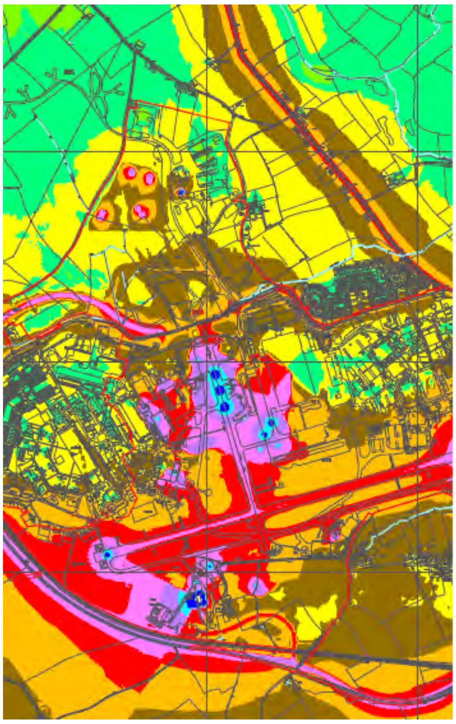
Department of Environment Northern Ireland

Provision of Second Round Noise Maps for Northern Ireland

Noise Mapping of Belfast City Airport



21 February 2013

AMEC Environment & Infrastructure UK Limited

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Department of Environment Northern Ireland

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21 February 2013

AMEC Environment & Infrastructure
UK Limited

Report for

Laura Duggan
Environment Executive,
George Best Belfast City Airport
Belfast
BT3 9JH

Dan Kennedy and Amy Holmes,
Air and Environmental Quality Unit,
Environmental Policy Unit,
Department for the Environment,
6th Floor, Goodwood House,
44-58 May Street,
Belfast,
BT1 4NN

Main Contributors

James Trow
Neil Webster

Issued by

....
Neil Thurston

Approved by

....
Ian Hepplewhite

AMEC Environment & Infrastructure UK Limited

Canon Court, Abbey Lawn, Abbey Foregate,
Shrewsbury SY2 5DE, United Kingdom
Tel +44 (0) 1743 342 000
Fax +44 (0) 1743 342 010

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Executive Summary

This document outlines the processes which have been adopted to develop the airport noise model for George Best Belfast City Airport (BCA) as used within Round Two of noise mapping within Northern Ireland under the Environmental Noise Regulations (Northern Ireland) 2006. The results of the noise mapping process are also presented.

This document aims to give the Northern Ireland Department of the Environment (DoE) and BCA an understanding of the model development process including data capturing and processing, development of the noise model and related QA procedures.

The report begins with providing an introduction to the requirements of the mapping exercise (Section 1) and outlining the extents of the Round Two data capture areas (Section 2). This provides the setting for the specific calculation methods used to develop the Round Two airport noise model for BCA (Section 3) and the data requirements needed to develop the final noise model maps (Section 4).

The report outlines the work which was undertaken to review the datasets used during the Round One mapping exercise and to identify new data for use within Round Two (Section 5). This includes confirming airfield definitions; average meteorological conditions; route definitions; ground terrain around the airport; and reviewing 2011 air traffic movements and modal splits. Each of these layers has been imported into the new INM model developed for Round Two. This section also outlines the automated and manual checks which were completed to ensure that the final datasets are both ‘fit for purpose’ and optimised for the final modelling exercise.

Section 6 of the report covers the final calculation and processing settings which have been used to run the INM modelling environment. This includes providing further details of the efficiency settings, calculation settings; and computational environment used in the modelling processes. The section concludes by outlining the post-processing steps which have been adopted to produce the final modelling outputs.

The final sections of the report (Section 7-9) detail the preliminary results of the Round Two noise exposure analysis for BCA. This includes providing area analysis of the different noise levels with the more detailed analysis of population and dwelling noise exposure (Sections 7 and 8). This provides the context for the final Section (Section 9) which provides an assessment of the key differences between the outputs of Round One and Round Two mapping exercises.

Contents

Glossary

Term	Definition
Agglomeration	Major Continuous Urban Area as set out within the Regulations
AIP	Aeronautical Information Publication
AMEC	AMEC Environment and Infrastructure UK Limited
ArcGIS	GIS software package produced by ESRI
ASL	Above Sea Level
Attribute Data	A trait, quality, or property describing a geographical feature, e.g. vehicle flow or building height
Attributing (Data)	The linking of attribute data to spatial geometric data
BCA	Belfast City Airport
BIA	Belfast International Airport
CORINE land cover 2000	Coordination of Information for the Environment (CORINE) land cover dataset last produced the UK in 2000
CRN	The Calculation of Railway Noise 1995. The railway prediction methodology published by the UK Department of Transport.
CRTN	The Calculation of Road Traffic Noise 1988. The road traffic prediction methodology published by the UK Department of Transport.
Data	Data comprises information required to generate the outputs specified, and the results specified
dB	Decibel
DEM	Digital Elevation Model
DoE	Department of Environment
DSM	Digital Surface Model
DTM	Digital Terrain Model
DWG/DXF	Autodesk Autocad Drawing (DWG) or Data Exchange File (DXF) format
EC	European Commission
EEA	European Environment Agency
EIONET	EIONET is a partnership network of the European Environment Agency (EEA) and its member and cooperating countries. The network supports the collection and organisation of data and the development and dissemination of information concerning Europe's environment
END	Environmental Noise Directive (2002/49/EC)
ENDRM	Environmental Noise Directive Reporting Mechanism
ENDRM DF8	Environmental Noise Directive Reporting Mechanism Data Flow 8
ESRI	Environmental Systems Research Institute
FDMI	Final Modified Data Inputs
GIS	Geographic Information System

Term	Definition
INM	Integrated Noise Model
Irish National Grid (ING)	The official spatial referencing system of Ireland
ISO	International Standards Organisation
KML/KMZ	Keyhole Markup Language (KML) is used to express geographic annotation and visualization within Internet-based, two-dimensional maps and three-dimensional Earth browsers. The file format is used within Google Earth and many GIS software packages.
Land Cover Map 2007 / LCM2007	CEH Land Cover Map 2007 depicting 23 individual land use classes across the UK.
LimA	Software product produced by Stapelfeldt for calculating noise levels
Metadata	Descriptive information summarising data
NTF	Ordnance Survey National Transfer Format
NISRA	Northern Ireland Statistics and Research Agency
Noise Bands	Areas lying between contours of the following levels (dB): L_{den} <55, 55 – 59, 60 – 64, 65 – 69, 70 – 74, >74 L_d <55, 55 – 59, 60 – 64, 65 – 69, 70 – 74, >74 L_e <55, 55 – 59, 60 – 64, 65 – 69, 70 – 74, >74 L_n <50, 50 – 54, 55 – 59, 60 – 64, 65 – 69, >69
Noise Levels	Free-field values of L_{den} L_d, L_e, L_n, and $L_{A10,18h}$ at a height of 4m above local ground level
Noise Level - L_d - Daytime	L_d (or L_{day}) = $L_{Aeq,12h(07:00 \text{ to } 19:00)}$
Noise Level - L_e - Evening	L_e (or $L_{evening}$) = $L_{Aeq,4h(19:00 \text{ to } 23:00)}$
Noise Level - L_n - Night	L_n (or L_{night}) = $L_{Aeq,8h(23:00 \text{ to } 07:00)}$
Noise Level - L_{den} – Day/Evening/Night	A noise rating indicator based upon Ld. Le and Ln as follows: L_{den} = 10 * lg 1/24 {12 * 10^((L_{day})/10) + 4 * 10^(($L_{evening}$+5)/10) + 8 * 10^((L_{night}+10)/10)}
Noise Level – $L_{A10,18h}$	$L_{A10,18h}$ = $L_{A10,18h}$ (06:00 to 24:00)
Noise Mapping (Input) Data	Two broad categories: (1) Spatial (e.g. road centre lines, building outlines). (2) Attribute (e.g. vehicle flow, building height – assigned to specific spatial data)
Noise Mapping Software	Computer program that calculates required noise levels based on relevant input data
Noise Model	All the input data collated and held within a computer program to enable noise levels to be calculated.
Noise Model File	The (proprietary software specific) project file(s) comprising the noise model
Output Data	The noise outputs generated by the noise model
OSNI	Ordnance Survey of Northern Ireland
Processing Data	Any form of manipulation, correction, adjustment factoring, correcting, or other adjustment of data to make it fit for purpose. (Includes operations sometimes referred to as 'cleaning' of data)
QA	Quality Assurance
Round One	Round One noise modelling for the European Noise Directive (Northern Ireland) - 2007

Term	Definition
Round Two	Round Two noise modelling for the European Noise Directive (Northern Ireland) - 2012
Shapefile	ESRI proprietary GIS dataset format. Contains both geometry to define features, and associated alphanumeric attribute information.
Spatial (Input) Data	Information about the location, shape, and relationships among geographic features, for example road centre lines and buildings.
Translink	The main public transport service provider for Northern Ireland
WG - AEN	Working Group – Assessment of Exposure to Noise

1. Introduction

1.1 Background

The Environmental Noise Regulations (Northern Ireland) 2006 (referred hereon in as the "Regulations") set out the requirements and responsibilities associated with the production of strategic noise maps and action plans as defined by European Directive 2002/49/EC (referred hereon in as the "Directive"). The Regulations set out the Competent Authorities who have been made responsible for producing noise maps and action plans. Under the Regulations, the Department of Environment (DoE) is named as the Authority responsible for overseeing the implementation of the Regulations. As the overseeing Authority, DoE decided that the noise mapping should be undertaken in a consistent manner and therefore let a single contract for the preparation of noise maps on behalf of the Competent Authorities.

AMEC Environment and Infrastructure UK Limited (AMEC) were commissioned to prepare noise maps for the Competent Authorities reporting directly to DoE. As part of the commission, AMEC have prepared noise maps, all associated population exposure data and supplementary reports as required under the Regulations and the Directive. The maps and reports will enable Northern Ireland to report the results of the mapping to the European Commission.

This project relates to the second round of noise mapping. Under the Regulations, noise maps and noise action plans must be prepared over a 5-year rolling cycle. The first round of noise mapping in Northern Ireland was undertaken and completed in 2007 using data representative of 2006. For reporting in 2012, the second round of mapping is being undertaken using data representative of 2011.

For the first round of mapping in 2007, the Regulations required the preparation of noise maps for the following:

- All major roads with more than 6 million vehicle passages per year;
- Major railways with more than 60,000 passages per year;
- Major airports with more than 50,000 movements per year;
- All agglomerations with more than 250,000 inhabitants.

Within agglomerations, the Regulations require the mapping of all road, railway, industry and airport noise sources regardless of the thresholds outlined above. For the second and subsequent rounds of mapping, the Regulations reduce the thresholds for which noise mapping and action planning should be prepared and reported to the following:

- All major roads with more than 3 million vehicle passages per year;
- Major railways with more than 30,000 passages per year;
- Major airports with more than 50,000 movements per year;

- All agglomerations with more than 100,000 inhabitants.

Under the Regulations, this project aims to establish estimates of the total number of people (in hundreds) living in dwellings that are exposed to major transportation noise sources and all transportation and industrial noise sources within agglomerations. The exposure estimates are for the L_{den} noise indicator calculated 4 metres above the ground and on the most exposed façade of a residential dwelling.

The L_{den} noise exposure statistics are required in the following bands: 55-59, 60-64, 65-69, 70-74 and >= 75. The total area (in km2) exposed to values of L_{den} higher than 55, 65 and 75 dB respectively, along with the estimated total number of dwellings (in hundreds) and the estimated total number of people (in hundreds) living in each of these areas must also be given and reported to the European Commission.

The same information is also required for the L_{night} indicator except reporting is necessary for noise level bands 5 dB lower than for L_{den}. Under the contract, noise level exposure statistics are also required for other supplementary noise indicators which are incumbent within national noise policy guidance.

The contract was delivered in two stages which are described below. This report documents work undertaken by AMEC for both stages of the contract

Stage 1 of the contract was undertaken to the following scope:

- Appraisal and quality assurance of the data provided by DoE and the Competent Authorities;
- Identification of gaps in order to define any further information requirements;
- Modifying and/or collecting further information through contractor survey. This includes any data cleaning and manipulation required to prepare the dataset for Stage 2;
- Collation of the data into relevant datasets;
- Preparation of Stage 1 report.

Stage 1 of the contract also included delivery of the following specific elements of work:

- Descriptions of the processes and approaches adopted for the collection, collation, validation, verification, integration and creation of the noise model;
- Description of the datasets to be generated;
- Detailed description of the noise modelling methodology to be applied to each noise source;
- Acceptable approximations and simplifications where appropriate;
- Software to be used (notably noise model and GIS software environments);
- Efficiency settings;
- Storage and backup of electronic data.

Stage 2 of the contract was undertaken to the following scope:

- Interrogation of the final datasets produced in Stage 1;
- Creating the digital model in an appropriate format;
- Calculating the defined noise data level outputs;
- Completing modelling, generating maps and reports;
- Presenting the final modified data, metadata and a technical manual for the modelling of industrial noise sources;
- Provision of a report in a suitable format specified by the Electronic Noise Data Reporting Mechanism as preferred by the Commission and suitable for uploading to EIONET.

1.2 Purpose of this Report

This report details the processes used to develop the Round Two airport noise model for Belfast City Airport (BCA). The aim of this report is to provide BCA and DoE with an understanding of the processes involved in the development of the noise model and the datasets which have used to support the assessment of noise for the second round of mapping. The results of the mapping are also presented.

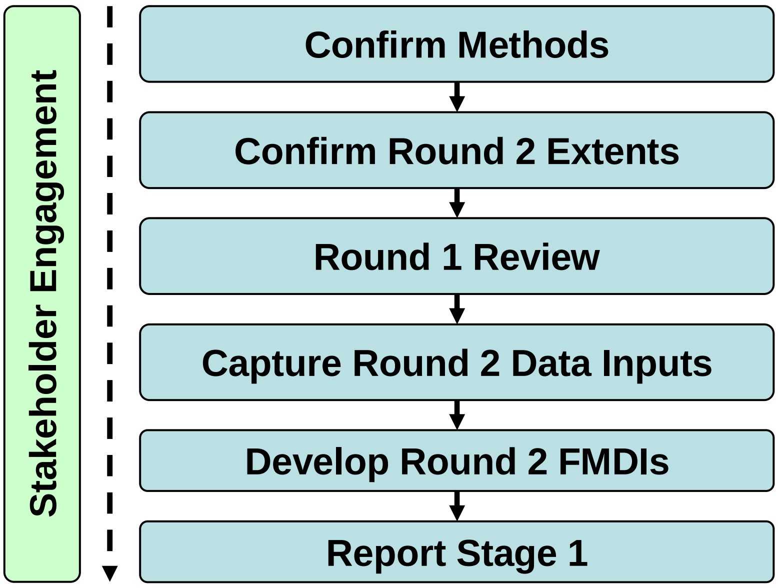
1.3 Overview of the Second Round Approach

Under the contract let by DoE, the second round of mapping was split into two stages as outlined as follows.

1.3.1 Stage 1

The aim of Stage 1 was the successful development of Final Modified Data Inputs (FMDIs) designed to facilitate the noise mapping and reporting of noise exposure under the Regulations. Plate 1.1 presents an overview of Stage 1.

