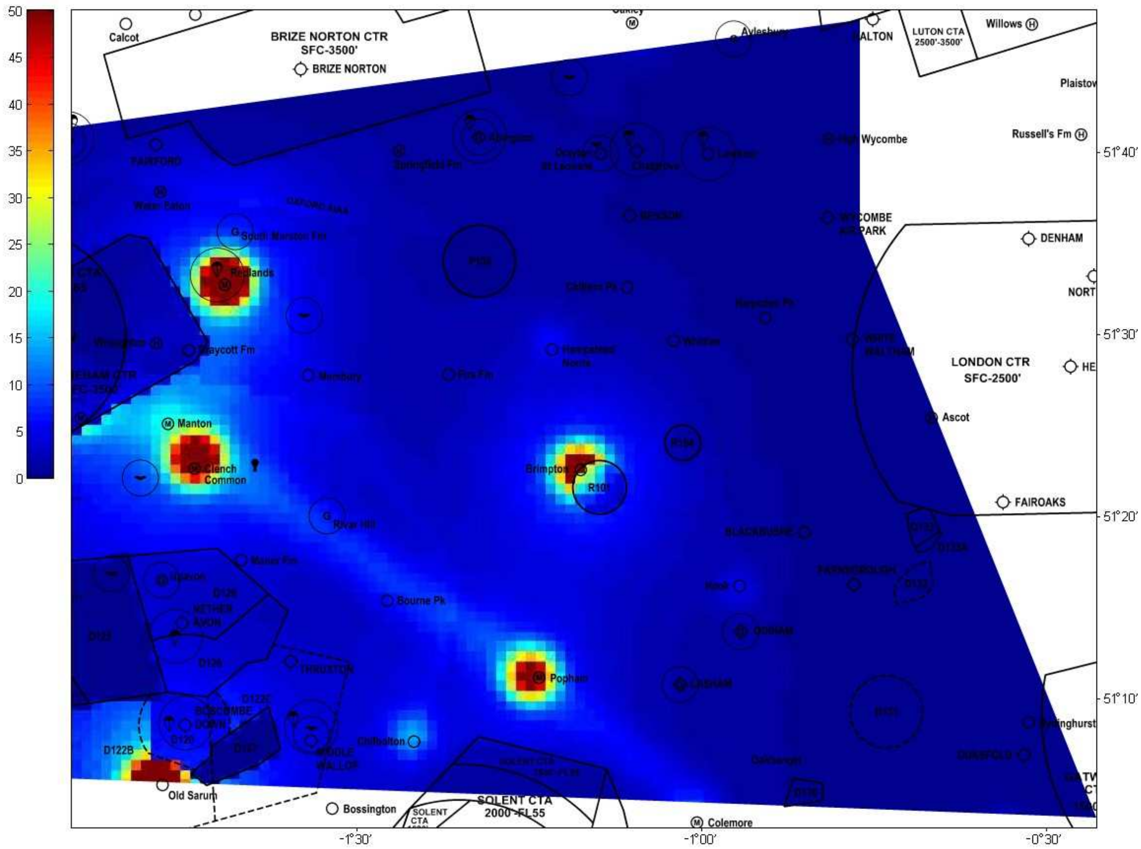


Figure 3-8: Flex wing microlight activity – ‘perfect’ conditions

Figure 3-9 shows the predicted activity between surface and 10,000 ft for the following conditions:

Month	Day	Time	Surface Temp	Dew Point	Cloud Cover	Cloud Base	Visibility	Wind
Jul	Thu	1900	25℃	10℃	Nil	N/A	>10 km	Calm

Analysis of survey data shows that many flex wing microlight pilots will be active during the late afternoon/early evening if the right weather conditions exist. The above conditions are considered 'ideal' for such evening flights, and are chosen to illustrate the level of activity that is expected to take place.

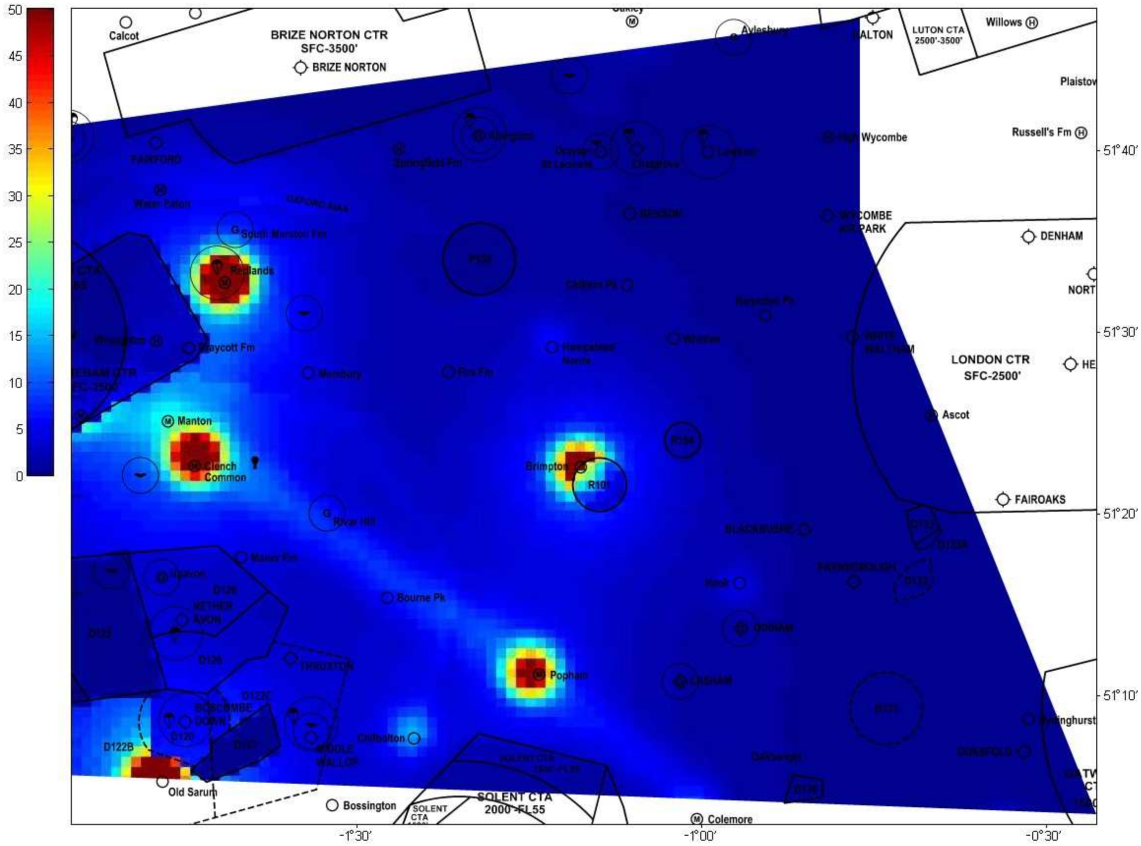


Figure 3-9: Flex wing microlight activity – good conditions (summer evening)

Figure 3-10 shows the predicted activity between surface and 10,000 ft for the following conditions:

Month	Day	Time	Surface Temp	Dew Point	Cloud Cover	Cloud Base	Visibility	Wind
Nov	Sat	1000	10℃	7℃	8/8	1,500 ft	5 km	340/15

The above conditions have been chosen to be representative of a marginal day, when most flex wing microlights are unlikely to fly.

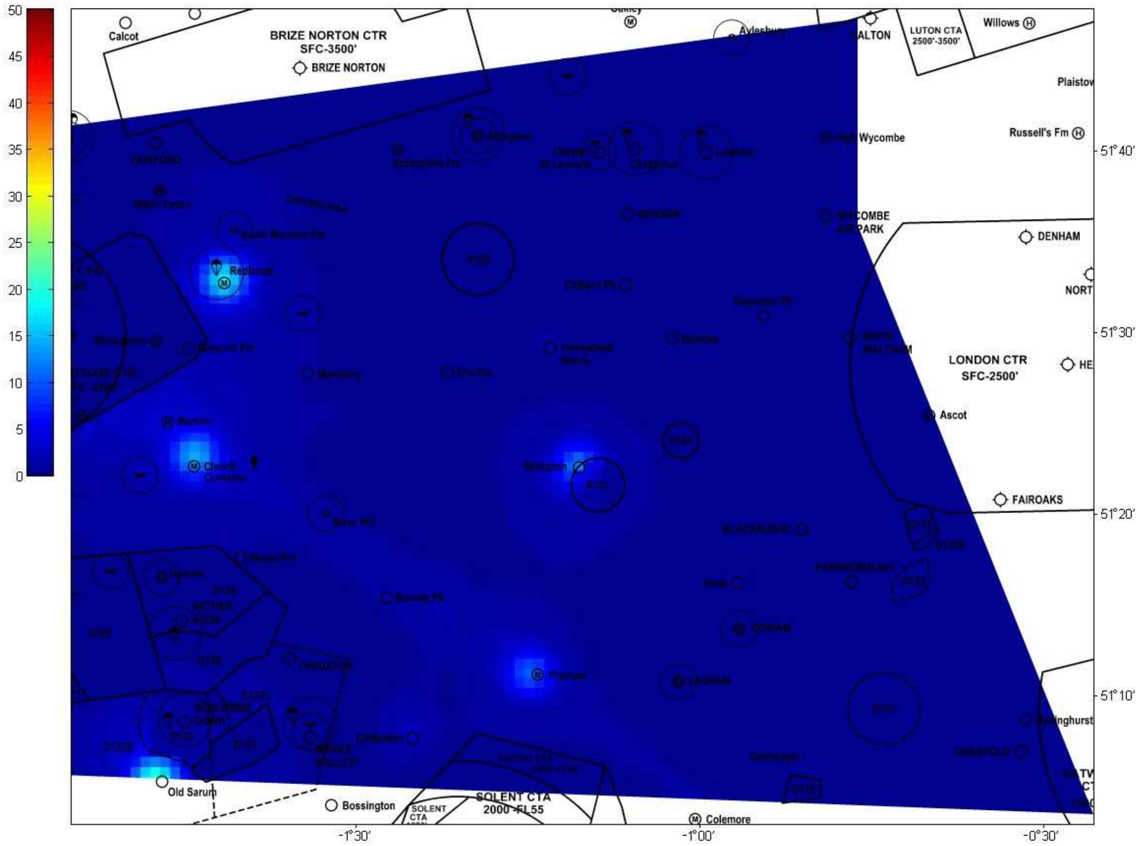


Figure 3-10: Flex wing microlight activity – marginal weather conditions

3.1.5 Paragliding Activity

Figure 3-11 shows the predicted activity between surface and 10,000 ft for the following conditions:

Month	Day	Time	Surface Temp	Dew Point	Cloud Cover	Cloud Base	Visibility	Wind
Jul	Sat	1300	25	10	0/8	10,000	10 km	020/05

This shows activity at the sites which are known to be suitable when the wind is northerly in direction.

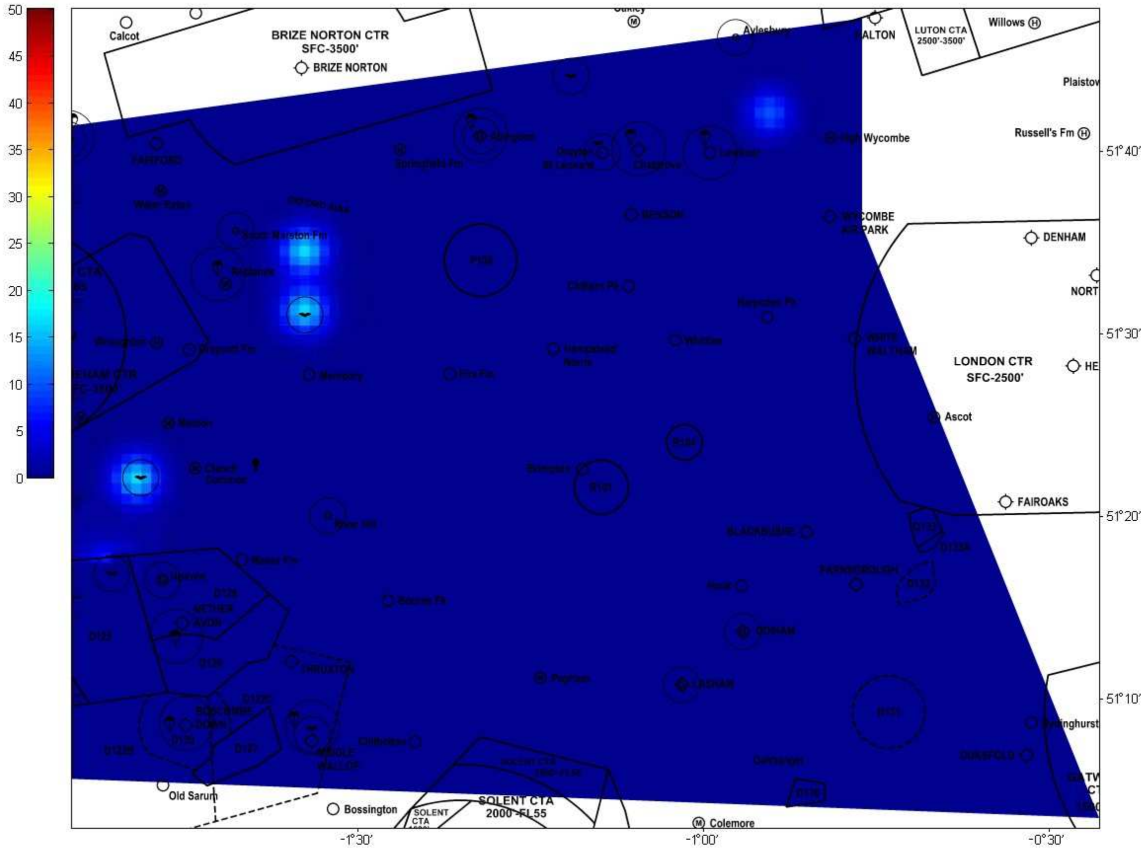


Figure 3-11: Good conditions – northerly wind

Figure 3-12 shows the predicted activity between surface and 10,000 ft for the following conditions:

Month	Day	Time	Surface Temp	Dew Point	Cloud Cover	Cloud Base	Visibility	Wind
Jul	Sun	1500	25	10	Nil	N/A	>10 km	250/05

This shows activity at the sites which are known to be suitable when the wind is from a south westerly direction.