Plate 1.1 Overview of Stage 1



Stage 1 was structured to identify and ensure that data inputs and information gathered and processed during the first round of mapping were where possible retained and utilised in the production of noise maps for the second round.

The process was initiated through confirming the methods to be used for the mapping and confirmation of the second round extents. This was followed by a review of the first round datasets and the information used in their development with respect to the project extents and methods. Following this review, and where necessary, data capture exercises were undertaken.

This report does not explicitly report the findings of the Round One review. Instead the report outlines the results of the Round One review alongside all other relevant sections. For example, noise calculation environments and the preparation of various elements of the BCA noise datasets are discussed in relation to both the approach undertaken in Round One and the methodology adopted for Round Two.

1.3.2 Stage 2

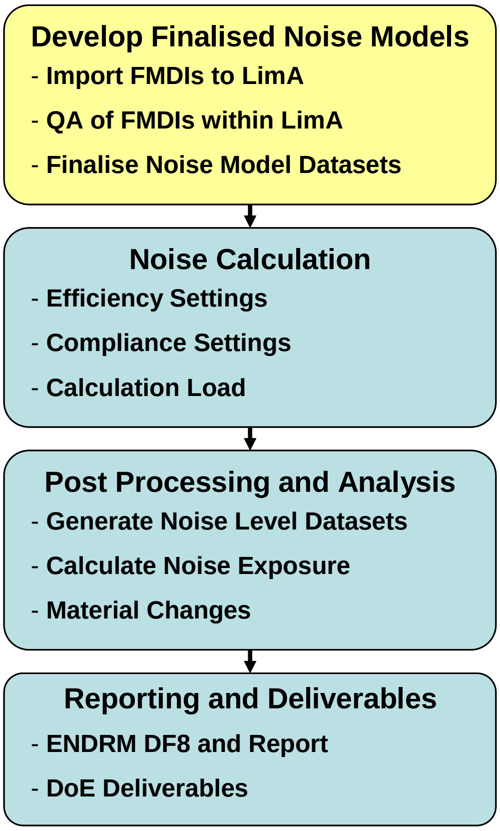
The aim and scope of Stage 2 was as follows:

- the development of digital noise models based upon the FMDIs developed during Stage 1;
- the production of second round noise maps including consolidated noise maps of road, rail, airport and industrial noise within the Belfast Agglomeration;
- generation of datasets identifying the total areas and populations within noise level bands as required by the Regulations and the Directive;

- provision of suitable Environmental Noise Directive Report Mechanism (ENDRM) Data Flow 8 (DF8) reporting and associated technical reports for submission to the Commission through the EIONET.

Plate 1.2 presents an overview of the Stage 2 process.

Plate 1.2 Overview of Stage 2



2. Mapping Extents

Under the Environmental Noise Regulations (Northern Ireland) 2006, Round Two noise maps in relation to airport noise must encompass:

- Major airports with more than 50,000 movements per year;
- All agglomerations (including road, railway, industrial and airport noise sources) with more than 100,000 inhabitants.

The remainder of this section details the extent of the Round Two data capture for BCA under the Regulations. Maps showing the geographical extent of the areas are also provided in Plates 2.1 – 2.2.

2.1 Agglomeration Modelling Extent

The only agglomeration considered in Round Two is the Belfast agglomeration, as defined in the Regulations. The Belfast agglomeration is presented in Plate 2.1 and has an approximate area of 198km^2. Data currently available for 2008 shows the Belfast Urban Metropolitan Areas has a total population of 267,742. The Agglomeration was considered in Round One due its population exceeding the Round One threshold of 250,000. The extents of the Agglomeration for Round Two are the same as for Round One.

A review of potential agglomerations qualifying for Round Two has also been undertaken for completeness. Data obtained from the Northern Ireland Statistics and Research Agency (NISRA) for 2008 shows that the second largest urban area in Northern Ireland is the Derry Urban Area. The Derry Urban Area has a population of 85,016 and therefore falls below the 100,000 threshold.

2.2 Belfast City Airport

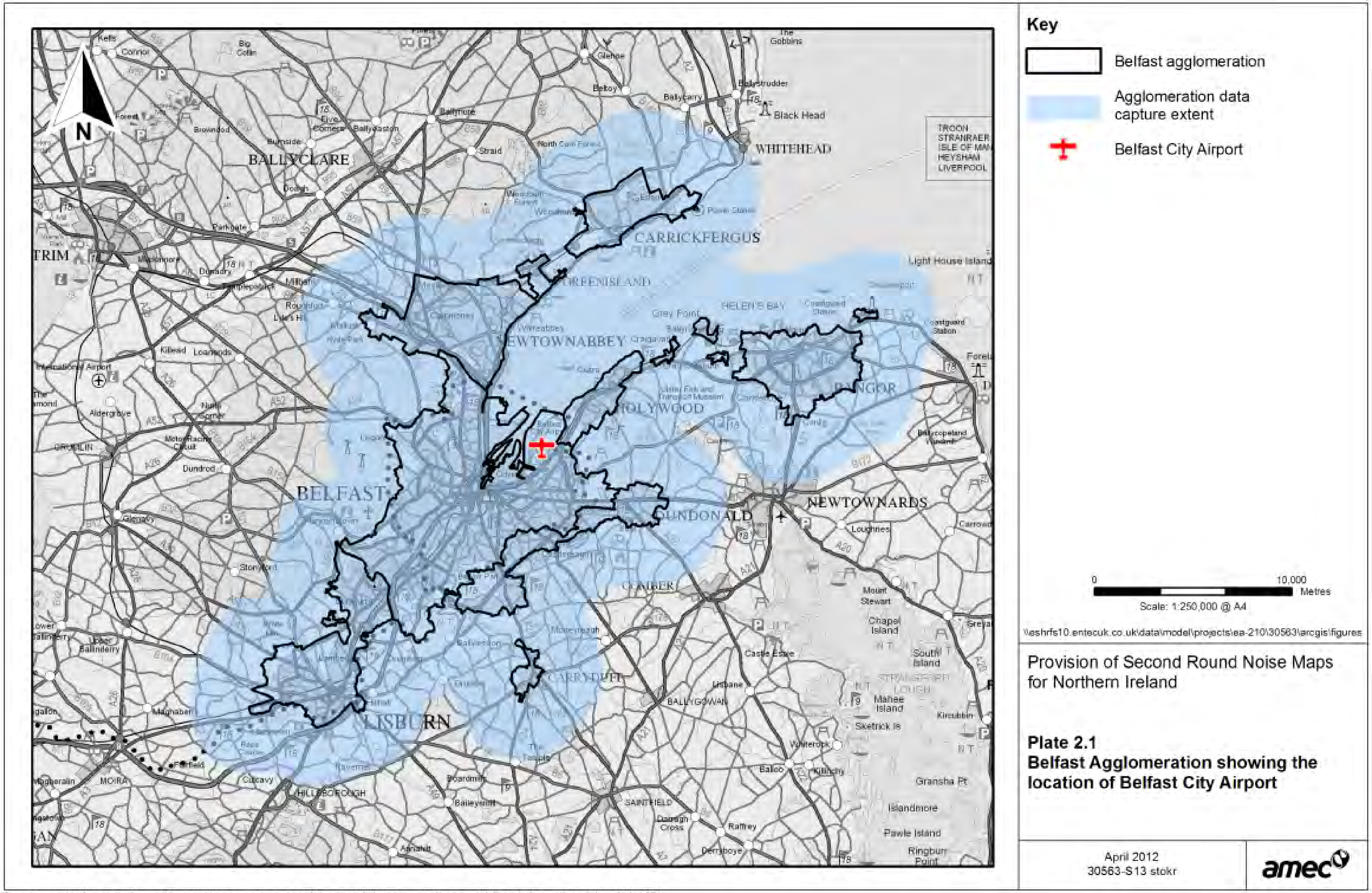
As BCA falls within the agglomeration boundary, it is to be considered as part of noise mapping in Northern Ireland and was considered during Round One. The airport's consideration is irrespective of the 50,000 movement 'major airport' threshold. The requirement to consider civil airports within agglomerations regardless of a movement threshold aligns with the Commission's for operators of 'City Airports' to manage and control noise from their operations. EC Directive 2002/30/EC in relation to the *"establishment of rules and procedures with regard to the introduction of noise-related operating restrictions at Community airports"* define a 'City Airport' as:

> *"an airport in the centre of a large conurbation, of which no runway has a take-off run available of more than 2000 metres and which provides only point-to-point services between or within European states, where a significant number of people are objectively affected by aircraft noise and where any incremental increase in aircraft movements represents a particularly high annoyance in the light of the extreme noise situation."*

To this extent Annex I of Directive 2002/30/EC names Belfast City Airport as a ‘City Airport’. On this basis, its inclusion within Round Two of strategic noise mapping is consummate with content of Directive 2002/30/EC.

Plate 2.1 presents the location of BCA in relation to the Belfast Agglomeration.

Plate 2.1 Belfast Agglomeration Showing the Location of Belfast City Airport



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3. Confirmation of Calculation Methods

3.1 Noise Calculation Method

Under the Regulations, the assessment method prescribed for the mapping of airport noise is outlined in Table 3.1. It is confirmed from a review of Round One that the same methods were adopted and applied during Round One.

Table 3.1 Methods of Assessment as Outlined in Schedule 2 of the Regulations

Assessment methods for aircraft noise indicators
8. For aircraft noise indicators the assessment method "Report on Standard Method of Computing Noise Contours around Civil Airports" (Second Edition, European Civil Aviation Conference, 2–3 July 1997)(g) shall be used in accordance with paragraph 2.4 of the Annex in the Recommendation.

For airport noise, the assessment for Round One was undertaken with reference to the *"Report on Standard Method of Computing Noise Contours around Civil Airports"* (Second Edition) (hereby referred to as ECAC Doc. 29v2) as implemented in the Federal Aviation Administrations (FAA) Integrated Noise Model (INM) version 6.2. For the Round Two, the method prescribed for airport noise is as described in *"Report on Standard Method of Computing Noise Contours around Civil Airports"* (Third Edition) (hereby referred to as ECAC Doc.29v3) as implemented in INM version 7 onwards.

The main change between the Second and Third Edition of the method within the INM model is the inclusion of additional functions and attenuations for bank angles, and the inclusion of new flight procedures and updated thrust reverser components. Key amendments between the Second and Third Editions of ECAC Doc 29 are outlined in Appendix H of Volume 2 of ECAC Doc 29v3. This documents changes in the consideration of lateral effects.

Changes do not however effect the requirements of the method in relation to 3D modelling and only terrain and geo-positioning information are required from the 3D modelling dataset prepared for the Round Two mapping exercise.

3.2 Software Methods

For Round One, the mapping of airport noise was undertaken using INM version 6.2a implementing ECAC Doc. 29v2. For the mapping of airport noise under Round Two, the project team are contracted to use INM version 7.0a or the latest version of the INM model implementing ECAC Doc29v3. The version of INM used for the mapping of airport noise is INM version 7.0b.

4. Dataset Specifications

4.1 Data Requirements

The development of an airport noise model requires several data inputs. Within the INM model, these inputs are clearly defined and can be split between those that relate directly to the airport and those that relate to air traffic movements. These data requirements are summarised in Table 4.1 and Table 4.2 below.

Table 4.1 Airport Data Requirements

Data	Description
Runway Centre Point	Centre point coordinate in latitude and longitude
	Elevation of runway centre point (m)
Runway End Points	Runway end points provided in km referenced from the runway centre point.
	Elevation of runway ends (m)
Runway Width	Width (m)
Take Off / Landing (per aircraft, destination and periods)	Start of roll coordinate referenced to centre point (km)
	Approach threshold coordinate relative to runway centre point (km)
	Glide slope (degrees)
	Threshold Crossing Height (m)
Average Airport Meteorological Conditions (historical – up to 20 years)	Wind Direction (for percentage of time)
	Average Airport Temperature (^{o}C)
	Average Pressure (mm Hg)
	Average Humidity (%)
	Average Headwind (km/h)
Actual Modal Split	Runway utilisation for the assessment period (%)
Standard Modal Split	Long-term runway utilisation (%)
Route Definitions (aircraft, route and period dependant)	Radar Track Data from Noise Track Keeping system (e.g. B&K, GEMS, Lochard)
	Plan View Drawing derived from a statistical distribution (CSV, DXF)
Terrain Data	Ground elevation data such as equal height contours (SHP, DXF)

Table 4.2 Air Traffic Movement Data Requirements

Data	Description
Movement Data (per aircraft)	Formatted Table of Movements against Aircraft
Arrival / Departure dates and times	S.O.R. (Start Of Roll - Not Stand Times)
	Provided in local time
Route	Departure Route provided per aircraft
	Arrival Route provided per aircraft
Destination	Destination of aircraft (used as an indication of fuel load)
	More critical for major aircraft, long haul and charter flights
	Runway
	Runway Direction
Aircraft types	ICAO (International Civil Aviation Organization) or IATA (Codes
	Engine variant details

4.2 Data Sources

Several data sources were available to the project team for Round Two. These are outlined in the following sections. A key data source for Round Two mapping was the Round One INM model. The use of the Round One model for the purposes of modelling in Round Two is discussed in Section 5.

4.2.1 Airport Data

Airfield Definitions and Airport Information

Airfield definitions and general airport information including procedures have been obtained from a number of sources including:

- BCA Airport Aerodrome Plan (reference: AD 2-EGAC-2-1);
- OSNI aerial and digital mapping data.

Airspace and Routes

Data regarding airspace and routes have been taken from the following:

- Standard Instrument Approach Charts;

- Departure procedures as defined within the airport's Aeronautical Information Publication (AIP);
- Graphical outputs of radar departure tracks provided by BCA; and
- Modelled routes as prepared by Bikerdike Allen Partners (BAP) for the preparation of Air Noise Contours for the Summer 2011 period.

Average Meteorological Conditions

Average meteorological conditions have been obtained from Belfast International Airport (BIA).

Terrain

Terrain data for BCA and its surroundings have been obtained from the OSNI 10m DTM product provided under licence for this contract.

4.2.2 Air Traffic Movement Data

Air traffic movements for the 2011 calendar year were obtained from BCA. The movements were provided in the form of flight records and outline movements in terms of aircraft type, and arrival or departure. The flight records also provide information such as flight destination and origin for departures and arrivals respectively.

5. Round Two Model Development

5.1 Reviewing the Round One Data Sources

As discussed in Section 4, a key data source for Round Two mapping was the Round One airport noise model for BCA which was obtained under contract from DoE. In addition to the Round One model, the project team also reviewed the technical documentation relating to the development of the Round One model, which included details of various data sources and assumptions employed in the model's development.

As part of the data capture exercise, the project team identified that it was likely that many of the data inputs required for Round Two may not have changed since Round One. In addition, the project team also identified a number of modelling improvements which would ultimately improve the accuracy of the outputs of Round Two.

From a review of the Round One model, the project team developed a data capture questionnaire for BCA. The main aim of the questionnaire was to identify elements of the modelling from Round One which could be retained for Round Two, and to identify areas where improvements could be made.

A data questionnaire was issued to BCA containing details of the data sources and assumptions employed during Round One. The data questionnaire contained 16 queries for BCA with regard to potential changes in airport operations between 2006 and 2011. The responses to these queries are discussed in the following sections along with the relevance of the Round One model.

5.2 Conversion from INM 6.2a to INM 7.0b

To facilitate the Round Two modelling of BCA, the project team converted the Round One model produced in INM6.2a to INM7.0b. The conversion was undertaken within INM7.0c using the software's built in conversion utility. During the conversion process, INM 7.0b warns of any aircraft records which are incompatible with INM 7.0b. No records were identified as being incompatible during the conversion process. Following conversion, the project team checked the geometry of the model to ensure that the conversion of all geometrical aspects had been undertaken successfully.

5.3 Airfield Definitions

As part of the data questionnaire, the project team queried the following issues with BCA:

- Has there been any change in the length of runway 04/22 since 2006?
- Have the thresholds of runway 04/22 changed since 2006?
- Can BCA issue the latest aeronautical changes for the airport to allow validation of the runway end points modelled during the first round?

BCA responded to these queries confirming that there had been no change in runway length or thresholds since 2006. In addition, the latest airport charts were provided to the project team along with the airport plan. The information provided by BCA was reviewed against the data held within the Round One INM model. From this review, it was identified that the runway ends were slightly misplaced with regards to the thresholds outlined in the airfield chart, as presented in Plate 5.1. As such, the project team amended the location of the runway thresholds within the model.

All airfield definitions and geometries were validated within a Geographic Information System (GIS) and projected within the Irish National Grid to ensure accurate alignment and position of the resulting air noise contours when overlain with base mapping and population data.

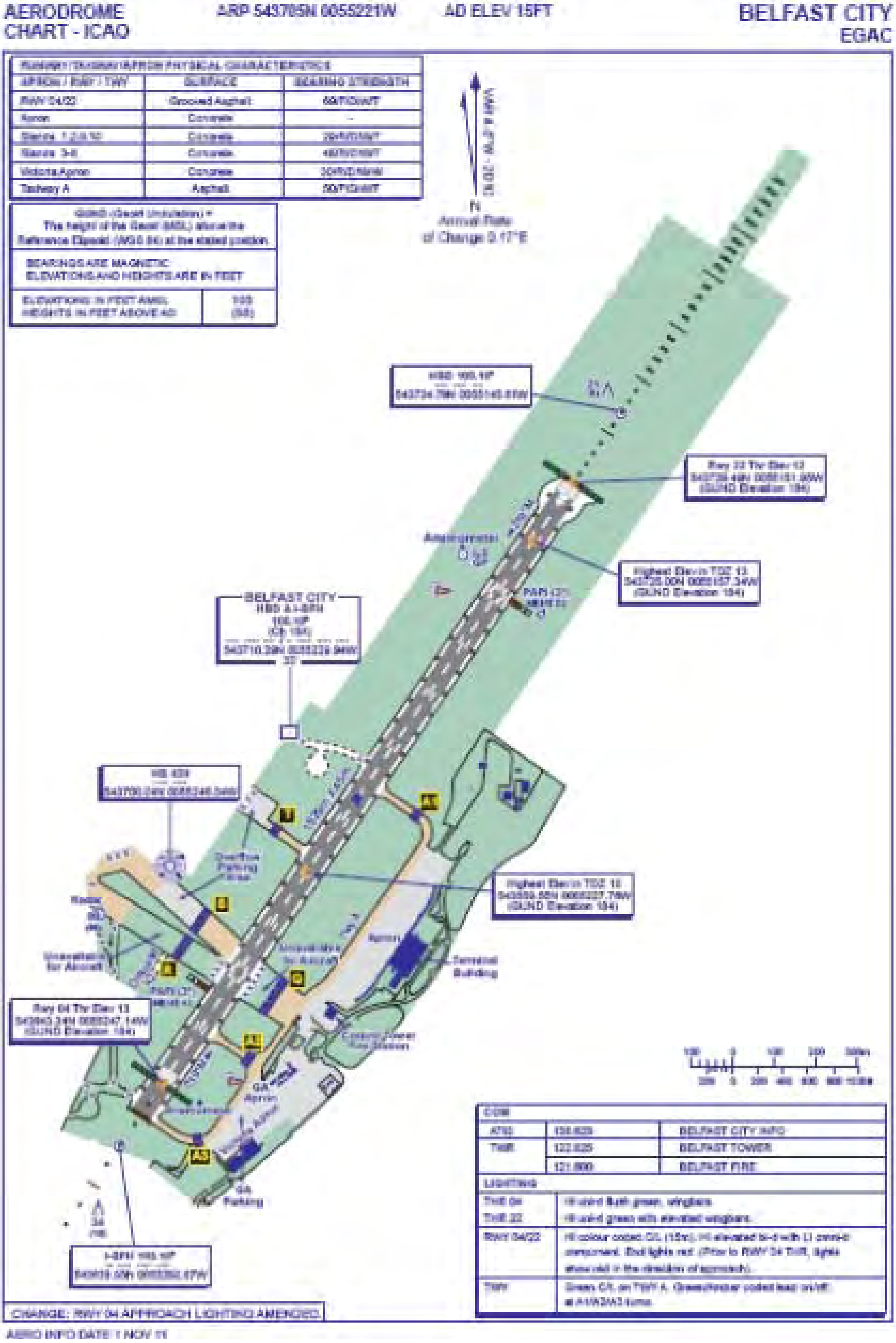
A summary of the key airfield geometries are presented in Table 5.1.

Table 5.1 Airfield Geometry

Location	Latitude	Longitude	Elevation (m)	Runway Width (m)
Airport Reference Point (ARP)	54.619525	-5.874983	30.39	n/a
Runway 04 Threshold[1] Runway 04 End	54.612039 54.611353	-5.879761 -5.880584	56.08m	46m
Runway 22 Threshold Runway 22 End	54.624858 54.624858	-5.864431 -5.864431	56.08m	46m

[1] Runway 04 has displaced thresholds of 90m on approach and departure with respect to the runway end.

Plate 5.1 BCA Airfield Chart



5.4 Average Meteorological Conditions

Average meteorological conditions for BCA were obtained from a weather station located at BIA. This was also the case during Round One. The conditions presented in Table 5.2 relate directly to the requirements of the INM model and represent annual average conditions over the four periods under consideration by the Regulations. It should be noted that the values for air pressure have been assumed and are based on a standard assumption of 759.96 mmHg. The same assumption was also employed during Round One.

Table 5.2 Modelled Average Meteorological Conditions for 2011

Meteorological Parameters	Unit	Day (0700-1900hrs)	Evening (1900-2300hrs)	Night (2300-0700hrs)	24-Hour
Airport Temperature	Degrees Celsius (°C)	10.7 °C	9.2 °C	8.1 °C	9.6 °C
Pressure[1]	mmHg	759.96	759.96	759.96	759.96
Humidity	%	76.9 %	82.5 %	86.9 %	81.2 %
Headwind	kmh^{-1}	14.4 kmh^{-1}	12.2 kmh^{-1}	11.5 kmh^{-1}	13.0 kmh^{-1}

[1] Air pressure has been assumed as the standard ICAO (International Civil Aviation Organisation) aviation atmosphere of 759.96mmHg (1013.2mbs). This assumption has been retained from Round One.

5.5 Route Definitions

Departure Routes and Dispersion

Departure routes define the routes taken by departing aircraft. Dispersion allows departures to be modelled in terms of their distribution around the route reflecting the fact that aircraft do not take the exact same paths. Instead, over time, aircraft tend to be disbursed around a central route. This is due to a number of factors, notably weather conditions.

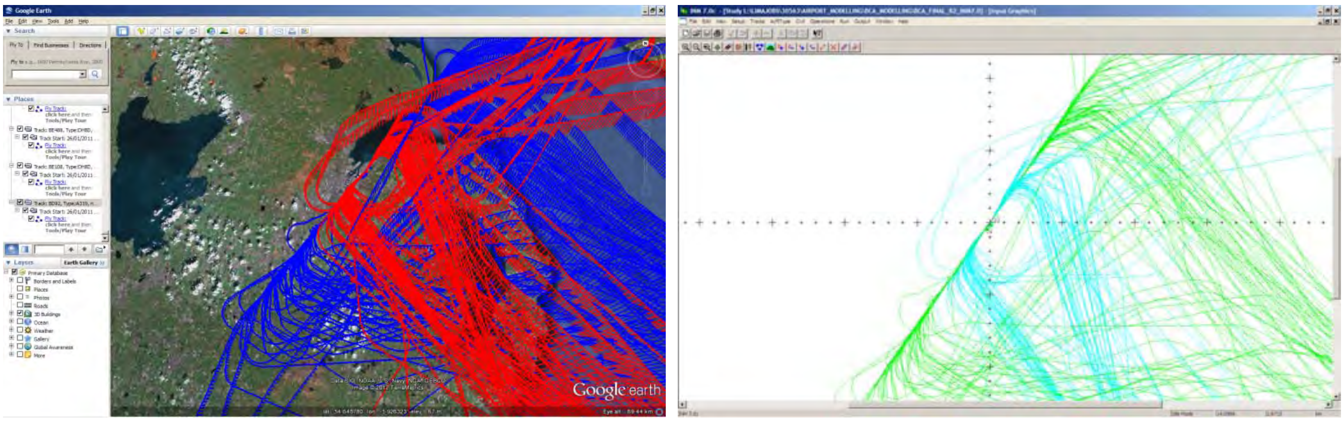
For Round One, departure routes were digitised using images provided by BCA from the airport's radar systems. These images were geo-rectified within a GIS system and the routes digitised. For each runway, it was determined from the radar tracks that aircraft would take one of three departure routes and arrive on a single route. An assumption was made that for each runway, aircraft depart on the runway heading before taking a turn at 2.5nm, 4nm and 6nm from start of roll. From reviewing these assumptions and the tracks digitised in the Round One model, the project team identified that these assumptions could be improved upon with the aid of detailed radar track information.

For Round Two, the project team requested radar tracks representative of typical operations for Runway 04 and 22 arrivals and departures. BCA provided radar tracks in the form of Google Earth KML files. Using a tool specially developed by AMEC for the modelling of airport noise, the KML files were converted into a CSV format which could be imported directly into INM. Plate 5.2 presents an example of the radar tracks in Google Earth and those imported into INM.

In addition to the radar tracks, BCA provided AMEC with details of a study undertaken by BAP for the purposes of preparing and validating Summer 2011 contours for BCA. This study investigated modelled arrival and departures routes and aircraft dispersion using information taken from the Airport’s Noise and Track Keeping (NTK) system. The study makes recommendations on what routes are to be modelled and corresponding dispersions across these routes.

To ensure consistency and following review by the project team, the modelling of airspace and dispersion at BCA was undertaken to reflect the modelled routes and dispersions derived by BAP.

Plate 5.2 Radar Tracks in Google Earth (Left) and INM (Right)

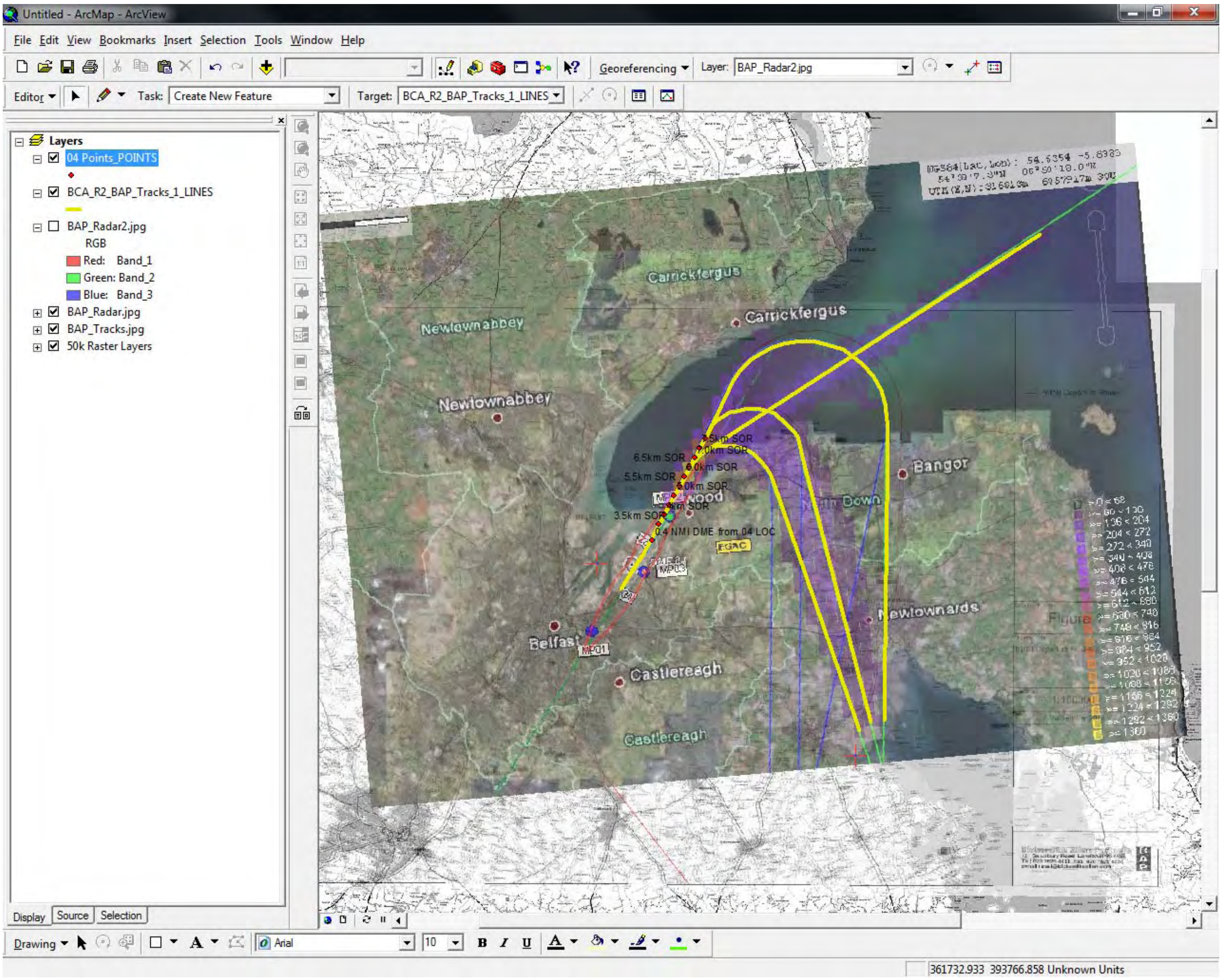


To allow airspace to be modelled in accordance with the airport’s existing Summer 2011 contouring, the project team used the information provided in the airport’s AIP and as documented and presented by BAP. This required the following processing steps to be implemented:

- Geo-rectifying modelled routes as presented by BAP in GIS to allow the location of turns to be identified and coordinates derived;
- Modelling of departure bearing to ensure consistency with the rules outlined in the AIP; and
- Measurement and derivation of coordinates at positions along each track to enable the modelling of dispersion patterns.