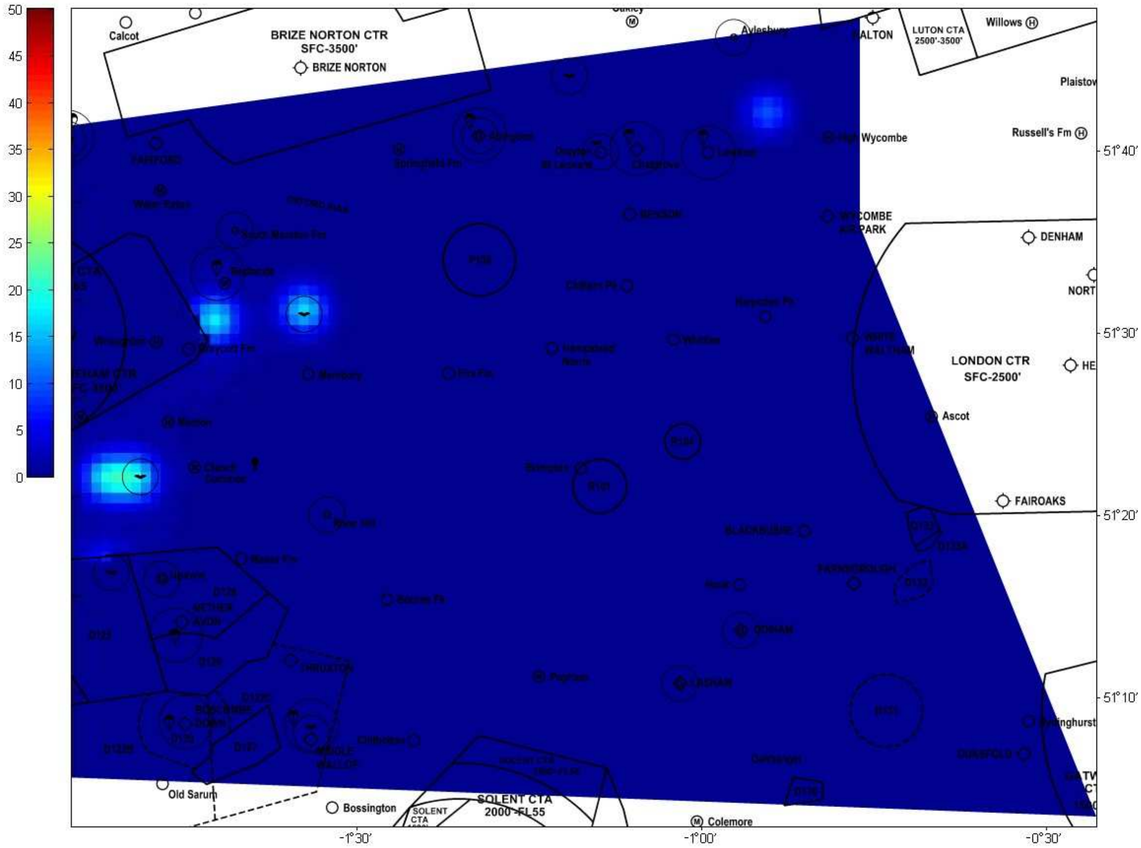


Figure 3-12: Good conditions – south westerly wind

3.1.6 Civil Helicopter Activity

Figure 3-13 shows the predicted activity between surface and 10,000 ft for the following conditions:

Month	Day	Time	Surface Temp	Dew Point	Cloud Cover	Cloud Base	Visibility	Wind
Jul	Sat	1500	25℃	10℃	Nil	N/A	>10 km	180/05

This set of conditions has been chosen to illustrate the level of civil helicopter activity taking place at weekends/bank holidays under ‘good’ weather conditions.

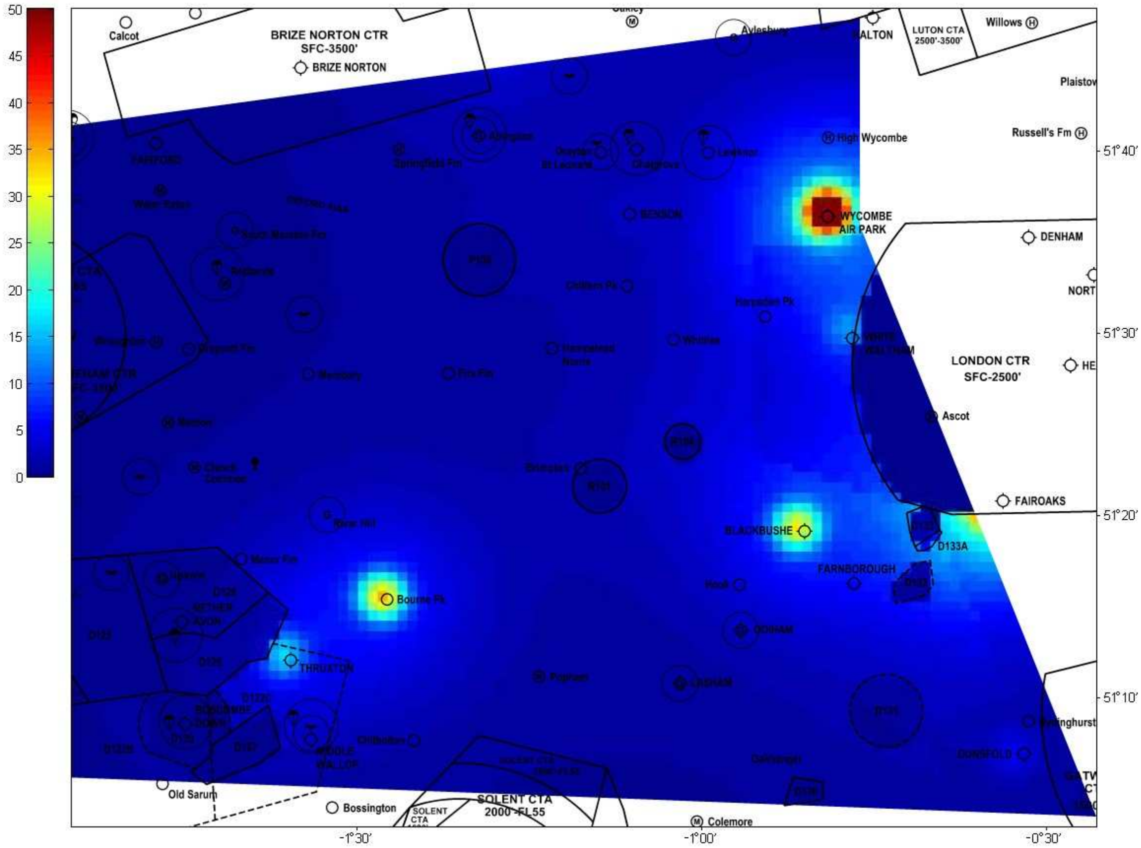


Figure 3-13: Weekend civil helicopter activity – good conditions

Figure 3-14 shows the predicted activity between surface and 10,000 ft for the following conditions:

Month	Day	Time	Surface Temp	Dew Point	Cloud Cover	Cloud Base	Visibility	Wind
Mar	Wed	1100	10℃	2℃	2/8	2,000 ft	>10 km	090/15

This set of conditions has been chosen to illustrate the level of civil helicopter activity taking place during the week under ‘good’ weather conditions.

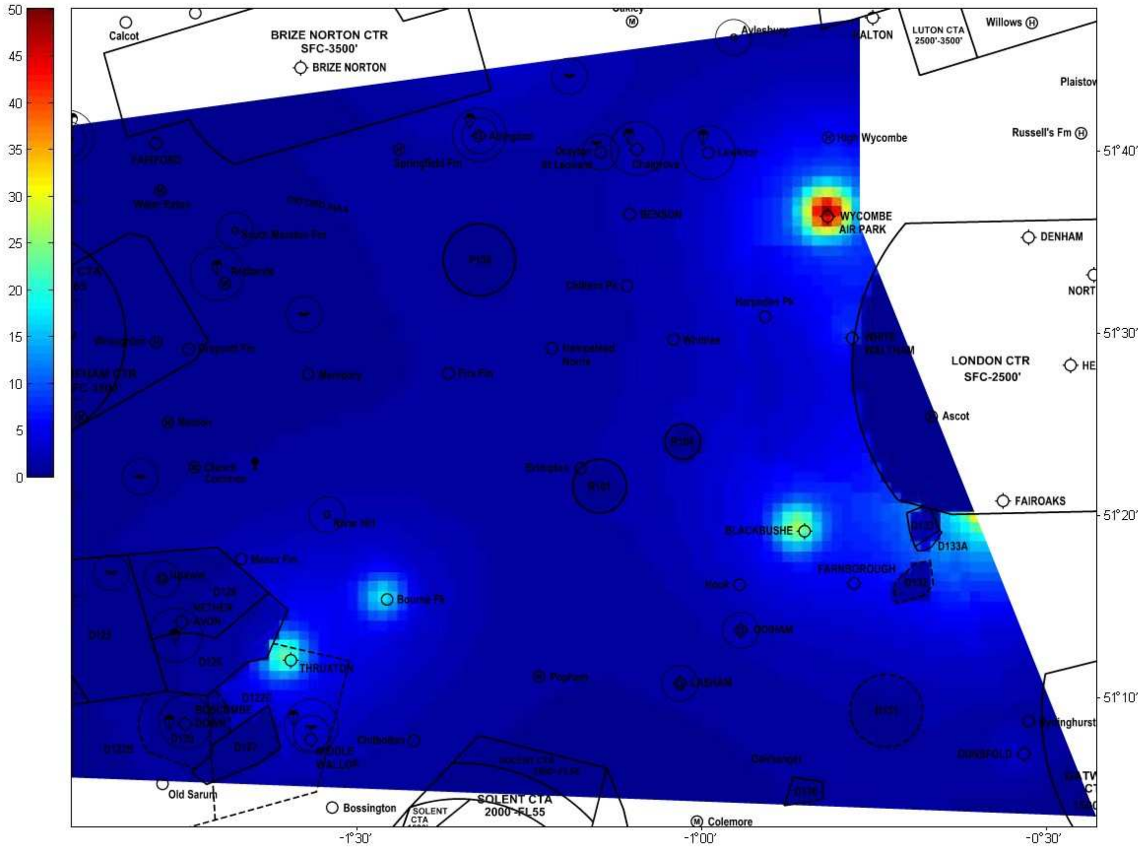


Figure 3-14: Mid-week civil helicopter activity – good conditions

3.1.7 Civil Multi-Engine Fixed Wing Activity

This category covers light twins and other multi-engine fixed wing aircraft routinely operated outside controlled airspace. Figure 3-15 shows the predicted activity between surface and 10,000 ft for the following conditions:

Month	Day	Time	Surface Temp	Dew Point	Cloud Cover	Cloud Base	Visibility	Wind
Aug	Sat	1200	25℃	10℃	Nil	N/A	>10 km	240/05

This set of conditions has been chosen to illustrate the level of activity taking place at the weekend under ‘good’ weather conditions.

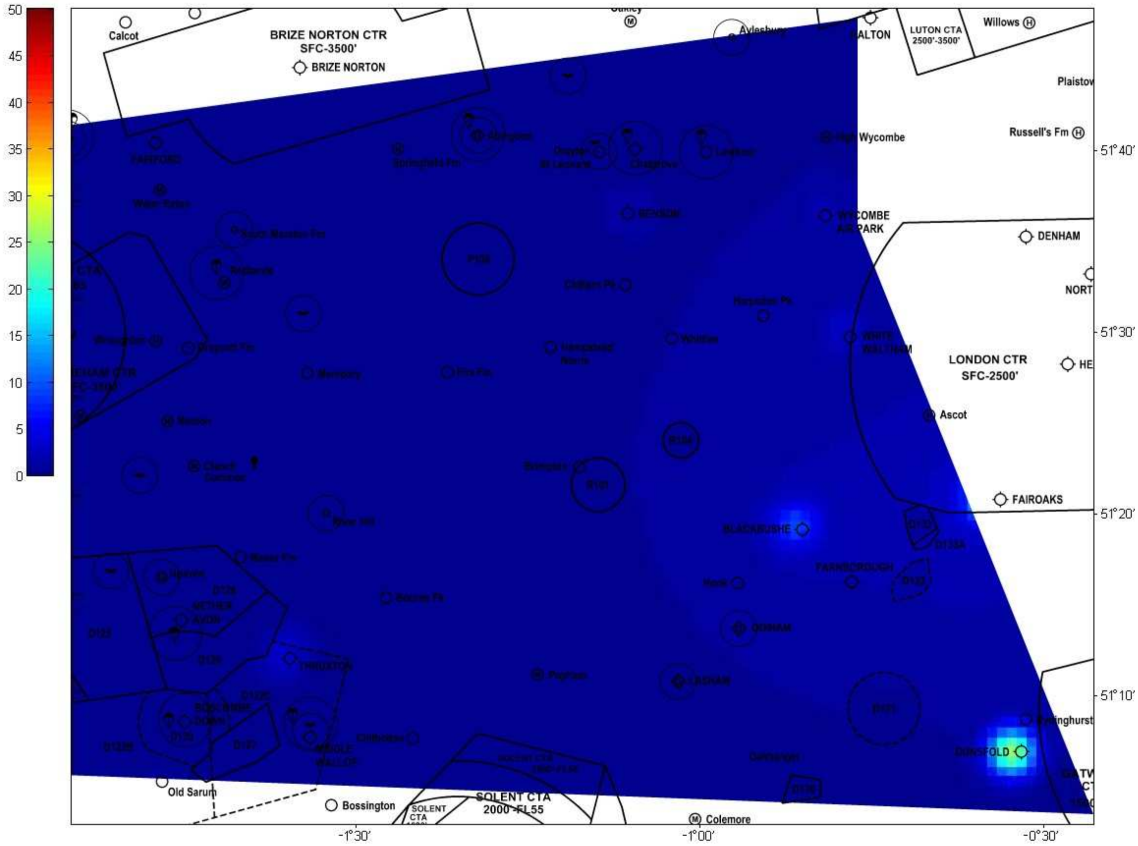


Figure 3-15: Weekend multi-engine fixed wing activity – good conditions

Figure 3-16 shows the predicted activity between surface and 10,000 ft for the following conditions:

Month	Day	Time	Surface Temp	Dew Point	Cloud Cover	Cloud Base	Visibility	Wind Speed
May	Wed	1100	10℃	2℃	2/8	2,000 ft	>10 km	150/15

This set of conditions has been chosen to illustrate the level of activity taking place during the week under 'good' weather conditions.