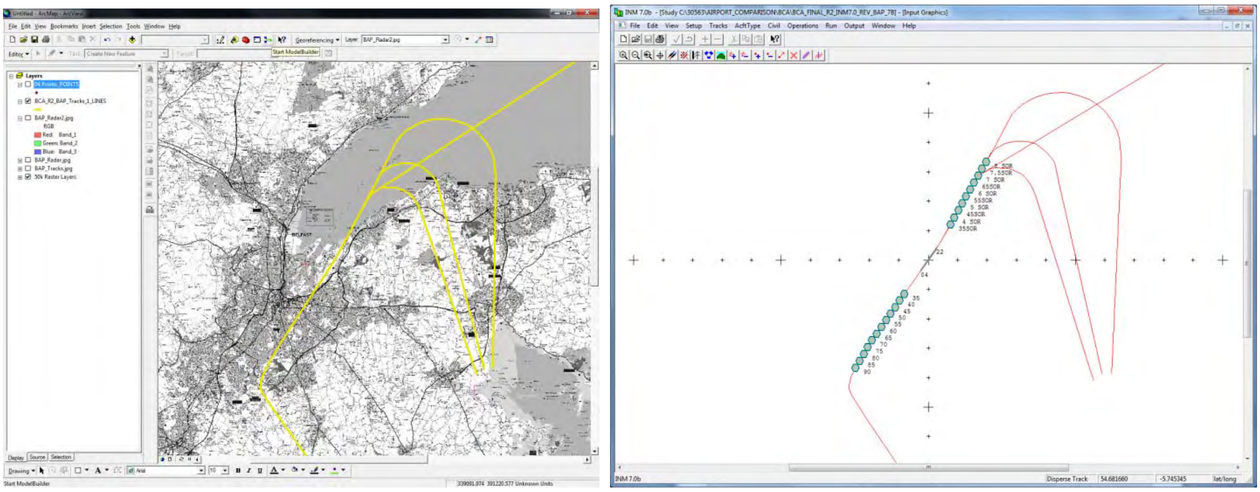
Once geo-rectified, the modelled departure tracks were digitised within GIS. Plate 5.3 presents an example of this process for Runway 04 departures. The Plate shows radar outputs and modelled tracks presented BAP along with points digitised at positions from Start of Roll (SOR) at bearings defined by the Airport’s AIP.

Plate 5.3 Geo-coding of Tracks in Accordance with BAP Contouring Report and AIP



Once all tracks were digitised, these were then converted to a format compatible with the importation of radar tracks within INM. Plate 5.4 presents the digitised tracks in GIS and within INM. This approach ensures that tracks which are digitised within INM can be cross-checked and reviewed against tracks which have been defined outside of INM.

Plate 5.4 Departure Tracks in GIS and INM



As can be seen in Plate 5.4, a total of 4 No. departure tracks were defined for Runway 04, with a single departure track defined for Runway 22. The allocation of departures along each of the routes was also taken from work undertaken by BAP for the Summer 2011 contouring. The allocation of departures is presented in Table 5.3 with each track illustrated in Plate 5.5 and Plate 5.6 for Runway 04 and Runway 22 departures respectively. Table 5.3 shows that for all departures which are not headed for Scottish airports, movements were equally distributed along across each track which turns right before heading south. An additional track was included for movements which were headed for Scotland.

For Runway 22, a single departure track was defined. It should be noted that the purposes of noise mapping under the Regulations and the various noise level thresholds for reporting, the allocation of movements to tracks and the location of turns is relatively insensitive. This is due to the extents of the noise contours relevant under the Regulations falling before the divergence of aircraft onto different modelled routes and before the point of any modelled turns. This was also identified by BAP in their analysis of the 2011 Summer contours.

Table 5.3 Allocation of Departures

Runway/ Departure Track	Allocation of Traffic
Runway 04 – Departure Track 1	33.3% of movements that are to destinations other than Scottish airports
Runway 04 – Departure Track 2	33.3% of movements that are to destinations other than Scottish airports
Runway 04 – Departure Track 3	33.3% of movements that are to destinations other than Scottish airports
Runway 04 – Departure Track 4	Movements that are to Scottish airports
Runway 22 – Departure Track 1	All destinations

Plate 5.5 Modelled Departure Routes on Runway 04

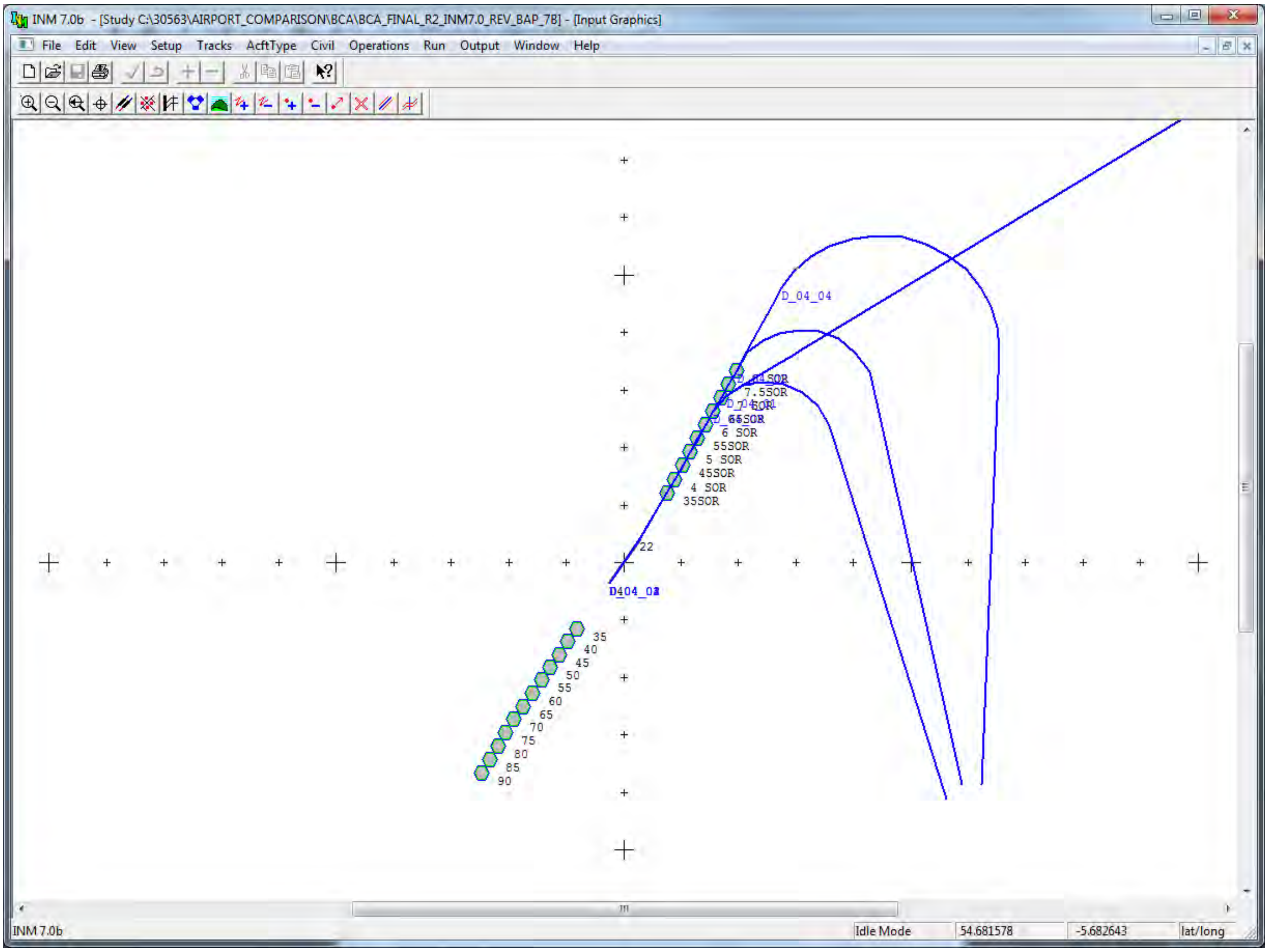
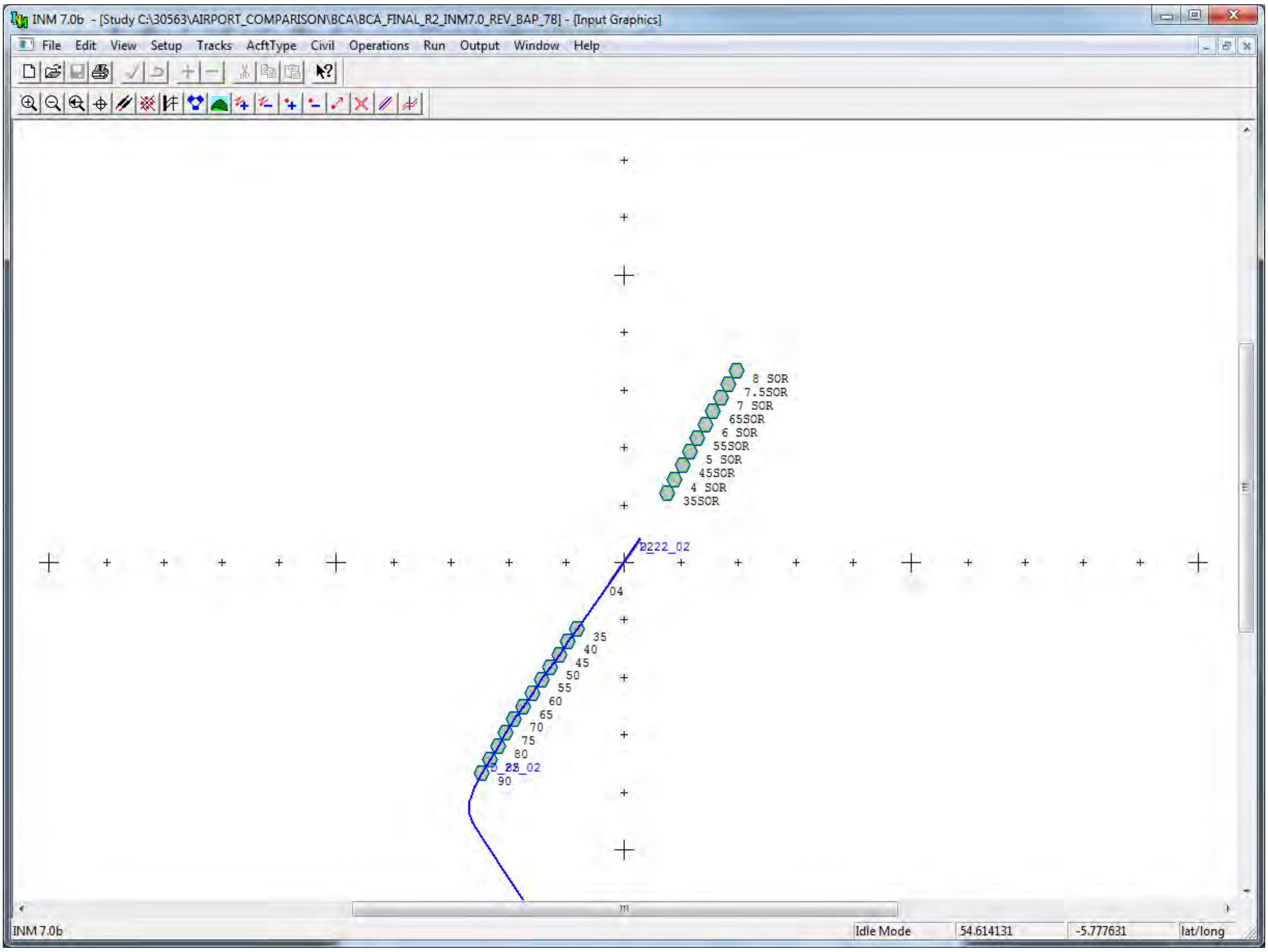


Plate 5.6 Modelled Departure Routes on Runway 22



For arrivals, both runways were modelled as a track on the runway heading from a point approximately 10nm from the runway threshold which replicated the airport's approach procedures and is in keeping with the radar arrival tracks.

The dispersion of air traffic around each departure and arrival route was taken from rules derived by BAP through analysis of the Airport's NTK system. As shown in Plate 5.4 and Plate 5.5, points from SOR were defined along each departure route. Using the points, dispersion of aircraft along departure routes were modelled in accordance with the patterns derived by BAP for Summer 2011 noise contouring.

Aircraft dispersion, in terms of the width of the dispersion, is presented in Table 5.4. The width of the dispersion was modelled to the outer of the dispersed tracks which are used within INM to model dispersion around the main departure track.

Table 5.4 Width of Aircraft Dispersion on Departure Tracks

Distance from Start of Roll (km)	Distance to Outer Dispersed Track for Runway 04 Departure Tracks (m)	Distance to Outer Dispersed Track for Runway 22 Departure Tracks
End of Runway	0	0
3.5	105	105
4.0	211	211
4.5	323	323
5.0	434	434
5.5	556	556
6.0	678	678
6.5	792	792
7.0	905	964
7.5	1007	1118
8.0	1109	1272
8.5	1184	1386
9.0	1260	1500
9.5	1324	1500
10.0	1387	1500
10.5	1444	1500
11.0 and above	1500	1500

It should be noted that the dispersion adopted for Runway 04 is identical to that adopted for Round One. This dispersion was applied to all tracks regardless of Runway. For Round Two, although this dispersion has been retained for Runway 04, it was modified for Runway 22 following review of radar data from the NTK. AMEC reviewed these assumptions against the radar track information provided by BCA and confirmed that these were reasonable representations.

Aircraft dispersions are not just related to the width of the dispersion but the density of aircraft. In INM, this can be modelled by proportioning the modelled movements across a number of sub-tracks which are generated between the outer dispersed tracks. Using a distribution profile, the sub-tracks can be modelled with a certain proportion of movements.

For the Summer 2011 noise contouring model at BCA, BAP modelled aircraft departure tracks with two sub-tracks either side of the main departure track. The allocation of movements adopted is set out as follows:

- 53.3% of departures along the main track

- 22.2% of departures split equally along two inner sub-tracks either side of the main track, offset by a distance of 1.355 standard deviations; and
- 1.15% of departures split equally along two outer sub-tracks either side of the main track, offset by a distance of 2.71 standard deviations.

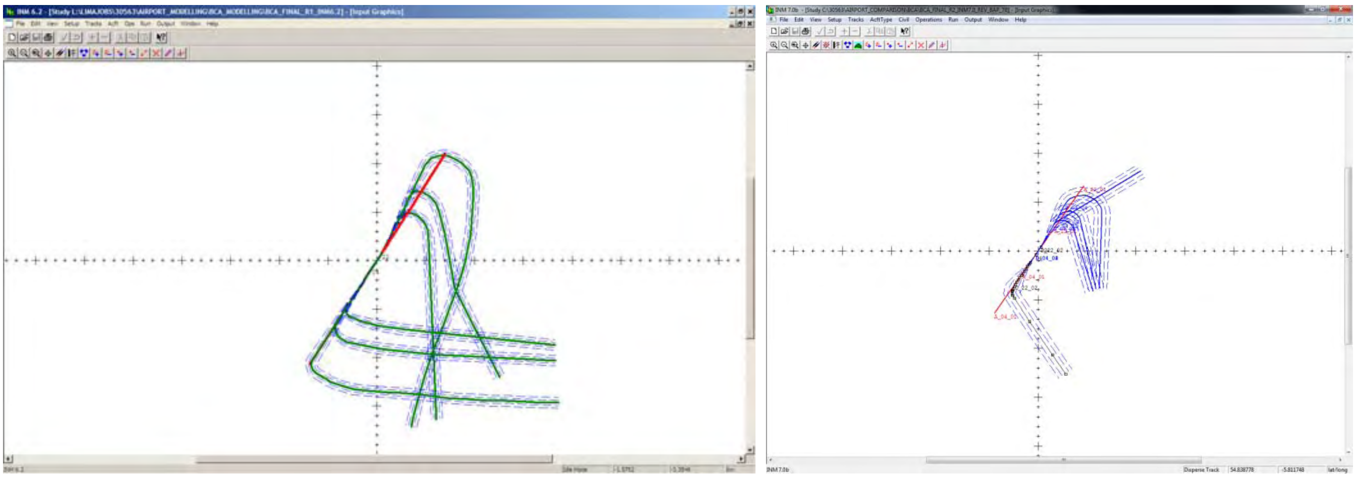
These dispersion modelling rules were also adopted within the INM model developed for the Round Two END. It should be noted that for aircraft arrivals, no dispersion has been assumed that arrival tracks have therefore been modelled as a single main track.

Comparison of Round One and Round Two Modelled Tracks

Plate 5.7 presents a comparison of Round One and Round Two modelled arrival and departure tracks. The plate shows the general trend in the airspace is similar for departure on Runway 04 however only a single departure route is now modelled for Runway 22. Arrival tracks continue to be modelled as a single track on the runway heading.

It should be noted that from review of the Round One airspace, issues regarding the heading and track of the Runway 04 departure routes have been identified. In Round One, Runway 04 departure routes do not follow the correct heading and are modelled several degrees to the west of the actual departure heading. This has been rectified for Round Two and will be visible within the shape of the resultant noise contours.

Plate 5.7 Round One and Round Two Modelled Routes

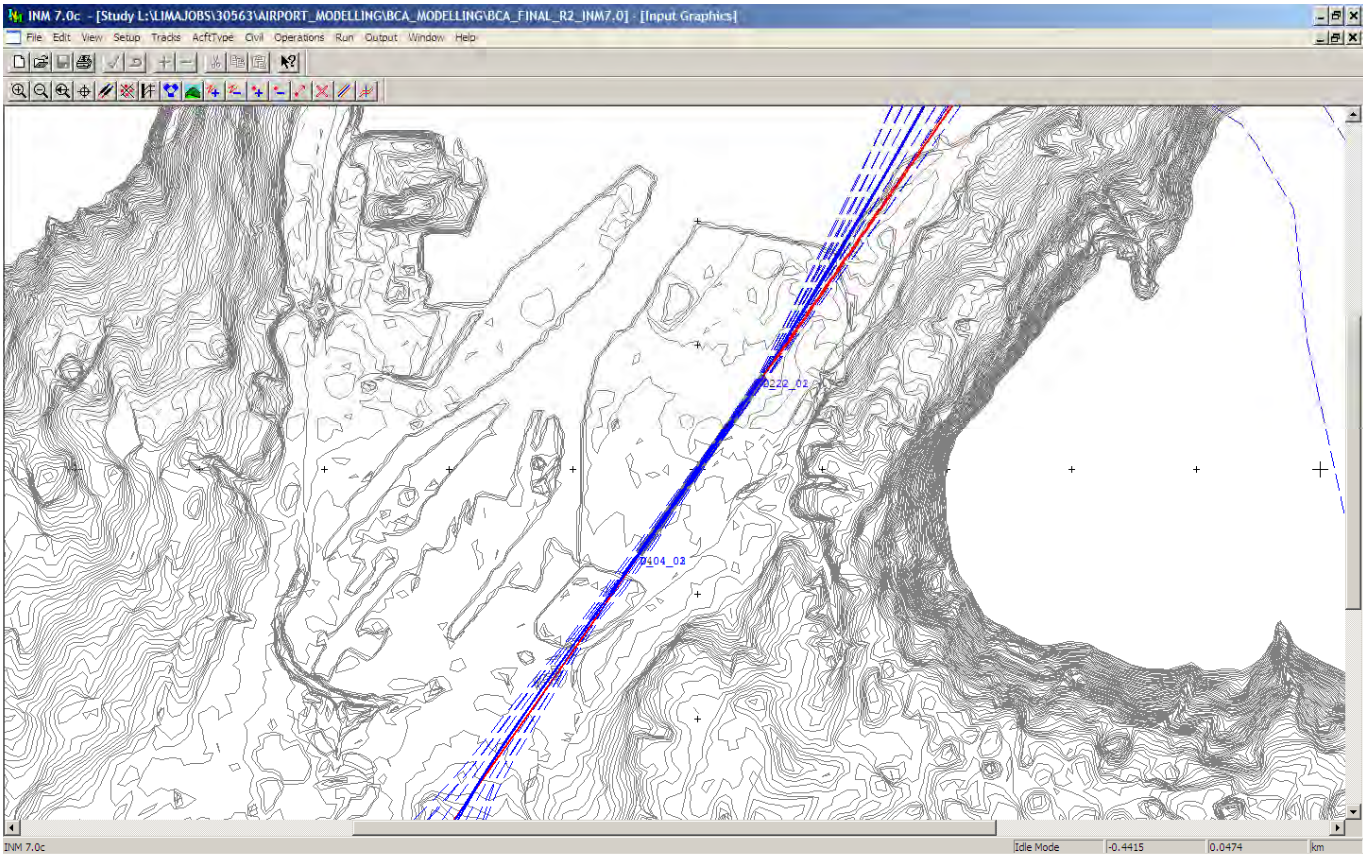


The Round One modelled tracks are presented on the left, while the Round Two modelled tracks are presented on the right.

5.6 Terrain

For the modelling of BCA during Round One, terrain was imported into the INM from data processed from the OSNI 10m DTM as projected into the geographic WGS84 coordinate system. To ensure consistency, the latest terrain information was clipped out of the OSNI 10m DTM and re-projected into the WGS84 coordinate system for an area 20km either side of BCA. This information was imported into INM and is shown in Plate 5.8.

Plate 5.8 Terrain data Imported into Round Two INM Model



Terrain zoomed into airport for reference purposes.

5.7 Air Traffic Movements

5.7.1 2011 Flight Records

Air traffic movements for 2011 were provided by BCA in the form of flight records. The flight records showed that in total, 41,941 movements were logged in 2011.

The logs contained the following information:

- Arrival/ Departure Date and Time (in Zulu i.e. GMT);
- Aircraft Arrival and Departure Route (expressed by IATA code);
- Aircraft IATA Code;
- Aircraft Registration;
- Flight Runway;

- Destination/ Origin.

The flight logs were imported into a database for processing. Following importation to the database, a series of queries were developed to prepare the data for importation into the noise model. The first of these queries were undertaken in order to identify any of the following:

- Inconsistent entries;
- Incorrect or blank entries;
- Unique inputs (such as aircraft, routes, runways and destinations);
- Daily trends and averages (such as runway utilisation and average movements).

From these queries, a number of key statistics were extracted. These are presented within Table 5.5.

Table 5.5 Statistics from 2011 Logs

Statistic	Number
Total number of logs	41,941
Total number of unique aircraft by reported IATA code	115
Total number of destinations	172

The following sections present the processing of the 2011 flight records for the model.

Aircraft and Airline Codes

The flight records contain various aircraft denoted by IATA code. For the 115 unique records within the flight logs, the project team matched these codes with their corresponding airframes. When modelling aircraft, it is essential that the correct variant of an aircraft is used in the modelling. For example, the Boeing 737 has several variants which have been developed since its first manufacture. Due to technical improvements, the latest Boeing 737 aircraft are considerably quieter than their predecessors. It is therefore important that the aircraft variant is established for the purpose of modelling. IATA codes can often represent aircraft simply by type rather than by variant. Fortunately, the flight records provided by BCA also provided details of airlines and aircraft registrations.

Based on airline and aircraft, a total of 226 combinations of aircraft and airlines were established for BCA for 2011. Where an aircraft variant could not be established by IATA code, the airlines fleet was researched and the variant established. Where no information was available, airline registrations were queried online and the aircraft variant determined.

From this analysis, it was possible to identify that a majority (182 of the 226) of the aircraft combinations related to general aviation movements and/ or business flights. A further 29 of the 226 combinations related to helicopter movements, while a further 15 airline and aircraft combinations could not be identified. The 15 unknown combinations were subsequently ignored in the modelling process.

Table 5.6 presents a breakdown of the movements in terms of identified aircraft. The table shows that all but 0.2% of the aircraft within the logs could be identified. The table also shows that 99.5% of the aircraft within the logs were fixed wing aircraft.

Table 5.6 Summary of Movements for Identifiable Aircraft

Aircraft Type	Total Number in 2011	Percentage of Total Movements
Fixed Civil Aircraft	41,732	99.5%
Helicopters	139	0.3%
Movements ignored due to no identifiable aircraft type	70	0.2%
TOTAL	**41,941**	**100%**

Destinations and Flight Profiles

The departure profile of an aircraft is dependant upon several factors. Aside from any specific procedural requirements, the rate of ascent and departure profile of an aircraft is governed mainly by take-off weights. The INM model provides a number of different departure profiles for most aircraft types which define different departure characteristics in terms of the speed, thrust and altitude of an aircraft at a distance along the flight path from S.O.R. As departure profiles are mainly determined by take-off weights, this is particularly relevant for larger aircraft which are used for charter, medium and long-haul flights, as the take-off weights of these aircraft are usually determined by fuel loads and destinations. This is addressed by INM through 'Stage Length'.

The INM model makes the assumption that aircraft take off with a full passenger load regardless of destination or flight duration. As the flight duration and distance increase, larger fuel loads and take-off weights are required on departure making the aircraft heavier resulting in a slower climb and increased noise exposure. The INM model incorporates a series of 'Standard' and ICAO aircraft departure profiles for different take-off weights which are based on flight distance and corresponding 'Stage Length'. Table 5.7 presents INM 'Stage Length' against distance.

Table 5.7 INM Stage Length

INM Stage Length	Distance (nmi)
1	0 – 500
2	500 – 1000
3	1000 – 1500
4	1500 – 2500
5	2500 – 3500
6	3500 – 4500
7	> 4500

A query of the flight logs for BCA revealed 172 unique destinations. Of these destinations, 26 were found to relate to a specific type of flight rather than a destination, such as police helicopter movements, or could not be identified. Any movements assigned against these 26 destinations were assumed to have stage length of 1.

For each destination, a direct 'straight line' distance from BCA was calculated in nautical miles and a corresponding stage length assigned. Using the database, each aircraft departure record was joined to these assumed stage lengths based upon the recorded destination. Table 5.8 presents a breakdown of the total number of fixed wing civil aircraft departures against INM stage length within the 2011 flight records.

Table 5.8 Total Number of Departures in 2011 against INM Stage Length

INM Stage Length	Total Number of Departures
1	20,788
2	66
3	3
4	0
5	8

Table presents departures for identifiable aircraft only and excludes helicopters

Following review of the destination, it was considered that given the high proportion of Stage 1 departures that all departures from BCA should be modelled as Stage 1.

5.8 Modal Splits

Runway usage (referred to as 'modal split') is a key data input into the INM model. Aircraft usually takeoff and land into wind, and therefore runway usage is influenced by weather conditions. The actual 2011 modal split has been identified through analysis of the runway utilisations within the 2011 flight records. In total 54 of the flight records did not have any runway assigned. Using the rest of the flight logs, the prevalent runway mode on the day of the incomplete entry was adopted. Table 5.9 presents a summary of runway utilisation for all arrivals and departures during 2011 for all fixed wing aircraft on Runway 04/22. The table also breaks down the modal splits into day, evening and night-time periods.

Table 5.9 'Actual' Modal Split for 2011 Based on Flight Records

Runway				
Arrival/ Departure Heading		**04**	**22**	**Total**
24-Hour (0000-2400hrs)	Total Number of Fixed Wing Aircraft Movements	8,680	33,052	41,732
	Runway utilisation (%)	20.80%	79.20%	100%
Day (0700-1900hrs)	Total Number of Fixed Wing Aircraft Movements	7,102	26,719	33,821
	Runway utilisation (%)	21.00%	79.00%	100%
Evening (1900-2300hrs)	Total Number of Fixed Wing Aircraft Movements	1,305	5,729	7,034
	Runway utilisation (%)	18.55%	81.45%	100%
Night (2300-0700hrs)	Total Number of Fixed Wing Aircraft Movements	288	589	877
	Runway utilisation (%)	32.84%	67.16%	100%

5.9 Modelled Aircraft

The INM model contains a database of noise emissions and flight profiles that cover most major aircraft types, models and variants. However this database is not exhaustive and therefore not all aircraft are covered by the database. Where specific data relating to an aircraft type or variant is not directly available within the database, the INM model contains built-in recommended 'substitutions' which are based on other aircraft or combinations of aircraft held within the INM database. These substitutions can be based on certification data, engine types, performance, airframe dimensions and characteristics or by comparison of measured values taken at the airport. Where the INM model does not contain a built-in substitution, the model allows users to create their own substitution based on likening the aircraft to one which is held within the database or by adding or editing the noise performance data of other aircraft or combinations of aircraft types. In the case of future aircraft, assumptions regarding the noise emissions and performance must be made based upon trends and targets within the aviation industry.

Where information can be obtained from NTK systems regarding the noise exposure from aircraft events, it is possible for noise calculations to be undertaken in INM for the purpose of validating measured against modelled aircraft noise emissions. For Round One, all aircraft were modelled using INM aircraft and appropriate substations. For Round Two, aircraft have also been modelled using verification adjustments as derived and adopted by BAP for the 2011 Summer contouring exercise.

This sections sets out the decisions, assumptions and approach to modelling the various aircraft fleets identified in the 2011 flight logs.

5.9.1 Modelled Fleet

As discussed in Section 5.7, 115 IATA aircraft codes were identified within the 2011 flight logs. Using information obtained from an analysis of airline and aircraft code combinations, and from looking up aircraft from registrations, a process of matching aircraft to those modelled within the INM database and built-in substitutions was undertaken.

The noise performance of aircraft can differ depending upon engine variants and as the IATA codes do not make reference to variants it has been necessary to crosscheck the IATA aircraft codes against a breakdown of destinations and airlines that operate from BCA. From this cross check, it was possible to review the fleets of the various airlines in order to identify whether certain airlines have fleets with a preference against a certain engine variant or model.

A good example of this process is for the Airbus A320 movements which were identified within the 2011 flight records under the IATA aircraft code ‘320’. There are several variants and models of the A320 due to various developments since its introduction in 1988. From analysis of the various destinations of these aircraft and through cross checking these with the airlines operating these destinations at BCA in their fleets, it was identified that EasyJet and BMI operate Airbus A320 into and out of BCA. From reviewing their fleets, it was established that EasyJet operate A320-214 variants which are fitted with General Electric CFM56-5B4 engines, whereas BMI operate A320-232 variant which are fitted with V2527-A5 engines.

For the 2011 flight logs and 175 airline and aircraft combinations relating to fixed wing aircraft, 77 aircraft were directly matched to aircraft within the INM database. A further 85 aircraft codes were matched to built-in INM substitutions. Two of the aircraft were modelled using specific substitutions. The remaining 13 aircraft were modelled based using aircraft registrations.