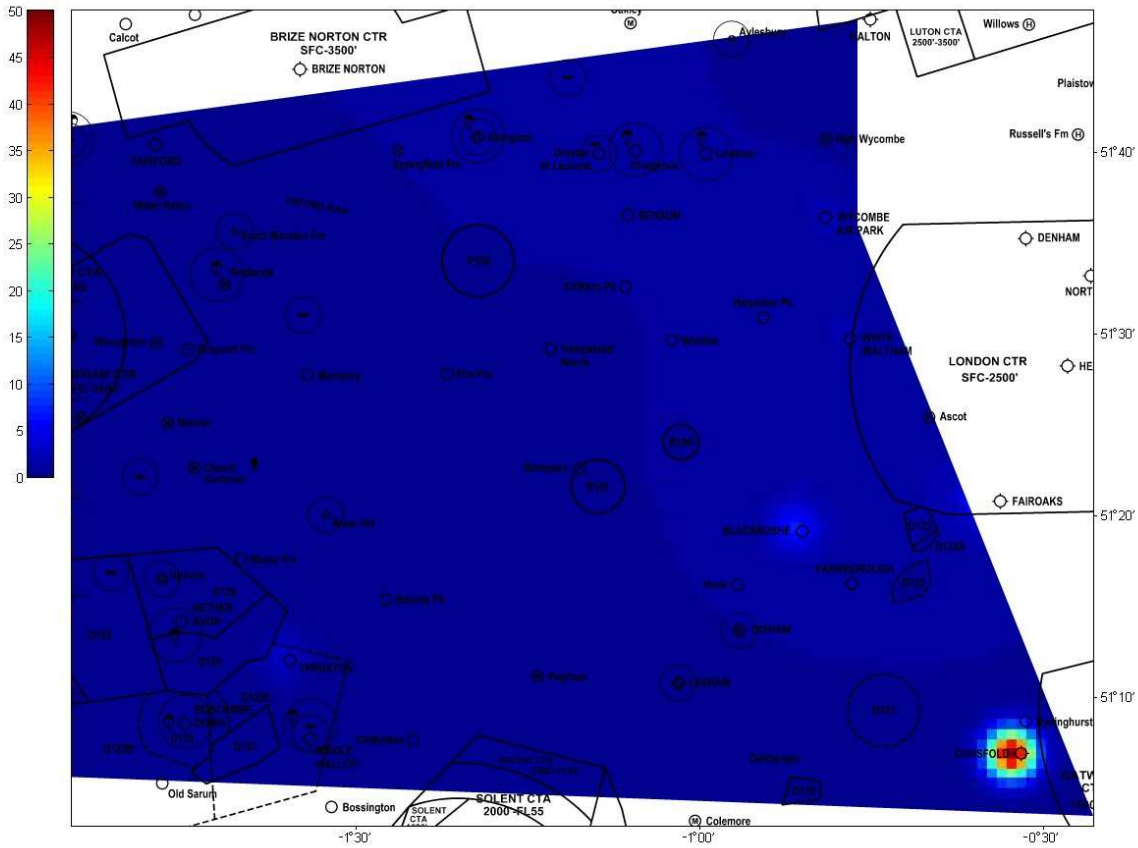


Figure 3-16: Mid-week multi-engine fixed wing activity – good conditions

3.2 All Categories of Use

The following graphical results show the output when all categories of use are modelled. In these simulations, date and time is fixed to show how combined activity levels vary with altitude.

The following common time and weather input conditions are used:

Month	Day	Time	Surface Temp	Dew Point	Cloud Cover	Cloud Base	Visibility	Wind
Aug	Sun	1400	25℃	10℃	Nil	N/A	>10 km	240/05

The lower image on each page represents the same simulation, but viewed using a logarithmic ('log') scale. This compresses the colours used for high traffic areas, and amplifies the low traffic areas. This technique provides a better indication of activity taking place in areas away from the busy main airfields. The calculated OF values remain unchanged.

3.2.1 Activity at 1,000 ft

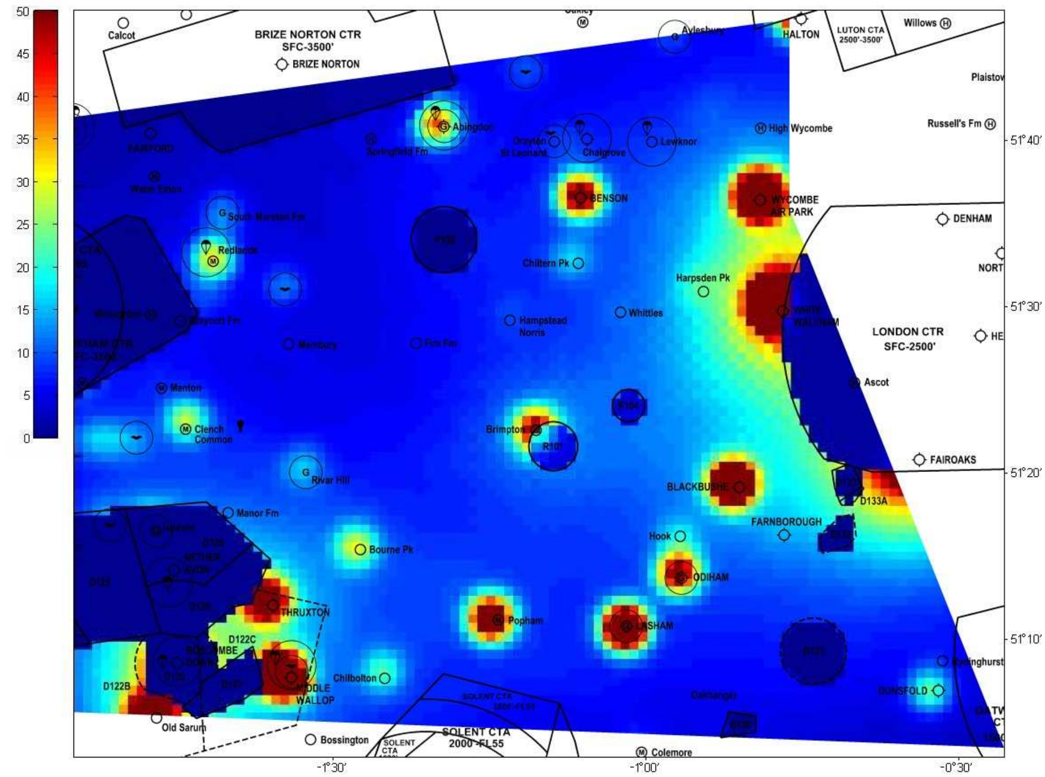


Figure 3-17: All categories of use at 1,000 ft

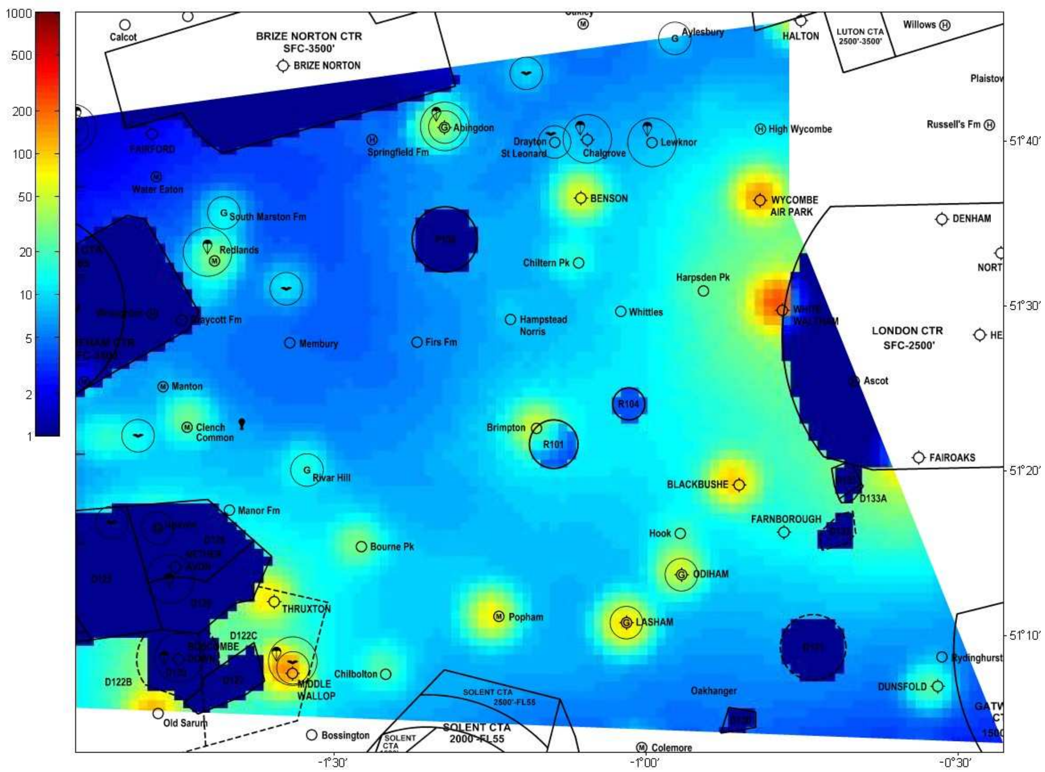


Figure 3-18: All categories of use at 1,000 ft ('log' scale)

3.2.2 Activity at 2,000 ft

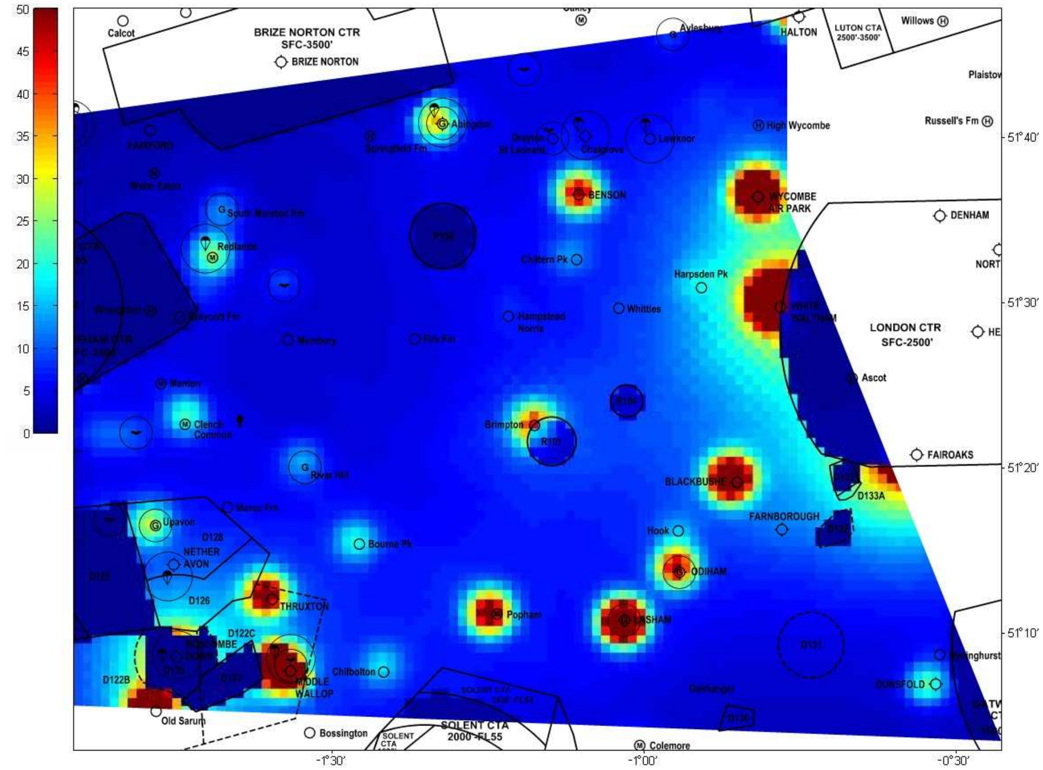


Figure 3-19: All categories of use at 2,000 ft

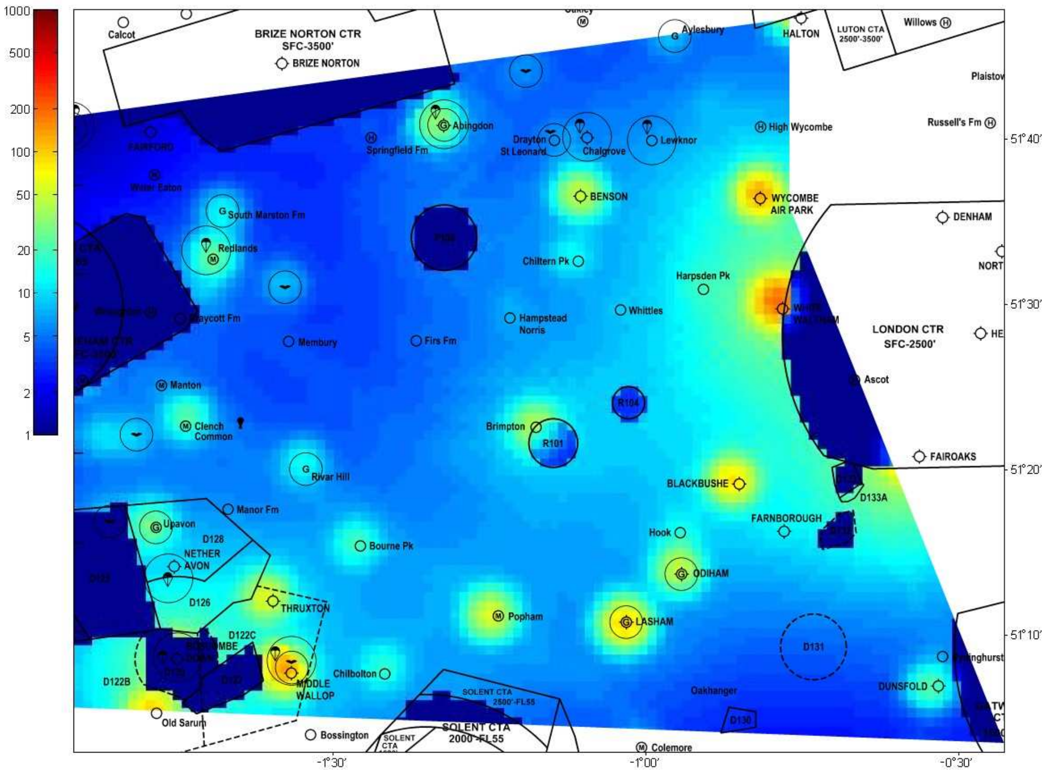


Figure 3-20: All categories of use at 2,000 ft ('log' scale)