As discussed in Section 5.9, for Round Two, verification adjustments have been made to allow the INM model to greater reflect measured aircraft noise emissions as obtained from the airport’s NTK system. Table 5.10 presents the adjustments which have been adopted for the Summer 2011 contours by BAP. These adjustments allows aircraft to be modelled with a greater or lesser number of movements, departure profiles and alternative INM aircraft emissions to better reflect measured noise emissions. These adjustments are representative of the most abundant aircraft at BCA. In most instances, the adjustments have been by correcting the number of modelled aircraft. For the Bombardier Dash 8-Q400, there are no emissions currently held within INM. As such, substitutions are required. The adjustments presented in Table 5.10 show that alternative aircraft substitutions are used along with adjustments to the number of modelled movements.

The use of verification adjustments is a significant departure from the approach adopted during Round One and will therefore have a marked effect upon the resultant noise contours.

Table 5.10 Summer 2011 INM Model Verification Adjustments

Aircraft Type	INM Standard Aircraft	Verification Adjustments applied to INM Aircraft Emission	
		Departures	Arrivals
Airbus A319	A319-131	A319-131 – Movements x 1.4	A319-131 – Movements x 1.5
Airbus A320	A320-232	Departures modelled as Stage Length 2	-
Boeing 737-300	737300	737300 – Movements x 1.7	737300 – Movements x 1.7
Boeing 737-500	737500	737500 – Movements x 1.9	737500 – Movements x 1.7
Bombardier Dash 8-Q400	-	DHC6 – Movements x 0.8	SD330 – Movements x 1.4
Embraer 195	GV	A319-131 - Movements x 2	A319-131 - Movements x 2
LET L-410	-	DHC6 – Movements x 1.8	SD330
Saab 340	SF340	SF340 – Movements x 2.5	SF340 – Movements x 2.0

Table 5.11 presents a breakdown of the number of movements against those modelled using INM aircraft data, built-in substitutions and specific substitutions. The table shows that the majority of modelled movements have been subject to verification adjustments. It should be noted that given the adjustments correcting the number of modelled movements that these verifications adjustments result in increasing the effective number of modelled movements to 53,563.

Table 5.11 Breakdown of INM Modelled Aircraft and Substitutions

Modelled Aircraft Source	Number of Modelled Movements	Percentage of Total Modelled Movements (%)
Verified and Adjusted INM Emissions	36,563	87.2%
INM aircraft database	4,173	9.9%
INM built-in substitutions	980	2.3%
User defined substitutions	14	<0.1%
Helicopters (Ignored)	139	n/a
Unidentifiable Aircraft (Ignored)	70	n/a

Appendix A presents the modelled INM substitutions against IATA codes for those aircraft appearing within the 2011 flight logs.

5.10 Importing Movements into INM

To import the movements into the INM model, it was necessary to modify the movement database to link the movements denoted against the aircraft types against the aircraft type codes held within the INM model. Once this process was completed, the project team used a bespoke software tool to import the movements into the INM model. The software tool performs a series of queries within the movement database and validates the records against the routes, stages and aircraft held within the model. The tool ensures that movements are also input by time periods, i.e. day, evening and night, and that all movements are annualised to reflect an annual average day.

6. Noise Level Calculations

Noise calculations have been undertaken within INM 7.0b. INM allows the calculation of various noise indicators relating to aircraft noise such as Effective Perceived Noise Level (EPNL), maximum A-weighted noise level (L_{Amax}) and Sound Exposure Level (SEL). For the purposes of calculating aircraft noise under the Regulations and in compliance with the conditions of contract, aircraft noise must be calculated in terms of the following:

- L_{day} – annual average daytime noise level (0700-1900hrs);
- L_{eve} – annual average evening noise level (1900-2300hrs);
- L_{night} – annual average night-time noise level (2300-0700hrs);
- L_{den} – annual average 24-hour day-evening-night noise rating level;
- $L_{Aeq, 16hr}$ – annual average 16 hour daytime noise level (0700-2300hrs).

As discussed in Section 3, noise calculations for Round One were undertaken using INM version 6.2a. For Round One, in order to reduce calculation times, calculations were undertaken on a 100m by 100m grid and interpolated to a 10m by 10m grid for analysis within GIS. Due to the distributed computing features introduced into INM version 7.0c, it has been possible for the project team to calculate all grid points directly on a 10m by 10m grid thus increasing the confidence of the population analysis.

It should be noted that the calculation of the $L_{Aeq, 16hr}$ indicator has been undertaken through post processing of the L_{day} and $L_{evening}$ results grids. As per the process undertaken during Round One, guidance on the noise mapping of airports issued by Defra ("Airport technical guidance: the Environmental Noise (England) Regulations 2006"; http://www.defra.gov.uk/environment/noise/ambient.htm) has been used to inform this calculation. The calculation of $L_{Aeq,16h}$ using the L_{day} and $L_{evening}$ results is presented below.

$$L_{A,eq,16h} = 10\log\left(\frac{12}{16} * 10^{\frac{L_{day}}{10}} + \frac{4}{16} * 10^{\frac{L_{evening}}{10}}\right)$$

7. Area Calculations

The first post processing step that was undertaken on the raw continuous output noise grids was a reclassification of the grids into bands. The reclassification bands used are outlined in Table 7.1 below.

Table 7.1 Noise Bands Used to Reclassify Output Grids

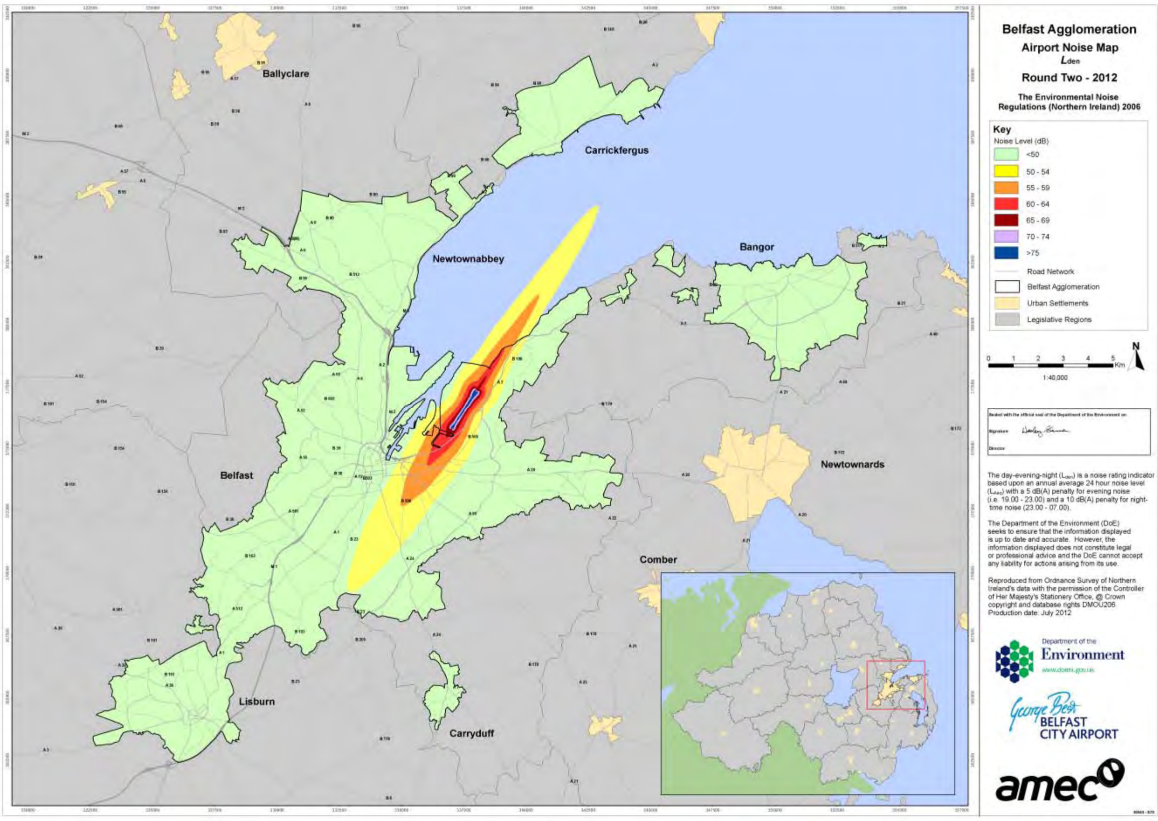
Noise Level Result	Noise Bands						
L_{den}	< 50	50-54	55-59	60-64	65-69	70-74	>=75
L_{night}	< 45	45-49	50-54	55-59	60-64	65-69	>=70
L_{day}	< 50	50-54	55-59	60-64	65-69	70-74	>=75
$L_{evening}$	< 50	50-54	55-59	60-64	65-69	70-74	>=75
$L_{Aeq,18\ hour}$	< 50	50-54	55-59	60-64	65-69	70-74	>=75
$L_{Aeq,\ 16\ hour}$	< 50	50-54	55-59	60-64	65-69	70-74	>=75
$L_{Aeq,\ 6\ hour}$	< 50	50-54	55-59	60-64	65-69	70-74	>=75

The geometric area of the noise bands for each of the bands was calculated based on the outputs. The results for the Belfast City Airport noise is shown in Table 7.2, with an example of a preliminary output (L_{den}) provided in Plate 7.1.

Table 7.2 Belfast City Airport - Area of Noise Bands in km²

Noise Level	$L_{Aeq,\ 16\ hour}$	L_{den}	L_{day}	L_{eve}		Noise Level	L_{night}
< 50	174.61	171.31	171.59	183.38		**< 45**	191.82
50-54	15.78	18.05	17.83	10.07		**45-49**	4.27
55-59	5.23	5.88	5.84	3.25		**50-54**	1.27
60-64	1.65	1.92	1.91	0.90		**55-59**	0.39
65-69	0.48	0.54	0.54	0.30		**60-64**	0.21
70-74	0.21	0.23	0.23	0.13		**65-69**	0.09
>=75	0.14	0.16	0.16	0.07		**>=70**	0.04
<50	174.61	171.31	171.59	183.38		**<45**	191.82
>50	23.48	26.78	26.51	14.72		**>45**	6.28
Total	198.10	198.10	198.10	198.10		**Total**	198.10

Plate 7.1 Round Two BCA Noise Map Example - L_{den}



8. Population Exposure and Analysis

8.1 Population Exposure Methodology

Annex VI of the END states that a population exposure assessment is required as an output of the END noise mapping process and that the results of this assessment need to be reported to the European Commission (EC). Annex VI also states that the estimated number of people (in hundreds) living in dwellings that are exposed to noise are to be calculated for the various scenarios mapped. There is no definition of a 'dwelling' in the END although the term is used within Article 3 (q), Annex I (1), Annex III, Annex IV (1) and Annex VI (1.5, 1.6) and (2.5, 2.6).

A number of key datasets have been used within the population exposure assessment developed in the second round study. The datasets used were:

(a) Detailed building polygons recorded in the OSNI large scale mapping. This data was also used as a key input into the development of the noise maps.

(b) OSNI Pointer dataset which provide details of the function of individual buildings across Northern Ireland. The Pointer data set is described by OSNI as the primary address database for Northern Ireland and is maintained by Land & Property Services (LPS), with input from Local Councils and Royal Mail.

(c) 2008 and 2010 estimates of population are provided by the Northern Ireland Statistics and Research Agency. The 2008 population dataset is the last published dataset available for the 5022 detailed census output areas, while the 2010 population estimates provides information for the coarser 890 super output areas covering Northern Ireland.

The first step in the population exposure assessment involved the development of an effective estimate of the 2010 population in each of the 5022 detailed census output areas. This was achieved by analysing the changes in population between 2008 and 2010 using the coarser datasets to derive an increase factor which could be applied to the detailed 2008 population data. This results in the production of the final dataset used in the remainder of the Round Two population analysis.

The second stage of the process was focused on developing an estimate of the number of people per house needed to undertake the population exposure assessment. This was generated by calculating the number of residential properties in each census area and dividing this value by the estimates of 2010 population in the census area. One limitation of this method is that the pointer data might not identify all of the residential properties, for instance if a residential property is located above commercial premises. As a consequence, the methodology is reliant on the accuracy and currency of the Pointer dataset and the classification of the class of building.

As per the assumptions used in the Round One study, Annex I (1) of the END indicates that noise exposure assessments should be at the most exposed façade. The most exposed façade is defined as the external wall facing onto and nearest to the specific noise source. For the purposes of this assessment the highest overall value assigned to a dwelling is to be considered the most exposed façade as per recommendations set out within the WG-AEN

Good Practice Guide v2. To calculate the level of exposure the residential dwelling building extents were intersected with the reclassified noise grids. From this process, the number of dwellings and the number of people exposed was calculated. The results of this analysis are presented in Section 8.2.

As identified in Round One, there are a number of differences as a result of the above methodology. The disparities were previously categorised as:

- Disparity between data currency. This is due to reliable dwelling counts being unavailable at NIOA level for any year more recent other than 2001. Building polygons used are consistent with the noise maps produced;
- Lack of resolution within the Pointer dataset prevents a number of parameters being determined. For example, communal residences can not be identified within the OSNI Pointer address database;
- Census data can be adjusted in order to protect confidentiality concerns.

An example of the data currency issues and an explanation of why some areas of the agglomeration have lower than expected exposure values are demonstrated on the Queens Road area of the docks development (Plate 8.1). The top left plate shows the buildings from the OSNI Largescale data, the dwellings are identified in colour and other buildings are shown in grey. The top right and bottom left plate show images from Google maps that show the development, in construction and more recently constructed. As the date of the census data is 2008, it is possible that the census data doesn’t include these apartment complexes and/or that the building data does not reflect the correct building classification.

Plate 8.1 Example of Data Currency in the Population Exposure Analysis

8.2 Belfast City Airport - Population Exposure Analysis

The estimate of the number of dwellings and population exposed to noise sources from BCA is provided below in Tables 8.1 and Table 8.2. These results have been produced using the methodology described in Section 8.1 above.

Table 8.1 Belfast City Airport - Number of Dwellings Exposure

Noise Level	$L_{Aeq, 16 hour}$	L_{den}	L_{day}	L_{eve}		Noise Level	L_{night}
< 50	236,649	234,015	234,112	246,730		< 45	254,578
50-54	16,417	17,536	17,468	11,901		45-49	6,828
55-59	8,157	9,085	9,054	3,337		50-54	569
60-64	752	1,339	1,341	7		55-59	
65-69						60-64	
70-74						65-69	
>=75						>=70	
< 50	236,649	234,015	234,112	246,730		< 45	254,578
>= 50	25,326	27,960	27,863	15,245		>= 45	7,397
Total	261,975	261,975	261,975	261,975		Total	261,975

Table 8.2 Belfast City Airport - Population Exposure

Noise Level	$L_{Aeq, 16 hour}$	L_{den}	L_{day}	L_{eve}		Noise Level	L_{night}
< 50	521,110	514,803	515,030	543,004		< 45	558,808
50-54	34,883	38,151	37,996	23,623		45-49	13,159
55-59	15,545	17,391	17,332	6,426		50-54	1,098
60-64	1,527	2,720	2,708	12		55-59	
65-69						60-64	
70-74						65-69	
>=75						>=70	
< 50	521,110	514,803	515,030	543,004		< 45	558,808
>= 50	51,955	58,262	58,036	30,061		>= 45	14,257
Total	573,065	573,065	573,065	573,065		Total	573,065

8.3 BCA - ENDRM Reporting

There is a requirement to report exposure assessments to the EC in order to comply with END. The ENDRM consists of 10 core Data Flows which cover the first two implementation rounds of the END. The results of the noise mapping including the population and the dwelling are reported via Data Flow 4 and 8

The results from this round were entered into the relevant Data Flow 4 and 8 data tables that are available from the EC (http://dd.eionet.europa.eu/datasets/2906). For the BCA report, the relevant table references are DF4_8_Agg_Air and DF4_8_Agg_Air_Major. Additional spatial datasets will be projected into ETRS89 Lambert Azimuthal Equal Area 52N 10E grid in line with EEA guidance (www.eionet.europa.eu/gis/).