3.2.3 Activity at 5,000 ft

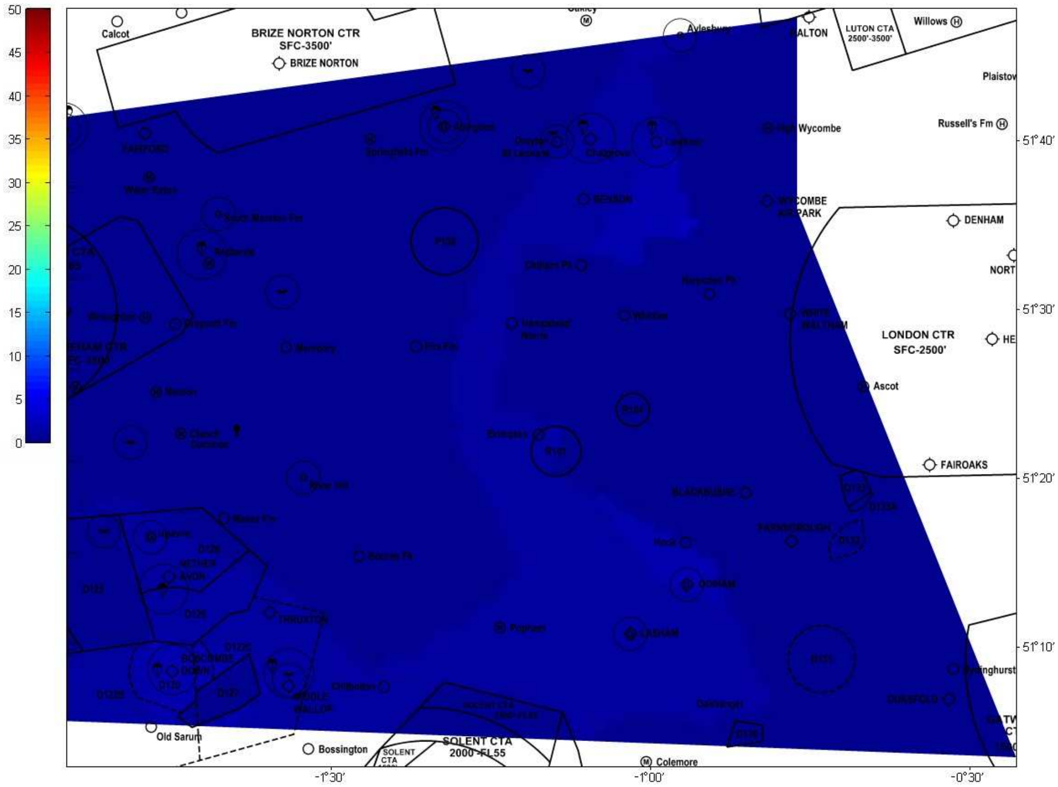


Figure 3-21: All categories of use at 5,000 ft

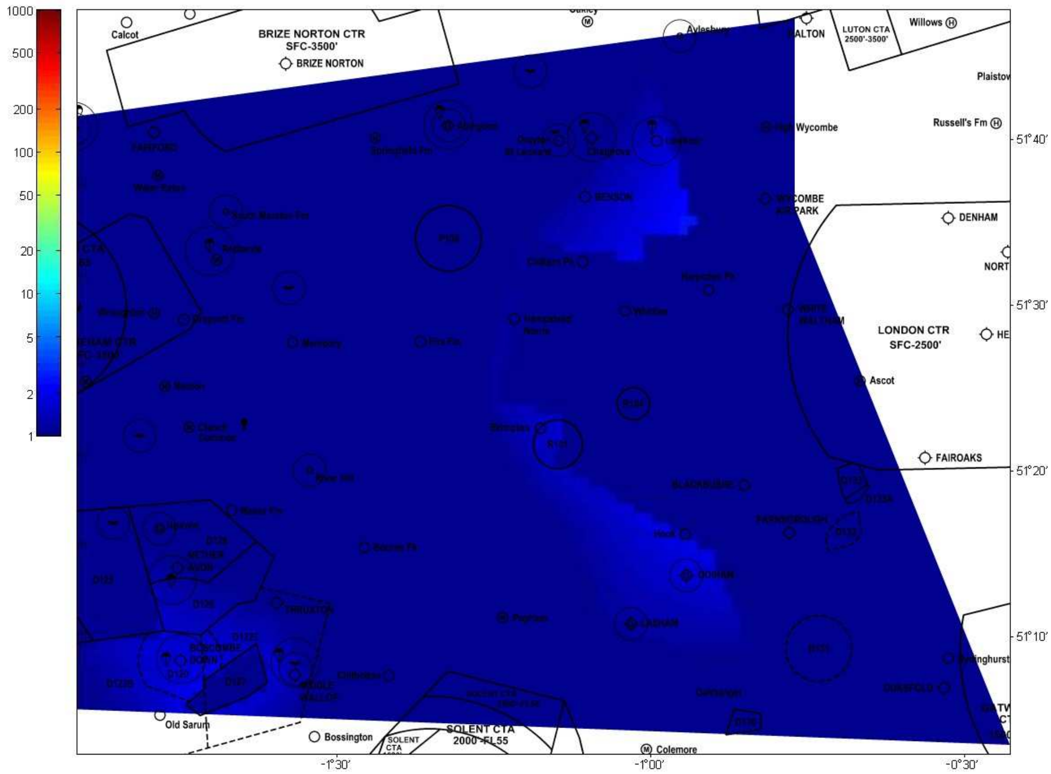


Figure 3-22: All categories of use at 5,000 ft ('log' scale)

3.2.4 Activity at 8,000 ft

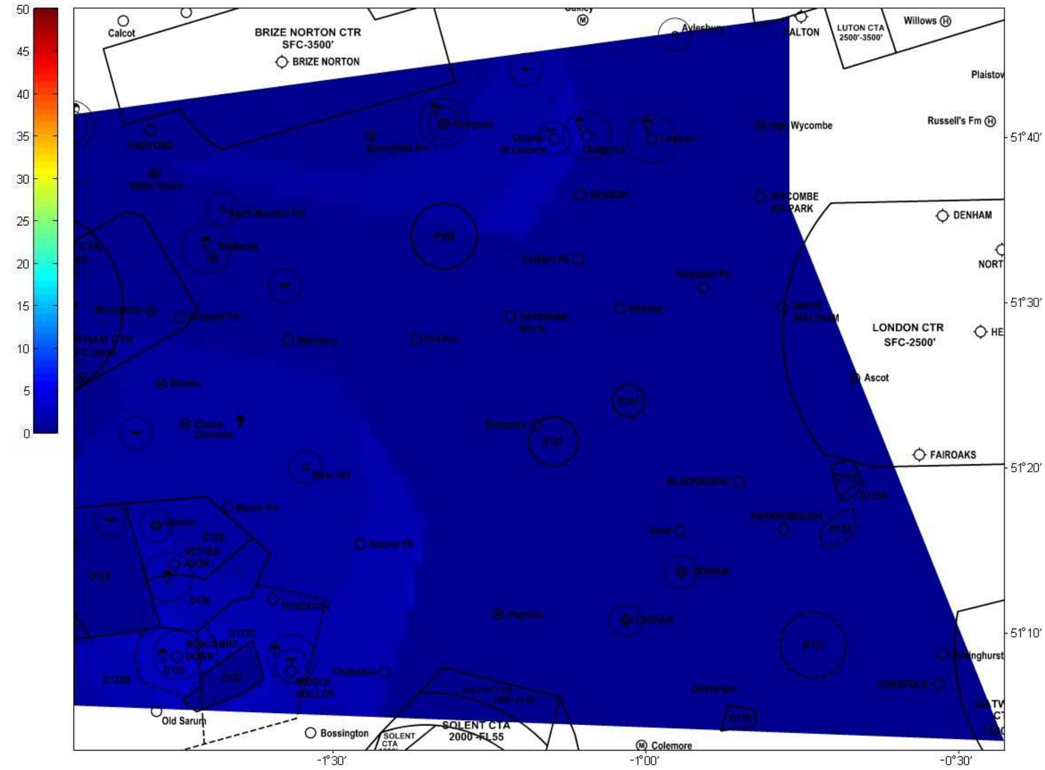


Figure 3-23: All categories of use at 8,000 ft

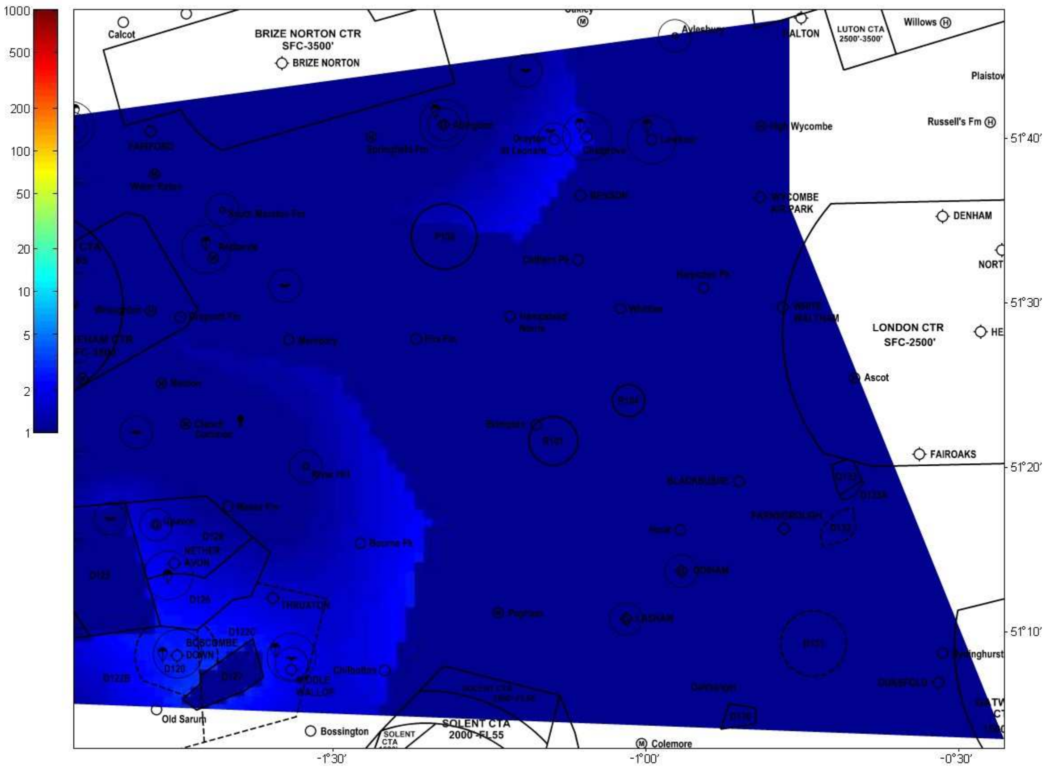


Figure 3-24: All categories of use at 8,000 ft ('log' scale)

4 Validation

4.1 Purpose

The purpose of validation is to compare the results produced by the model with the actual levels of activity taking place at a given location, for a given time of day and under the same meteorological conditions.

4.2 Scenarios

Three scenarios were agreed during the project definition phase:

- Scenario 1 – will compare the model predictions with actual radar data obtained for the weekend of 22/23 May 2010. These were notably busy days for general aviation due to the weather conditions at the time. This comparison will allow the method used to calculate Occupancy Factor to be validated at spot points.
- Scenario 2 – will compare the model predictions of glider activity against GPS data provided by BGA members for Jan–Sep 2009. The BGA data supplied represents the cross-country flights made (excluding competitions) for submission to the BGA Ladder. It is important to recognise that this does not represent all glider flights, and specifically excludes training and general handling flights (which are the most popular). Given this limitation, it is not possible to make a direct, quantitative comparison of Occupancy Factor. However, by suppressing the local return-to-base glider traffic, it is possible to get the model to display only the route traffic. Comparison of the distribution of route traffic with GPS data provided by the BGA should provide confidence in the model's ability to predict glider hot spots and popular cross country routes.
- Scenario 3 – will focus on the effect of temporary airspace restrictions around Farnborough, put in place for the Farnborough Air Show (12-25 July, 2010). Specifically, the weather conditions on Wednesday 21 July were conducive for gliding and other general aviation activity. The model prediction for this day, having taken account of the temporary airspace restrictions (see Annex D) will be compared with radar data. This should enable the model's airspace masking and dispersion techniques to be validated.

4.3 Scenario 1

4.3.1 Weather Conditions

The following historical weather records were obtained for Farnborough Airport (EGLF).

Saturday 22 May, 2010.

Time (UTC)	Temp (℃)	Dew Point (℃)	Wind Speed	Wind Direction	Visibility	Cloud Coverage	Cloud Base
0820	15	11	5 kt	NE	7 km	Nil	N/A
1120	20	12	8 kt	ENE	>10 km	Nil	N/A
1420	23	9	11 kt	ENE	>10 km	Nil	N/A
1720	23	8	13 kt	E	>10 km	Nil	N/A

The weather conditions for the morning period would have been conducive for a wide range of general aviation categories, including light aviation, gliding and microlight flying. However, the strengthening wind is likely to have deterred many microlights or student/low hour powered pilots from flying from mid-afternoon onwards.

Sunday 23 May, 2010.