It is important to note that only certain elements (mandatory fields) in Data Flow 4 and 8 are required to be reported and these fields are detailed below in Table 8.3.

Table 8.3 ENDRM Mandatory Fields for Table DF4_8_Agg_Air and DF4_8_Agg_Air_Major

Required Reporting Element	Description
UniqueAgglomerationId	Unique Agglomeration ID assigned by the reporting entity to each agglomeration.
* Lden5559	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden between 55-59 dB(A), 4 m above the ground and on the most exposed façade.
* Lden6064	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden between 60-64 dB(A), 4 m above the ground and on the most exposed façade.
* Lden6569	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden between 65-69 dB(A), 4 m above the ground and on the most exposed façade.
* Lden7074	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden between 70-74 dB(A), 4 m above the ground and on the most exposed façade.
* Lden75	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden from a Major Source >75 dB(A), 4 m above the ground and on the most exposed façade.
* Lden5559FromMajorSource	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden from a Major Source between 55-59 dB(A), 4 m above the ground and on the most exposed façade
* Lden6064FromMajorSource	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden from a Major Source between 60-64 dB(A), 4 m above the ground and on the most exposed façade
* Lden6569FromMajorSource	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden from a Major Source between 65-59 dB(A), 4 m above the ground and on the most exposed façade
* Lden7074FromMajorSource	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden from a Major Source between 70-74 dB(A), 4 m above the ground and on the most exposed façade

Table 8.3 (continued) ENDRM Mandatory Fields for Table DF4_8_Agg_Air and DF4_8_Agg_Air_Major

Required Reporting Element	Description
* Lden75FromMajorSource	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden from a Major Source >75 dB(A), 4 m above the ground and on the most exposed façade.
* Lnight5054	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight between 50-54 dB(A), 4 m above the ground and on the most exposed façade.
* Lnight5559	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight between 55-59 dB(A), 4 m above the ground and on the most exposed façade.
* Lnight6064	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight between 60-64 dB(A), 4 m above the ground and on the most exposed façade.
* Lnight6569	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight between 65-69 dB(A), 4 m above the ground and on the most exposed façade.
* Lnight70	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight >70 dB(A), 4 m above the ground and on the most exposed façade
* Lnight5054FromMajorSource	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight from a Major Source between 50-54 dB(A), 4 m above the ground and on the most exposed façade.
* Lnight5559FromMajorSource	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight from a Major Source between 55-59 dB(A), 4 m above the ground and on the most exposed façade
* Lnight6064FromMajorSource	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight from a Major Source between 60-64 dB(A), 4 m above the ground and on the most exposed façade
* Lnight6569FromMajorSource	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight from a Major Source between 65-69 dB(A), 4 m above the ground and on the most exposed façade
* Lnight70FromMajorSource	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight from a Major Source >70 dB(A), 4 m above the ground and on the most exposed façade.
* ComputationAndMeasurementMethodsReportDetails	The full name of the report, the author/publisher and date of production.

The final Data Flow 4 and 8 tables have been provided as a separate deliverable under this contract and will enable DoE to fulfil Northern Ireland's requirements for the END.

9. Comparisons between Round One and Two

As can be seen from the development of the model in Section 5, airport noise modelling requires a significant number of data inputs. Changes to these data inputs can result in both increases and decreases in air noise exposure levels and statistics. There are number of key factors which must be considered when attempting to compare the results of one airport noise contouring exercise to another. For the comparison of Round One and Round Two for BCA, these key factors are outlined below:

- Use of Aircraft Emission Adjustments instead of standard INM aircraft
- Change of method from INM version 6.2a (ECAC Doc29v2) to INM version 7.0b (ECAC Doc29v3);
- Change in modal split between 2006 and 2011;
- Change in airport fleet mix and air traffic movements;
- Change in demographic (i.e. change in population);
- Change in modelled airspace and dispersion between Round One and Round Two;
- Full 10m grid calculations rather than interpolated grids.

In order to address and understand these factors, the project team have undertaken a number of studies to identify the effect of these changes where they are considered to significantly influence the population exposed to aircraft noise from BCA. Where necessary, the project team have undertaken additional calculations using the Round One and Round Two models and versions of the INM model. These calculations have yielded noise level grids and air noise contours which have been used to assist the comparisons. All comparisons have been undertaken in terms of L_{den} and L_{night} due to their relevance to ENDRM.

The results of these studies are outlined in the following sections.

9.1 Change in INM Model and ECAC Doc 29 Method

To inform the influence of the change in INM model and edition of the ECAC Doc 29 method, the project team have run a converted version of the Round One model in INM version 7.0b. Both models have been reviewed to ensure, where possible, that inputs are identical. This has resulted in some changes to the INM aircraft substations within INM 7.0b.

Contours and noise level grids have been produced using both version of the INM model. Plate 9.1 presents a comparison of the 55 dB L_{den} contours respectively for the Round One models in both versions of INM. A noise difference scale is also presented for context.

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Plate 9.1 L_{den} Comparison of Change in Model from INM 6.2a to INM 7.0b

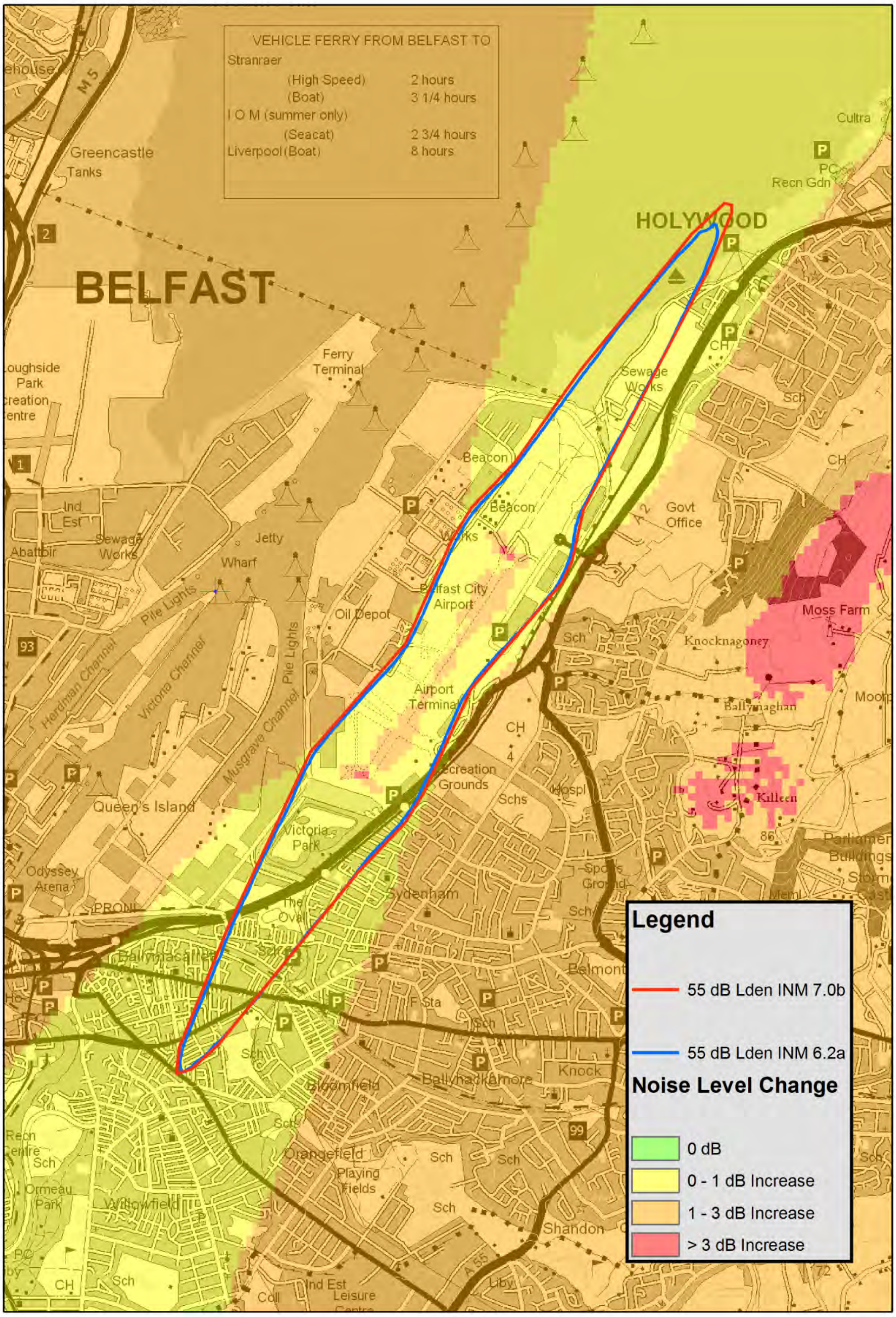


Plate 9.1 shows a slight increase in 55 dB L_{den} contour as a result of the use of INM 7.0b. It is important to note that for locations under the flight path, noise level differences remain within 1 dB. However increases of at least 1 dB are visible at positions that are perpendicular to the flight paths. This is consistent with changes to the method to address lateral effects, a key change between the methods employed in the Second and Third Editions of ECAC Doc. 29. A similar effect is identified for L_{night}.

In conclusion, the change in INM model alone has a relatively small effect upon the size and shape **o**f the contours between the first and second rounds of mapping.

9.2 Change in Modal Split

Table 9.1 presents the modal split of Runway 04/22 in terms of a 24-hour measure as modelled during Round One and Round Two for 2006 and 2011 respectively.

Table 9.1 Change in Modal Split between Round One and Round Two

	Runway 04	Runway 22
Round One Modal Split (2006)	35.7%	64.3%
Round Two Model Split (2011)	20.8%	79.2%
Change in modal split	-14.9%	+14.9%

Table 9.1 shows that the modelled modal split for Round Two has around 15% more activity occurring on Runway 22. This means that, in general, and with respect to overall air traffic movements, a greater proportion and number of aircraft departed over Belfast on Runway 22 during 2011 than in 2006. This means that when comparing the noise contours and population statistics, that dwellings to the south-east of the airport were exposed to more aircraft departure noise during 2011 than during 2006.

Routine assessment of airport noise often requires the consideration of ‘actual’ and ‘standard’ modes. Actual modes are the modal splits in a given year or time period, whereas standard modes are an average modal split of an airports operations over a period of several years. Best practice is to assess standard modals splits over a period of 20 years.

However it is important to note that there is no requirement under the Directive or Regulations to produce air noise contours for standard modes. Even so it is important factor in airport noise exposure and allows pragmatic assessment of change in airport noise by discounting annual variations in modal split.

To assess the influence of the change in modal split, the project team prepared an additional Round Two model of BCA operations in 2011 using INM 7.0b. This model was configured to assign arrivals and departures using the Round One modal split.

Plate 9.2 presents a comparison of the 55 dB L_{den} contours for the 2006 and 2011 modal splits and this highlights the impact of the 15% difference in modal split between the two dates. It should be noted that this comparison does not include the effect of the introduction of aircraft noise emission adjustments and uses standard INM aircraft noise emissions.

Plate 9.2 Comparison Modal Splits between Round One and Round Two using Round Two Movements - L_{den}

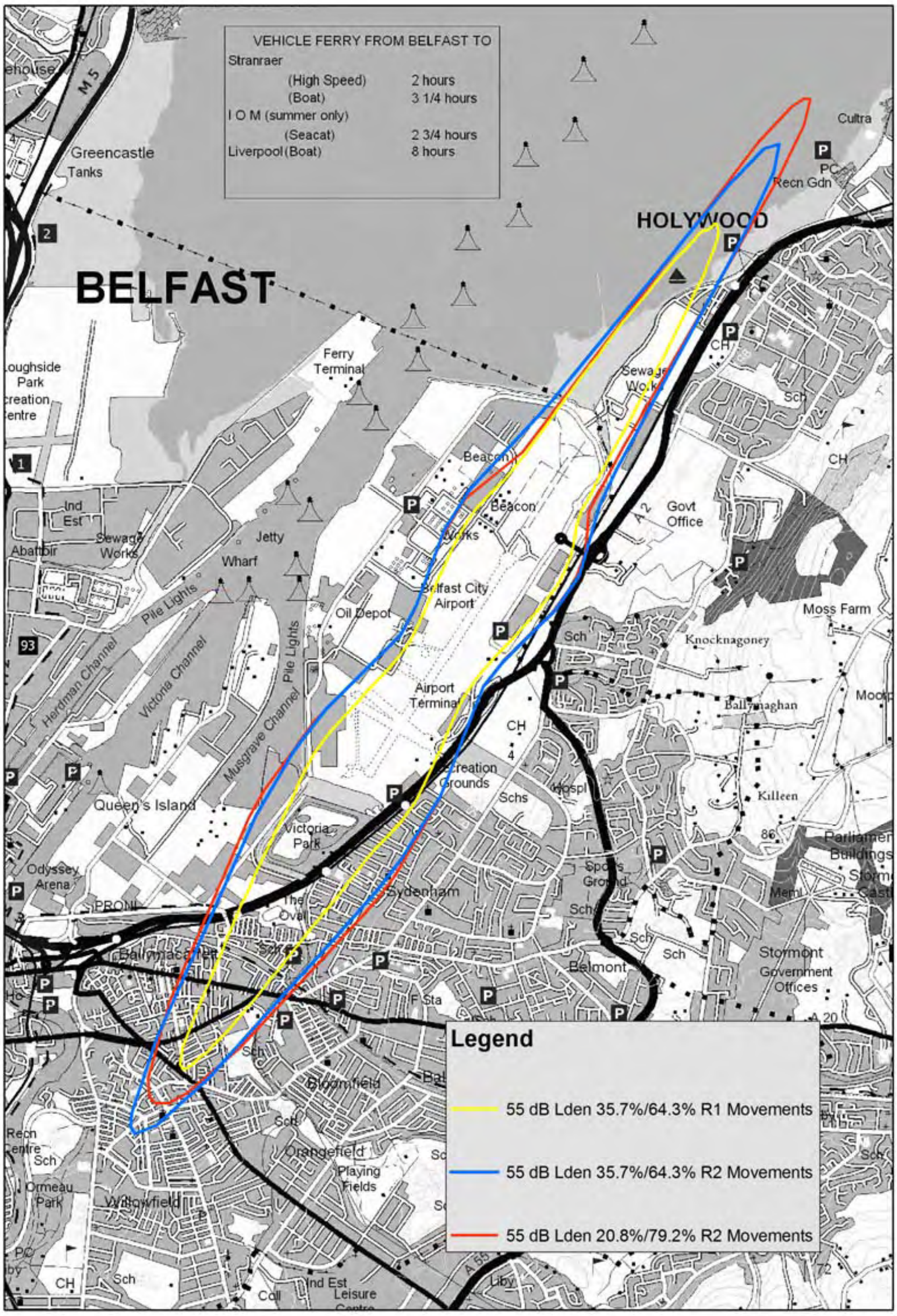


Plate 9.2 shows that assuming the same number of movements and fleet mix, the change in modal split between Round One and Round Two results in a change in the orientation and shape of the contours to the south-west and north-east. The effect of modelling increased arrivals on Runway 22 is to extend the length of the contour to the north-east. To the south-west the width of the contours increase due to the increased proportion of departures but decrease in length due to the lower proportion of arrivals on Runway 04. Plate 9.3 also presents the Round One 55 dB L_{den} contour which is much smaller than the Round Two contours. This indicates that other factors are contributing towards the increase in the contour size between Round One and Round Two.