Time (UTC)	Temp (℃)	Dew Point (℃)	Wind Speed	Wind Direction	Visibility	Cloud Coverage	Cloud Base
0820	17	12	4 kt	ENE	>10 km	Nil	N/A
1120	24	10	4 kt	(VRB)	>10 km	Nil	N/A
1420	26	12	4 kt	SE	>10 km	Nil	N/A
1720	26	11	4 kt	(VRB)	>10 km	Nil	N/A

The weather conditions for Sunday would have been conducive for a wide range of general aviation categories, including light aviation, gliding and microlight flying.

4.3.2 Radar Data

From analysis of radar data, it is possible to determine the actual traffic operating within the area of interest on the two days.[3] Of course, radar recordings display actual radar tracks, and any calculation of occupancy would only apply to the 1 × 1 km squares that the tracks pass through. In order to make a meaningful comparison with the model, it is necessary to ‘smooth’ out the real data, by distributing it between adjacent grid squares within 1.5 NM.

Figures 4-1 and 4-2 show the smoothed radar data for 1100–1200 UTC on Saturday 22 May, and Sunday 23 May 2010 respectively.

[3] The data was filtered on the basis of altitude and Mode A code (when available) to remove aircraft operating above 10,000 ft and GAT being separated by ATC. Mode A code was also used to filter out aerobatic flying and Police Air Support Units which tend to remain in a single square for extended periods and produce anomalous ‘spikes’ in the occupancy.

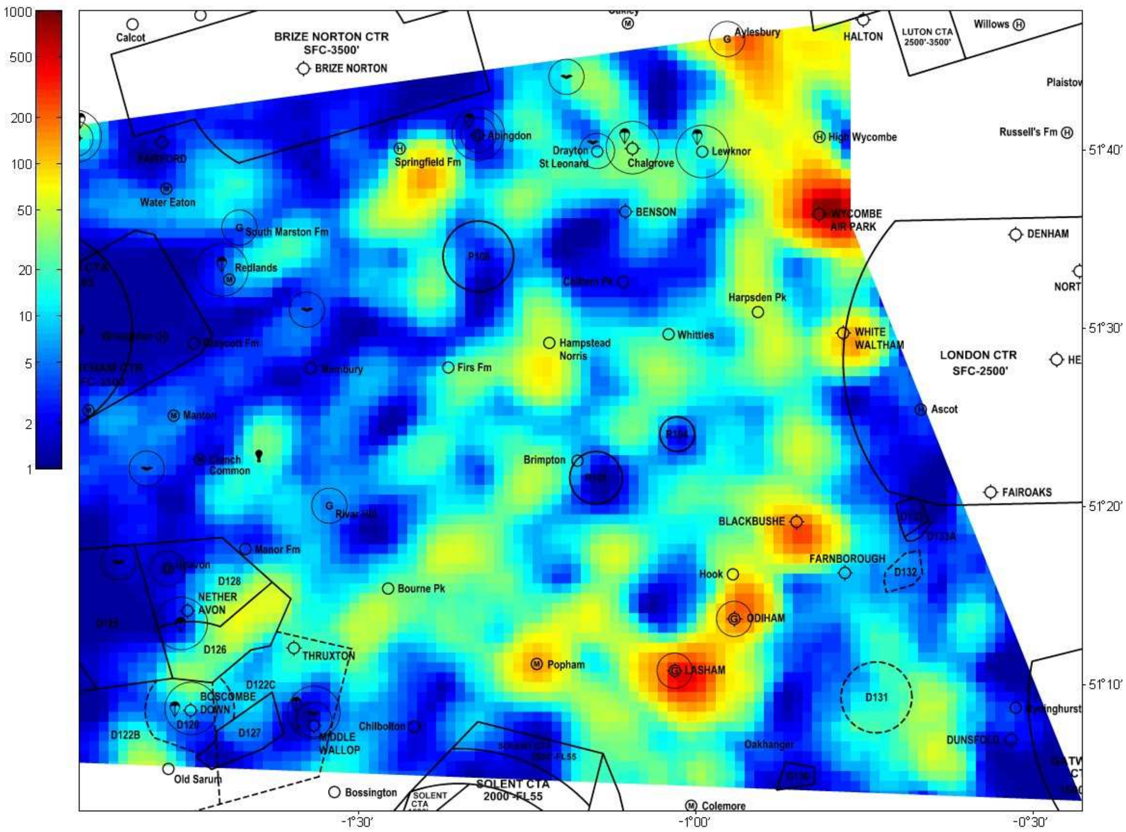


Figure 4-1: Smoothed radar data, 1100-1200 UTC, 22 May, 2010 ('log' scale)

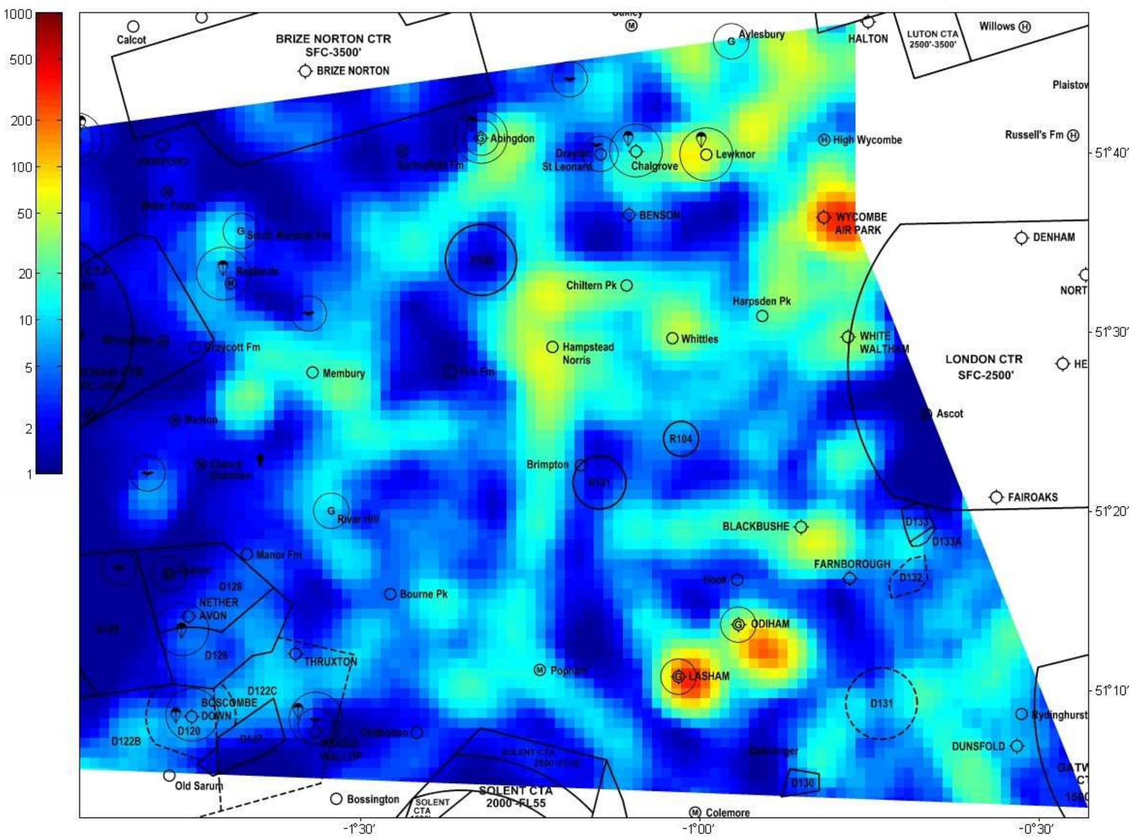


Figure 4-2: Smoothed radar data, 1100-1200 UTC, 23 May, 2010 ('log' scale)

These images show OF values of between 200 and 400 for busier general aviation airfields and glider sites on both days. Sunday (23 May) has slightly less activity than Saturday, particularly in the southwest corner of the area. This may be due to poor local visibility.

The image for 23 May clearly shows a north-south passage of aircraft from Popham through Hampstead Norris (Compton VOR) and then continuing in a northerly direction past Abingdon.

The radar data for Sunday captures parachuting taking place at Lewknor, and appears to show gliders following the Chiltern escarpment. Gliding activity at Lasham and VGS activity to the south east of Odiham is also clearly visible.

4.3.3 Model Prediction

Figure 4-3 shows the predicted level of activity for 1100–1200 UTC on Saturday 22 May, 2010 (using a logarithmic scale). In general terms, this shows the most intense activity occurring in the area surrounding the Heathrow zone (below the TMA), due to activity associated with Wycombe Air Park, White Waltham, Blackbushe and Fairoaks. Another area of intensity is broadly centred on D127, with Thruxton, Boscombe Down (Southampton University Air Squadron) Middle Wallop and Old Sarum.

OF values of around 250 are predicted at the busiest airfields (Wycombe Air Park, White Waltham, Blackbushe etc.). Values of between 20 and 50 are predicted for popular thoroughfares, away from the main airfields.

Virtually no activity is predicted to take place inside the Heathrow CTR, Danger Areas D125 and D127.

Figure 4-4 shows the predicted level of traffic for 1100–1200 UTC on Sunday 23 May, 2010. Both predictions are virtually identical as the input conditions are similar in so far as the weather conditions for 1100–1200 UTC on both days were equally conducive for all categories of user. Furthermore, the model only discriminates by weekday or weekend/bank holidays, and the same user behavioural patterns are applied for Saturdays, Sundays and bank holidays.

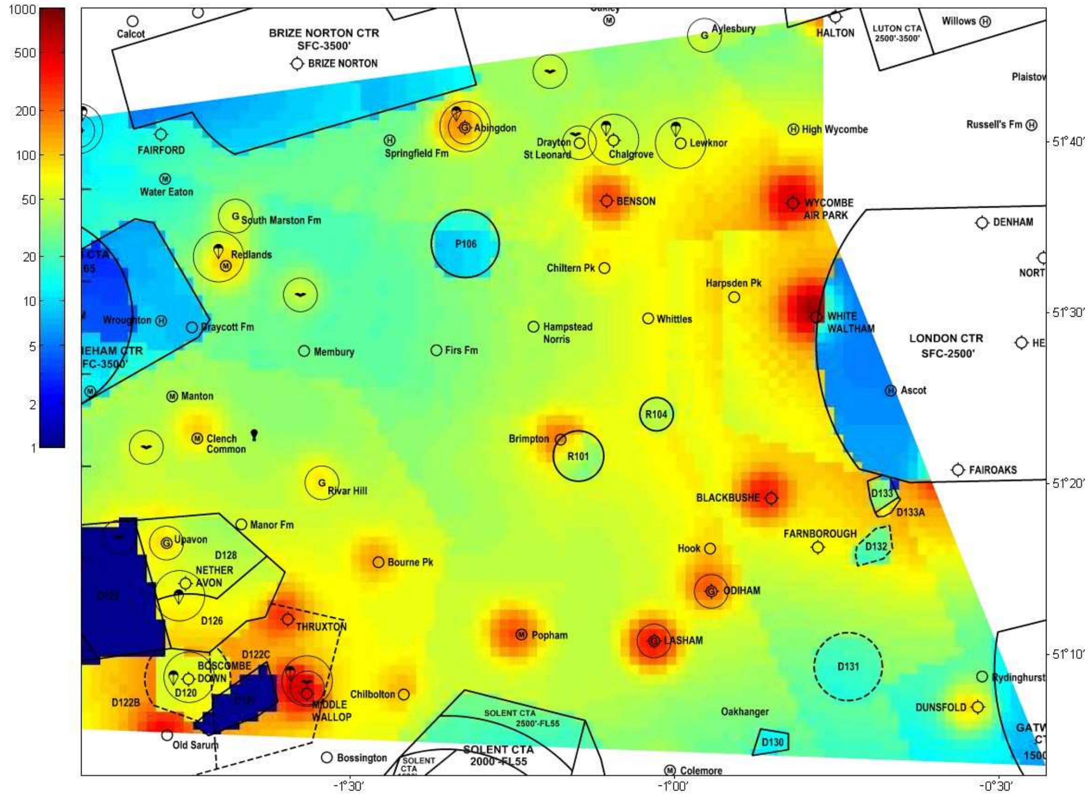


Figure 4-3: Predicted Level of Activity, 1100-1200 UTC, 22 May 2010 ('log' scale)

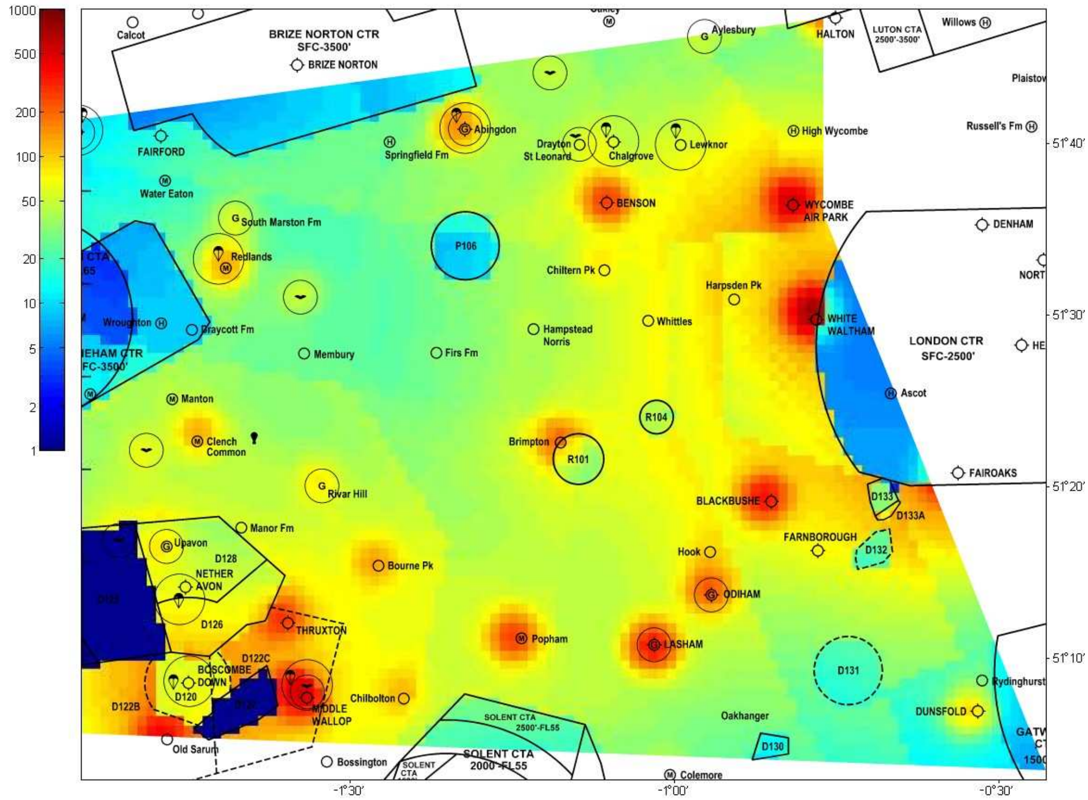


Figure 4-4: Predicted Level of Activity, 1100-1200 UTC, 23 May 2010

4.4 Scenario 2

4.4.1 Combined Cross-Country Glider Activity (2009)

The GPS data supplied by the BGA was analysed and processed in order to derive OF. This was achieved by calculating the time each glider spends in the 1 × 1 km grid squares it passes over. As each glider track is processed, the OF for each square accumulates (the quantity of data available – several months' worth – meant that no smoothing was required). The total accumulated Occupancy Factor can then be plotted on a map (see Figure 4-5). *Note: a larger image showing this data superimposed onto the 1:500 000 aeronautical chart can be found at Annex E*.

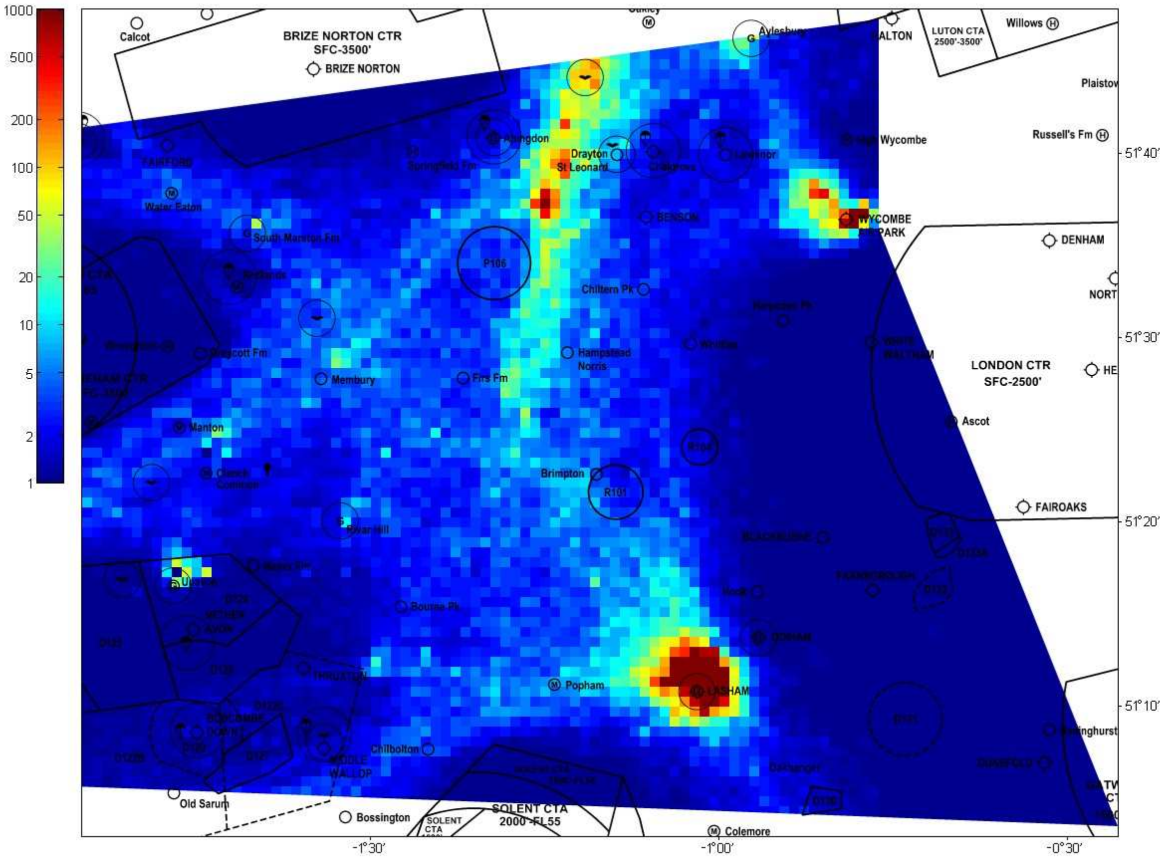


Figure 4-5: Actual Cross-Country Glider Activity (Jan–Sep 2009)

Much higher OF values (some in excess of 1,000) can be seen here due to the accumulation of tracks over a 9-month period.

As well as the dominant activity at Lasham and Wycombe (Booker), a very popular north-south transit route, passing west of Aldermaston (R101), then on in the direction of Bicester can be seen. The red/orange areas to the northeast of Harwell (P106) appear to represent a crossroads with a northeast/southwest route. Whilst other routes radiate away from Lasham to the west and southeast, there is a notable complete absence of cross-country activity to the east (i.e. below the London TMA).

4.4.2 Predicted Cross-Country Glider Activity

By suppressing the local area (return-to-base) glider activity, it is possible to view the residual cross country routes that have been programmed into the model using information supplied from long answer surveys, and analysis of popular routes on the BGA Ladder website.

As previously stated, it is not possible to directly compare occupancy factor on any given day with the accumulated total (actual value) for the 2009 data supplied. However, it is possible to compare the route structure and location of hot spots.

To enable cross country routes within the model, appropriate time and weather conditions must be input. In this respect, the following values were used:

Month	Day	Time	Surface Temp	Dew Point	Cloud Cover	Cloud Base	Visibility	Wind Speed
August	Sat	1400	25℃	15℃	1/8	5,000 ft	>10 km	12 kt

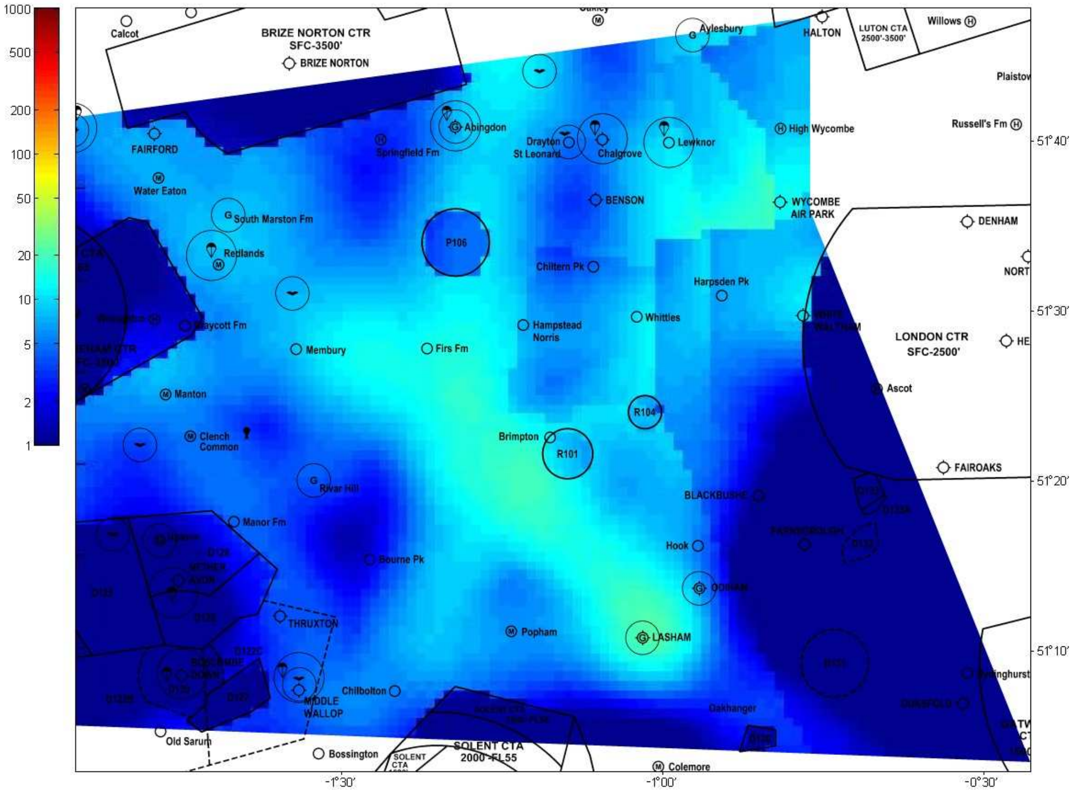


Figure 4-6: Predicted Cross-Country Glider Activity

The predicted output for these input conditions shows activity at all of the glider sites within the area of interest. Upon first inspection, OF values appear low, but this can be explained due to the relatively low percentage of gliders participating in cross-country flights (recognising that the model is currently not programmed to take account of gliding competitions, with specific waypoints). Furthermore, the cross-country activity modelled is spread out over a wide area, and this dilutes the OF values considerably.

The prediction shows a series of routes between glider sites and commonly used turning points. It also shows the application of masking for controlled airspace, Prohibited airspace and Danger Areas.

4.5 Scenario 3

4.5.1 Overview

As previously mentioned, the objective of this scenario was to validate the model's ability to take account of airspace changes. The imposition of Temporary Restricted Airspace (TRA) around Farnborough for the 2010 Farnborough Air Show (see map at Annex D) was chosen for the scenario. The objective was to assess how well the model predicted changes to activity in Class G airspace following the imposition of a change to the existing airspace. As with the other validation scenarios, NATS radar data was used to provide an indication of actual traffic.

On the day in question, Wednesday 21 July, the airspace restrictions did not come into effect until 1315 hours to coincide with the flying display at the Farnborough Air Show. It is therefore possible to view the effect the TRA had on local traffic operating in the surrounding Class G airspace by comparing the level of activity in the morning with that of the afternoon. Consequently, the period 1100-1200 UTC was used to represent the 'before' case and the period 1400-1500 UTC was used to represent the 'after' case.

4.5.2 Weather Conditions

The following historical weather records were obtained for Farnborough Airport:

Wednesday 21 July, 2010.

Time (UTC)	Temp (℃)	Dew Point (℃)	Wind Speed	Wind Direction	Visibility	Cloud Coverage	Cloud Base
0820	17	12	9 kt	SW	>10km	2/8	1,500 ft
1120	20	10	11 kt	SW	>10km	3/8	4,000 ft
1420	22	8	12 kt	SW	>10km	Nil	N/A
1720	21	11	14 kt	SW	>10km	Nil	N/A

These 1120 and 1420 weather conditions were used by the model for the respective predictions.

4.5.3 Radar Data

The radar data was processed as before (see section 4.3.2).

Figure 4-7 shows the smoothed radar data for 1100-1200 UTC on Wednesday 21 July, 2010 (i.e. before the activation of Temporary Restricted Airspace). Figure 4-8 shows smoothed data for the same area for 1400-1500 UTC (i.e. during the airspace restrictions).

These images are shown together on page 44 to allow differences to be compared. A ‘log’ scale has been chosen for these images to accentuate the detail.

The differences between the images can be summarised as follows:

Lasham:	Less activity taking place in the afternoon. The afternoon traffic appears to have been re-distributed to the south and west, presumably in the knowledge of the restrictions put in place around Farnborough.
Farnborough:	The afternoon image show intense activity at Farnborough, which is almost certainly Air Show traffic, legitimately operating inside the Restricted Airspace.
Dunsfold:	The activity seen in the morning is not present in the afternoon. This is thought to be a coincidence, and not related to the Farnborough airspace restrictions.
South of R104:	The afternoon image shows an absence of activity in the diamond shaped area to the south of R104. This is usually a busy operating area for general aviation, and the reduction in activity cannot be explained in this instance.

4.5.4 Predicted Activity

Figure 4-9 (page 46) shows the predicted activity in the Farnborough area between 1100 and 1200 UTC on Wednesday 21 July before the activation of Temporary Restricted Airspace. This shows moderate levels of activity at Lasham, Odiham, Blackbushe, and White Waltham.

Figure 4-10 (page 46) shows the predicted activity for 1400-1500 UTC the same day, after the activation of airspace restrictions.

The main effect of the airspace is to suppress all activity at Blackbushe, and to re-distribute the Lasham activity around the northwest and southwest segments of the TRA boundary. As a result of the re-distribution, there is an increase to the predicted level of traffic operating in the area north of Blackbushe, and west of the Heathrow CTR.

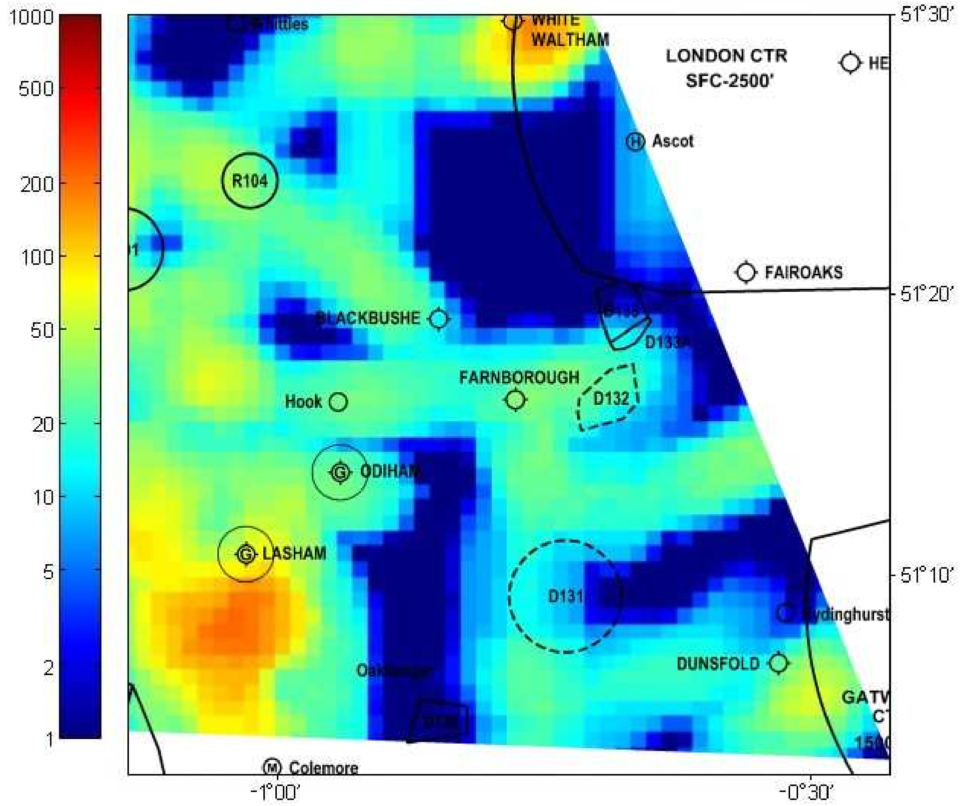


Figure 4-7: Smoothed radar data, 1100-1200 UTC, 21 July 2010 ('log' scale)

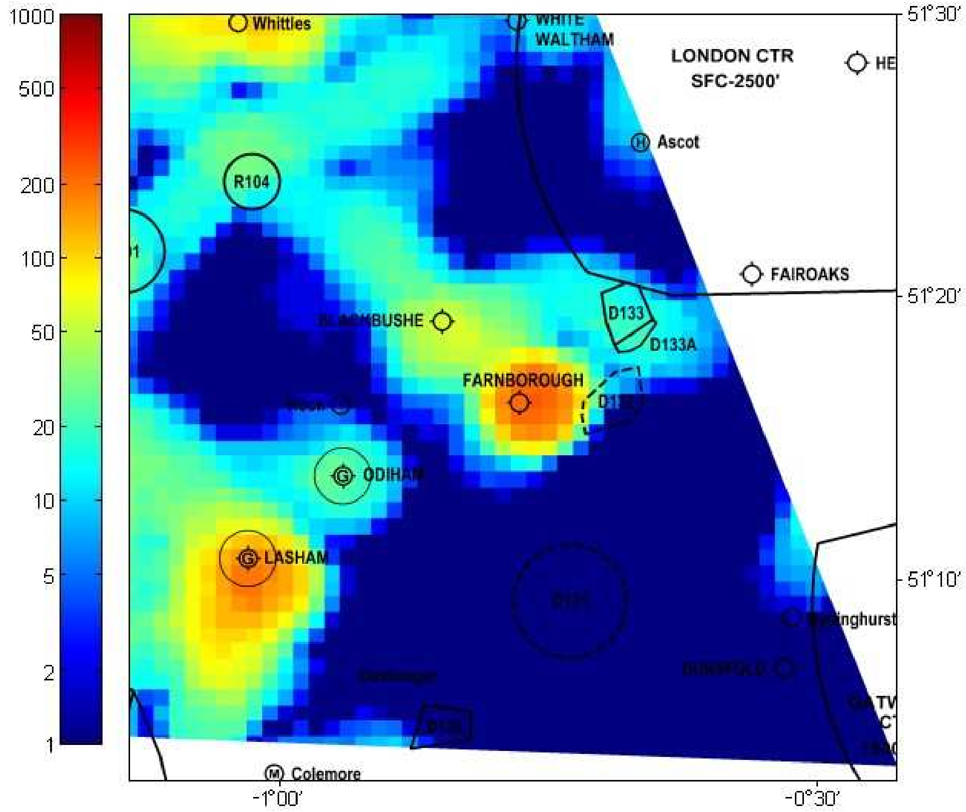


Figure 4-8: Smoothed radar data, 1400-1500 UTC, 21 July 2010 ('log' scale)

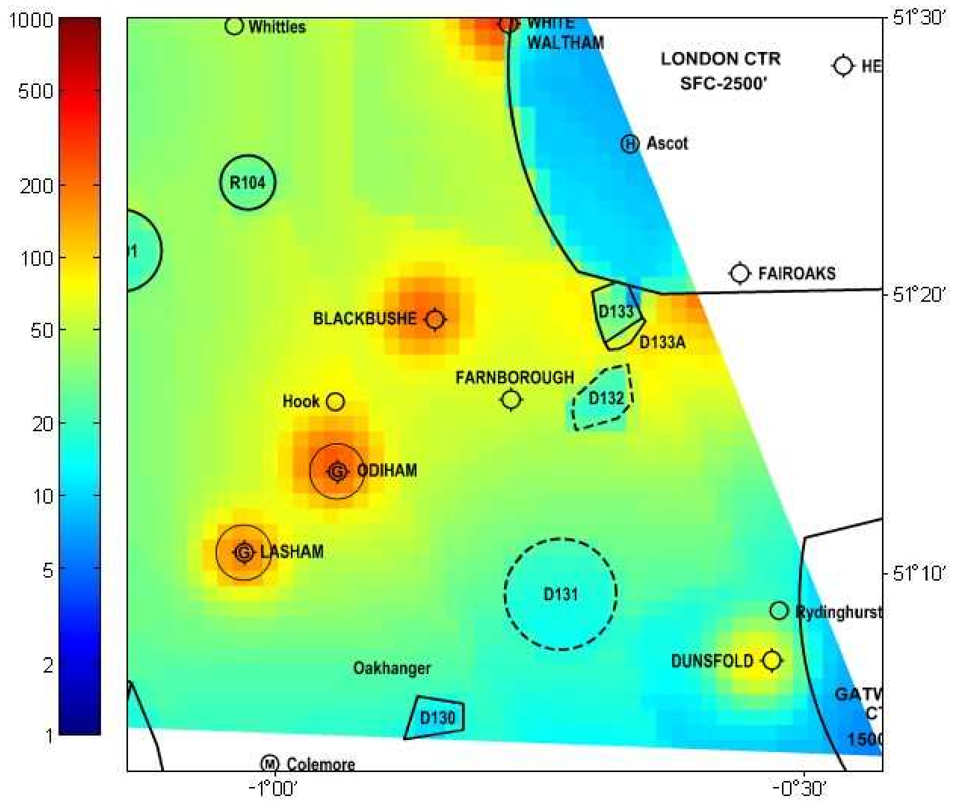


Figure 4-9: Predicted Level of Activity, 1100-1200 UTC, 21 July 2010 ('log' scale)

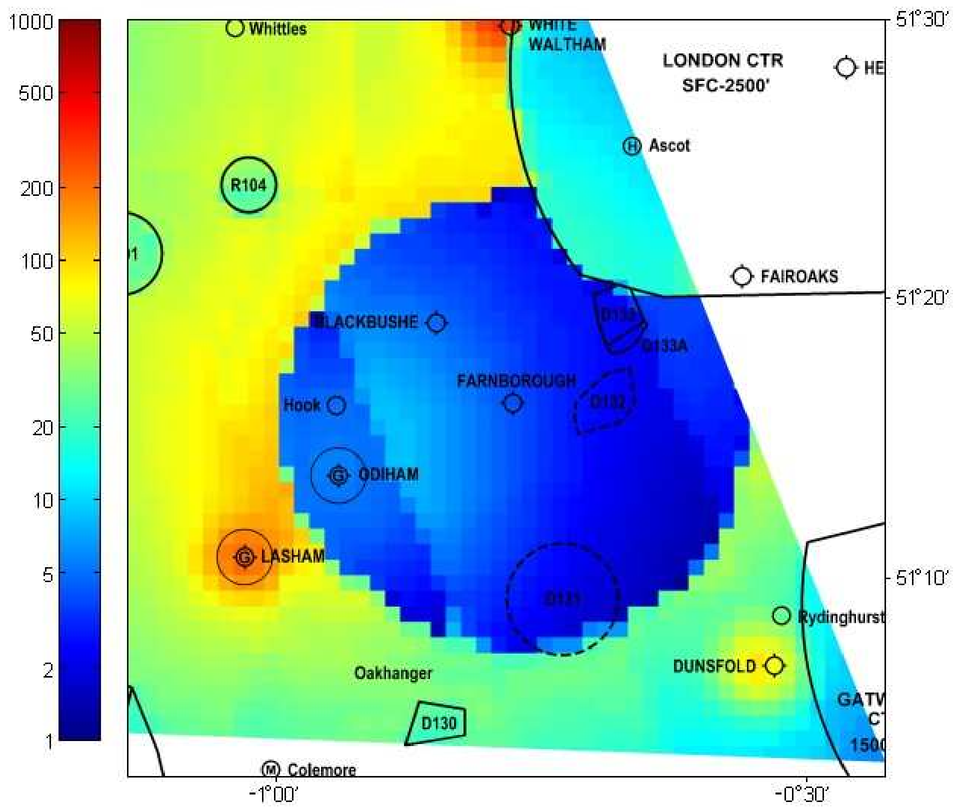


Figure 4-10: Predicted Level of Activity, 1400-1500 UTC, 21 July 2010 ('log' scale)

5 Observations

5.1 Prediction of Activity Patterns and 'Hot Spots'

From the Scenario 1 and 2 validation exercises, the model output appears to correspond well with radar data and glider GPS data in so far as indicating the relative level of activity taking place across the area of interest.

The model shows very high activity levels in the airspace immediately adjacent to the Heathrow CTR, not surprisingly caused by a high density of general aviation airfields, each with significant numbers of resident aircraft. The problem is exacerbated by the need for these aircraft to remain below the TMA, typically 2,500 ft QNH, and a minimum of 1,000 ft above built-up areas (of which there are many – depicted as yellow areas on the VFR chart excerpt, see Figure 1-1).

Within the area of interest, there is also clear evidence of a north-south flow of traffic routing between Brize Norton and Benson and either Lasham (for gliders), and Popham (for powered aircraft) which may then continue towards the South Coast/Isle of Wight, or route west towards airfields such as Thruxton and Old Sarum.

It is interesting to note that the predicted level of activity rapidly increases within 2-3 NM of an airfield (i.e. the ATZ). Within such distances, ten fold or more increases in traffic densities are not uncommon, and this emphasises the hazards associated with over-flying busy airfields or glider sites.

From radar data it can be seen that traffic associated with airfields whose ATZs are either inside or overlap with controlled airspace, routinely enter controlled airspace in order to join the visual circuit. The model needs to be modified on a case-by-case basis to reflect such practices rather than apply general rules for the airspace each category of aircraft will penetrate.

With regard to the Scenario 3 validation exercise, there appear to be several unexpected (and potentially complex) factors influencing the re-distribution of traffic patterns whilst the Airshow restrictions were in place. Whilst the model performed in the way that was expected, it did not accurately reflect the traffic patterns that were observed on radar. With hindsight, the very temporary nature of the airspace changes modelled in this scenario may not have been a good choice for assessing the way in which traffic re-distributes itself in the light of a permanent airspace change.

The use of a 'log' scale to view output data has proved extremely valuable, given the range of OF values that typically exist. Whilst standard 'linear' images can be used to show the more obvious 'hot spots' in the vicinity of airfields, the use of a 'log' scale is considered to be more useful and easier to interpret since it allows the detail and structure away from the hotspots to be observed.

In addition, it would be useful to be able to view routing traffic independently of local (return-to-base) traffic. By suppressing the dominant return-to-base traffic, it should be possible to get a clearer picture of the areas used by routing traffic, and associated hotspots.

5.2 Accuracy

Table 5-1 lists the peak OF values obtained at various locations from smoothed radar and model predictions in Scenario 1. Given the low certainty factors associated with predicting activity over such a short time period, and the number of assumptions that have been made in the modelling process, predicted OF values are remarkably close to the values derived from radar data.

A key point in this respect is the need to lengthen the time window if greater accuracy is a requirement. Prediction of activity over a week, month or year long period will inevitably be more accurate than any prediction for a single hour during a particular day.

Location	Date	Actual OF Value (smoothed radar)	Predicted OF Value	Difference
Wycombe Air Park	22 May	399	561	+40%
Lasham	22 May	243	385	+58%
Popham	22 May	131	254	+93%
Blackbushe	22 May	196	369	+88%
Abingdon	22 May	142	159	+12%
Lewknor	23 May	119	54	–54%

Table 5-1: Scenario 1 – Comparison of peak OF values

Whilst the values in the table would suggest that the model is over-estimating, it should be borne in mind that the radar data may not include some of the smaller aircraft, particularly gliders or others of non-metal construction. Also, some aircraft will be operating below the radar coverage, particularly if they are just airborne or on final approach to land.

Given these factors, and the limited set of data available relating to activities at smaller civil airfields in the pilot study area, this result would appear to be well within the range of acceptability.

5.3 Shortcomings and Limitations

A significant number of minor civil airfields did not respond to the site survey questionnaire, and as a result, little detail is known about activities and operating patterns at these airfields. Such additional information would greatly enhance the accuracy of the model, and the ability to show routing traffic in more detail.

It is also recognised that very little knowledge has been obtained relating to commercial multi-engine activity. Whilst the number of aircraft in this category is small, some perform specific, predictable tasks for long periods of time, and such activity could be significant if accurately modelled.

The model is currently only capable of outputting OF for a given hour-long period on any day. The ability to view accumulated OF over a full day, month or year would be extremely useful as it can show the overall importance of Class G airspace (i.e. the 'carpet wear' model). Similarly, the ability to predict the number of flights passing through each kilometre square may be a useful additional metric. These enhancements are entirely feasible, and could be developed with modest additional effort.

A current limitation of the model is the amount of data that has to be handled, and the time required to perform simulations. This is due to the use of off-the-shelf analytical software applications, and as a consequence, most simulations take several minutes to complete using a fast PC and locally stored data files. Any development of the model's capability, or increase to the size of the area modelled would require a dedicated database management tool.

Finally, the model is presently unable to display the proportion of use by individual user categories at each altitude band. A more complex graphical interface should enable this information (which has already been calculated as part of the modelling process) to be displayed.

6 Conclusions

This feasibility study has shown that the activity that takes place within Class G airspace is sufficiently well understood and predictable in its nature, such that the level of activity at any time can be calculated (using computer modelling techniques) with a fair degree of accuracy. More significantly, modelling can identify activity hot spots, and areas where higher than usual levels of activity warrant extra vigilance on the part of pilots with regard to application of ‘see and avoid’.

The modelling performed only attempted to predict activity over an hour-long period for a given set of weather conditions. With hindsight, the ability to also predict activity over a much longer period would be useful to understand the strategic importance of Class G airspace, and should provide greater accuracy.

Whilst the principles applied are straight forward and relatively simple, significant volumes of data are required, and this has implications both in terms of time to gather the data, and processing requirements (i.e. computer performance). Such issues need to be understood and quantified if attempting to model a much larger geographical area. However, there is no reason why, with the right technical approach, such modelling could not be performed on a much larger scale. This would have the added advantage of increased accuracy, given that a greater proportion of visiting/transiting aircraft would originate from within the geographical area modelled.

Related to this issue is the approach adopted to gather data. The on-line survey was particularly successful with high participation levels, and good quality data provided. The same was true of the long answer surveys and military site surveys. However, a very poor response rate (less than 10%) was experienced for the civil site surveys, and this is a concern given the propensity of such sites. An improved method for capturing site data (e.g. site visits or telephone interviews), and in particular the number of movements and land away destinations for each airfield would greatly enhance the overall performance and accuracy.

A valuable by-product of this project is the assimilation of data from a wide variety of airspace users, relating to how, when and where they utilise Class G airspace. By collating this data and sharing it with airspace users at large, many airspace users will gain a better understanding of other activities taking place in the airspace they use.

ANNEX A. LIST OF SITES

Site No.	Site Name	OS Coordinates (X,Y)	
01	Abingdon	447369	198970
02	Alton Barnes	412933	164442
03	Aylesbury (Thame)	473207	209104
04	Benson	462735	191073
05	Blackbushe	480403	158933
06	Boscombe Down	417768	139242
07	Bourne Park	437969	152011
08	Brimpton	457682	165307
09	Brize Norton	428837	205782
10	Chalgrove	463344	197699
11	Challow Hill Farm	436433	190105
12	Charlton Clump	409994	154704
13	Chilbolton	440583	137517
14	Chiltern Park	461811	184499
15	Chinnor	476700	200600
16	Clench Common	418721	165640
17	Colemore Common	469498	129484
18	Combe	436200	162300
19	Drayton St. Leonards	460546	196515
20	Dunsfold	502268	136278
21	Fairford	414615	198306
22	Fairoaks	500464	161976
23	Farnborough	485451	153676
24	Firs Farm	444294	174992

Site No.	Site Name	OS Coordinates (X,Y)	
25	Golden Ball	412700	163800
26	Halton	487146	211180
27	Hampstead Norris	454767	177540
28	Harpsden Park	476440	180749
29	Hook	473803	153495
30	Horespath	456502	205181
31	Kirdford	500666	127846
32	Lasham	467854	143439
33	Lewknor	470977	197547
34	Liddington Castle	420800	179800
35	Lyneham	400559	178470
36	Manor Farm (Wilts)	403601	127851
37	Manton	415797	169949
38	Membury	430805	175393
39	Middle Wallop	430352	138262
40	Milk Hill	410050	164100
41	Netheravon	417231	149935
42	Oakley	463938	209961
43	Odiham	473904	148862
44	Old Sarum	415200	133300
45	Oxford	446949	215595
46	Popham	453471	144178
47	Redlands	421670	184058
48	Rivar Hill	431927	160626

Site No.	Site Name	OS Coordinates (X,Y)	
49	Rybury	408400	163700
50	Rydinghurst Farm	503152	139687
51	Sandhill Farm	422605	189493
52	South Cerney	405569	198752
53	Springfield Farm	439244	197695
54	Sugar Hill	423800	178600
55	Tan Hill	408500	164600
56	Thruxton	428037	145775
57	Uffington	430200	186800

Site No.	Site Name	OS Coordinates (X,Y)	
58	Upavon	415206	154192
59	Upper Lambourne	429500	180900
60	Water Eaton	415090	193544
61	White Waltham	485161	178700
62	Whittles	467103	178392
63	Wroughton	413823	178655
64	Wycombe Air Park	482612	190987
65	Yatesbury	406951	170547

ANNEX B. AIRCRAFT USE CATEGORIES

Category	Aircraft	Type of Use
A4	Airship	Commercial
B1	Balloon	Private
B2	Balloon	Syndicate
B4	Balloon	Commercial
G1	Glider	Private
G2	Glider	Syndicate
G3	Glider	Flying Club
T3	Glider Tug	Flying Club
GY1	Gyrocopter	Private
GY2	Gyrocopter	Syndicate
GY3	Gyrocopter	Flying Club
HG1	Hang Glider	Private
HG2	Hang Glider	Syndicate
HG3	Hang Glider	Flying Club
HS1	Helicopter (Single Engine)	Private
HS2	Helicopter (Single Engine)	Syndicate
HS3	Helicopter (Single Engine)	Flying Club
HS4	Helicopter (Single Engine)	Commercial
HT1	Helicopter (Twin Engine)	Private
HT2	Helicopter (Twin Engine)	Syndicate
HT3	Helicopter (Twin Engine)	Flying Club
HT4	Helicopter (Twin Engine)	Commercial
MF1	Microlight (Flex Wing)	Private
MF2	Microlight (Flex Wing)	Syndicate
MF3	Microlight (Flex Wing)	Flying Club

Category	Aircraft	Type of Use
MA1	Microlight (3-Axis)	Private
MA2	Microlight (3-Axis)	Syndicate
MA3	Microlight (3-Axis)	Flying Club
ME5	Military (Elementary)	Military
MB5	Military (Basic)	Military
MH5	Military (Helicopter)	Military
MT5	Military (Transport)	Military
MJ5	Military (Fast Jet)	Military
FL1	Motor Paraglider	Private
FL2	Motor Paraglider	Syndicate
FL3	Motor Paraglider	Flying Club
PD3	Parachute Dropping	Flying Club
PG1	Paraglider	Private
PG3	Paraglider	Flying Club
MG1	SLMG	Private
MG2	SLMG	Syndicate
MG3	SLMG	Flying Club
LS1	Light Single (450-5700kg)	Private
LS2	Light Single (450-5700kg)	Syndicate
LS3	Light Single (450-5700kg)	Flying Club
LS4	Light Single (450-5700kg)	Commercial
LT1	Light Twin (<5700kg)	Private
LT2	Light Twin (<5700kg)	Syndicate
LT3	Light Twin (<5700kg)	Flying Club
LT4	Light Twin (<5700kg)	Commercial

Category	Aircraft	Type of Use
TC2	Multi-Engine (>5700kg)	Syndicate
TC3	Multi-Engine (>5700kg)	Flying Club
TC4	Multi-Engine (>5700kg)	Commercial

Category	Aircraft	Type of Use
VB1	Vintage/Bi-plane	Private
VB2	Vintage/Bi-plane	Syndicate
VB3	Vintage/Bi-plane	Flying Club

ANNEX C. ASSUMED SITE ACTIVITY

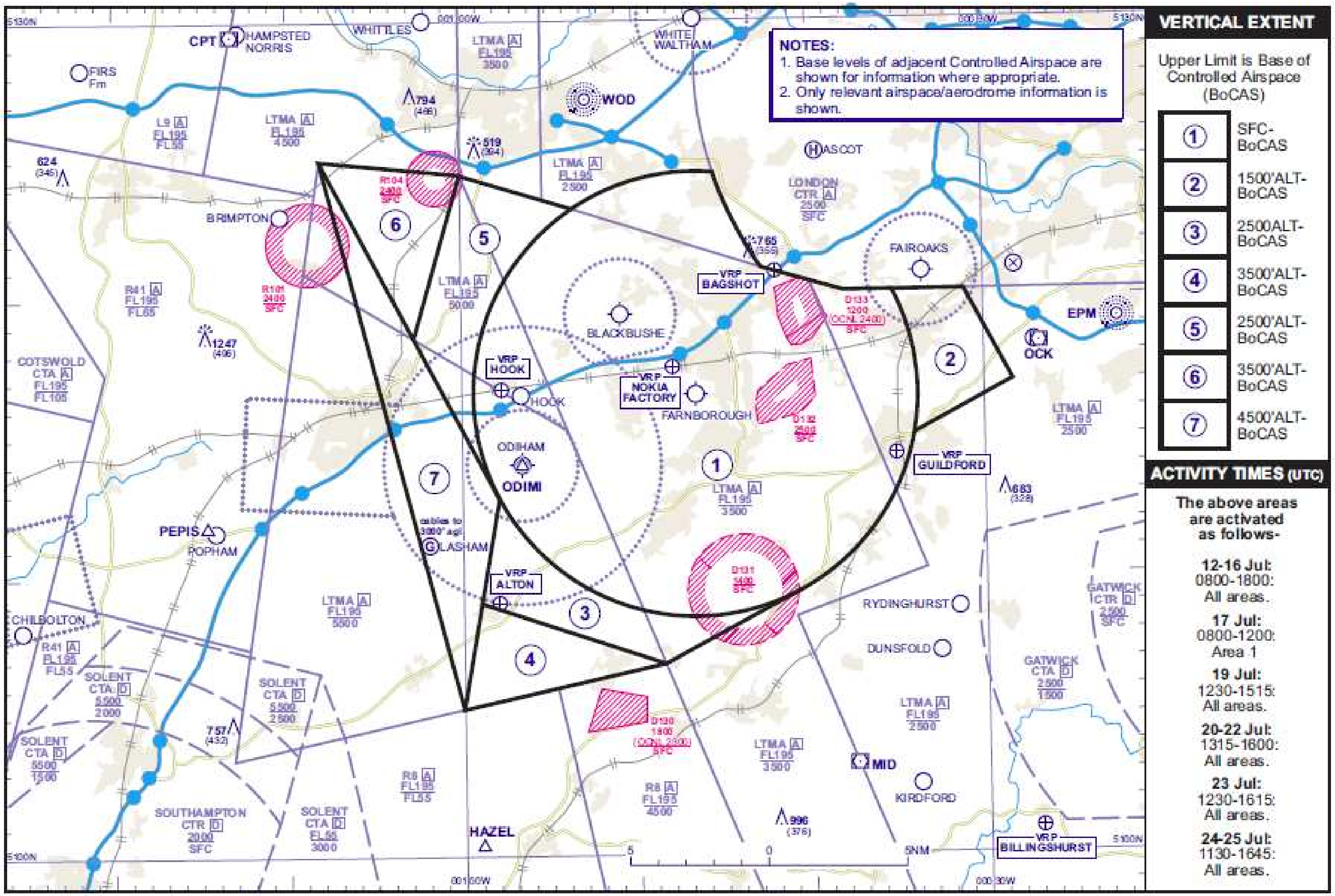
Site ID	A4	B1	B2	B3	B4	G1	G2	G3	T3	GY1	GY2	GY3	HG1	HG2	HG3	HS1	HS2	HS3	HS4	HT1	HT2	HT3	HT4	MF1	MF2	MF3	MA1	MA2	MA3
01																													
02													X																
03						X		X	X																				
04										X		X				X							X						
05										X						X		X					X						
06																													
07																X	X												
08																								X	X		X	X	
09																													
10																													
11													X																
12													X																
13										X														X			X	X	
14																											X	X	
15																													
16										X														X	X	X	X	X	X
17										X														X			X		
18																													
19																													
20																X							X						
21																													
22																X		X									X		
23																													
24																													
25																													
26						X		X	X																				
27																													
28																													
29																								X			X	X	
30													X																
31																								X			X		
32						X		X	X																				
33																													

Site ID	A4	B1	B2	B3	B4	G1	G2	G3	T3	GY1	GY2	GY3	HG1	HG2	HG3	HS1	HS2	HS3	HS4	HT1	HT2	HT3	HT4	MF1	MF2	MF3	MA1	MA2	MA3
34																													
35																													
36																													
37																								X					
38																													
39																													
40													X																
41																													
42																								X			X		
43								X	X																				
44												X												X	X		X	X	
45																X		X	X	X			X						
46																								X			X	X	
47																								X	X	X	X	X	X
48						X		X																					
49													X																
50																													
51						X		X	X																				
52																													
53																													
54																													
55																													
56																X		X	X				X				X		
57													X																
58						X		X	X																				
59																													
60																								X					
61																X													
62																													
63																								X					
64						X		X	X							X		X	X				X					X	
65																								X	X		X	X	

Site ID	ME5	MB5	MH5	MT5	MJ5	FL1	FL2	FL3	PD3	PG1	PG3	MG1	MG2	MG3	LS1	LS2	LS3	LT1	LT2	LT3	LT4	TC1	TC2	TC3	TC4	VB1	VB2	VB3
01	X														X													
02										X																		
03																												
04	X		X												X	X	X	X										
05															X	X	X	X	X	X	X							
06	X	X	X	X	X											X	X		X									
07															X	X										X	X	
08												X			X	X										X		
09																	X											
10																												
11										X																		
12										X																		
13															X													
14																X												
15											X																	
16																												
17						X																						
18										X																		
19						X									X													
20															X	X		X							X			
21																												
22															X	X	X	X	X	X								
23																	X											
24															X													
25										X																		
26	X											X		X			X											
27												X			X													
28															X	X												
29												X			X											X		
30																												
31																		X										
32												X		X														
33									X																			

Site ID	ME5	MB5	MH5	MT5	MJ5	FL1	FL2	FL3	PD3	PG1	PG3	MG1	MG2	MG3	LS1	LS2	LS3	LT1	LT2	LT3	LT4	TC1	TC2	TC3	TC4	VB1	VB2	VB3
34										X																		
35				X													X											
36																X												
37																												
38															X													
39	X		X														X											
40										X																		
41									X																			
42																		X										
43	X		X											X														
44														X	X	X	X	X								X	X	
45															X	X	X				X				X			
46															X	X				X						X	X	
47									X																			
48																												
49																												
50															X											X		
51																												
52																												
53															X													
54										X																		
55										X																		
56															X	X	X	X		X	X					X	X	
57										X																		
58														X														
59						X				X																		
60																												
61															X	X	X			X						X	X	
62															X													
63																										X		
64												X		X	X	X	X	X		X	X					X		
65																												

ANNEX D. FARNBOROUGH TEMPORARY AIRSPACE RESTRICTIONS



ANNEX E. ACTUAL CROSS-COUNTRY GLIDER ACTIVITY (2009)