9.3 Movements

Table 9.2 presents the headline movements in each modelled period for Round One and Round Two.

Table 9.2 Change in Annual Average Movements between Round One (2006) and Round Two (2011)

Round of Mapping	Day (0700-1900hrs)	Evening (1900-2300hrs)	Night (2300-0700hrs)
Round One (2006)	90.9	15.3	0.6
Round Two (2011)	92.7	19.3	2.4
Change	**+1.8**	**+4.0**	**+1.8**

In all periods, there have been increases in movements. The main increases are in the evening and night-time periods which will have a greater influence upon L_{den} due to the respective +5 dB and +10 dB penalties that are applied to the L_{eve} and L_{night} noise levels.

Assuming the same fleet mix as Round One, and the same modelled airspace, increases in modelled movements would result in increased contour sizes. In order to evaluate the effect of the increased movements, the Round One model has been "factored up" to reflect the movements in each period for Round Two. This presents a scenario whereby the fleet mix and airspace remains the same therefore isolating the change in movements as the variable. Plate 9.3 presents the 55 dB L_{den} for this scenario. It should be noted, again, that this comparison does not include the effect of the introduction of aircraft noise emission adjustments and uses standard INM aircraft noise emissions.

Plate 9.3 Comparison Round One and Round Two with "Factored Up" Round One Model - 55 dB L_{den}

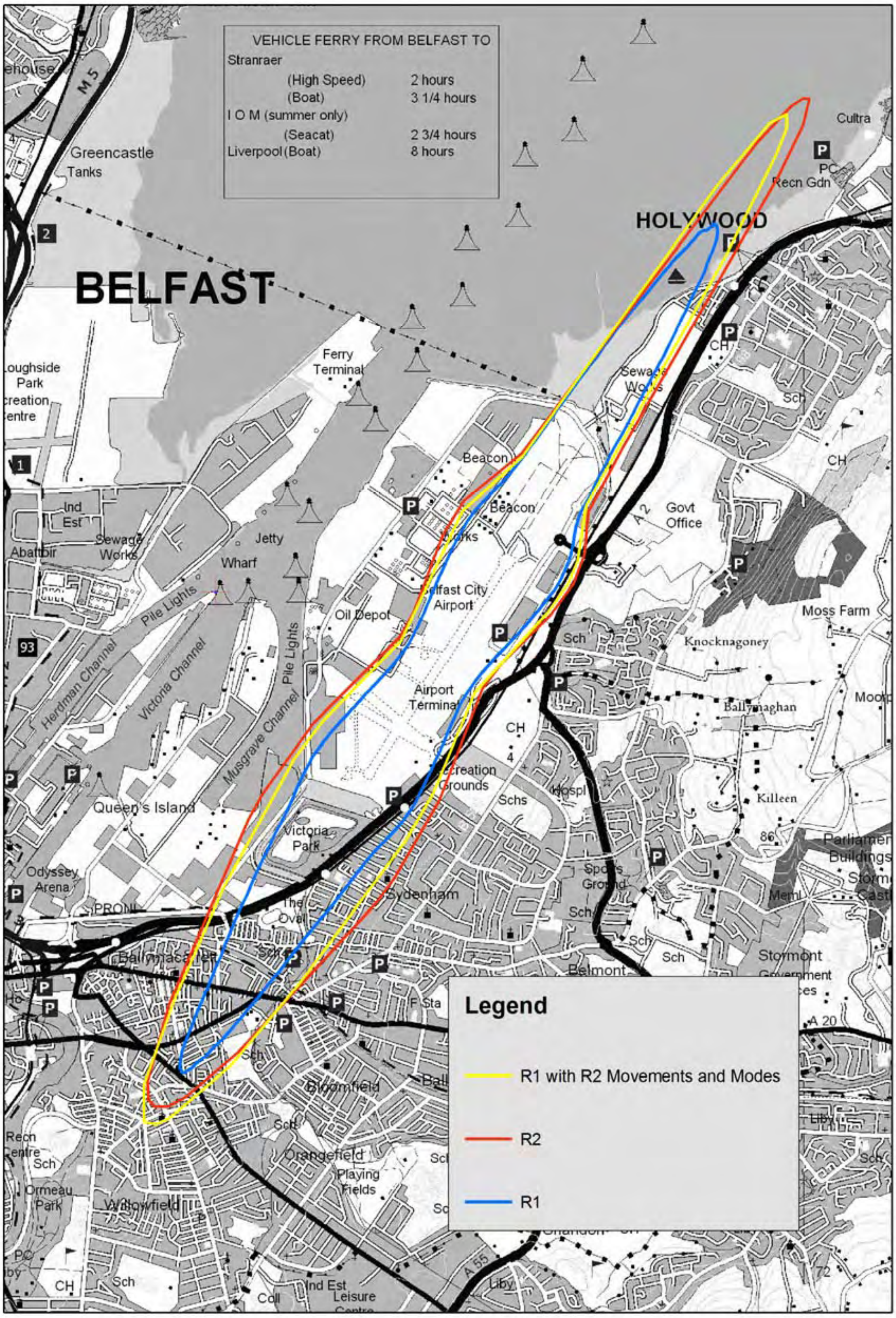
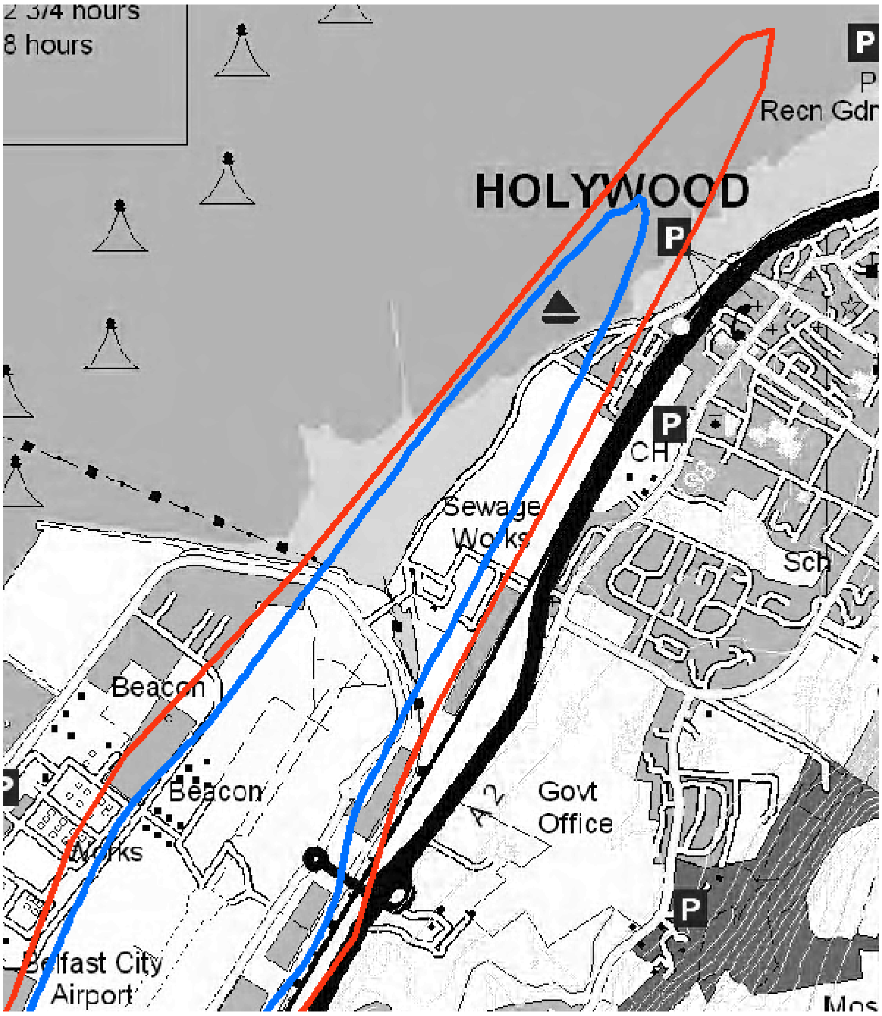


Plate 9.3 highlights that if the airspace, fleet and modal split had remained the same as Round One and movements had increased to Round Two levels, the 55 dB L_{den} contour would have increased encompassing populations to the south-west. This highlights that increases in aircraft movements is a key factor contributing to the increase in the size of the Round Two noise contours.

9.4 Change in Modelled Airspace

Changes in modelled airspace and particularly dispersion can have an effect upon both the size and extent of the contours. Although the changes in airspace assumptions between Round One and Round Two are generally limited, it should be noted that the orientation of the Round Two contours has moved slightly to the north-east. This is shown in Plate 9.4. This is due to issues with the modelled heading of departure tracks on Runway 04. In Round One, the modelled heading was incorrect and has been modelled in accordance with the AIP for Round Two.

Plate 9.4 Impact of Improving the Departure Track for Round Two



Note: Round One contour presented in Blue with Round Two contour presented in Red.

9.5 Changes in Fleet Mix and use of Emission Adjustments

The project team have reviewed the fleet mixes of BCA as modelled for Round One and Round Two. Although it is not possible to directly link changes in fleet mix to changes in noise exposure, some understanding can be gained by reviewing the aircraft responsible for the majority of movements at an airport. Table 9.3 presents this comparison for the top five modelled aircraft at BCA during Round One and Round Two mapping.

Table 9.3 Comparison of Top 5 Aircraft in Terms of Movements between Round One and Round Two

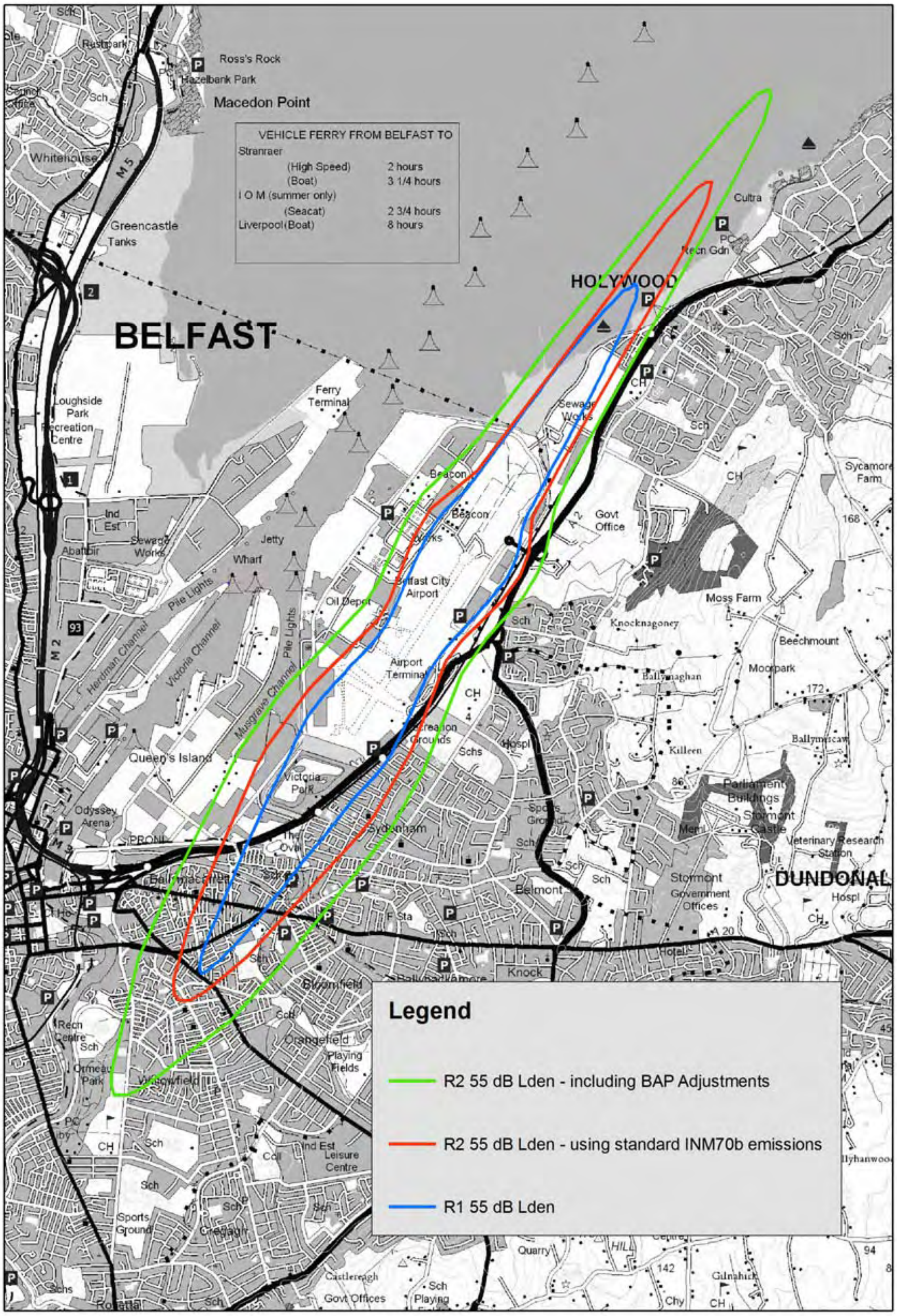
Order	Round One (2006)		Round Two (2011)	
	Aircraft	Number of Movements (24-hours)	Aircraft	Number of Movements (24-hours)
1	De Havilland Canada DHC-8-400 Dash 8	15901	De Havilland Canada DHC-8-400 Dash 8	22457
2	BAe 146 - 300	5532	Boeing 737-300	4943
3	Bombardier Dash 8 - 300	3648	EMBRAER EMB-190 / EMB-195 / ERJ-190 / ERJ-195	4747
4	Airbus A320	3529	Airbus A319	3615
5	Airbus A321	1843	LET L-420 Turbolet	2368

The comparison shows that Dash 8 aircraft has increased in number between Round One and Round Two by approximately 6500 movements but remains the most frequent aircraft at BCA. In terms of noise emissions, these aircraft are very similar in that they comprise of short-haul regional turboprop aircraft and short-medium haul jets. It is therefore considered that any change in the size and shape of the noise contours is unlikely to be as a result of changes in the airport’s fleet. Any change in fleet mix is likely to affect the general shape of the contours.

The most significant change between Round One and Round Two affecting the size of the noise contours is the use of verification adjustments to INM’s standard aircraft noise emissions, as discussed in Section 5.9. This change is related to fleet mix however as adjustments have been made to aircraft emissions for Round Two and not for Round One, it is not possible to state exactly how changes in fleet mix have resulted in changes in the noise contours. All previous comparisons do not consider the effect of the adjustments and from that analysis it is considered that the effect would be limited.

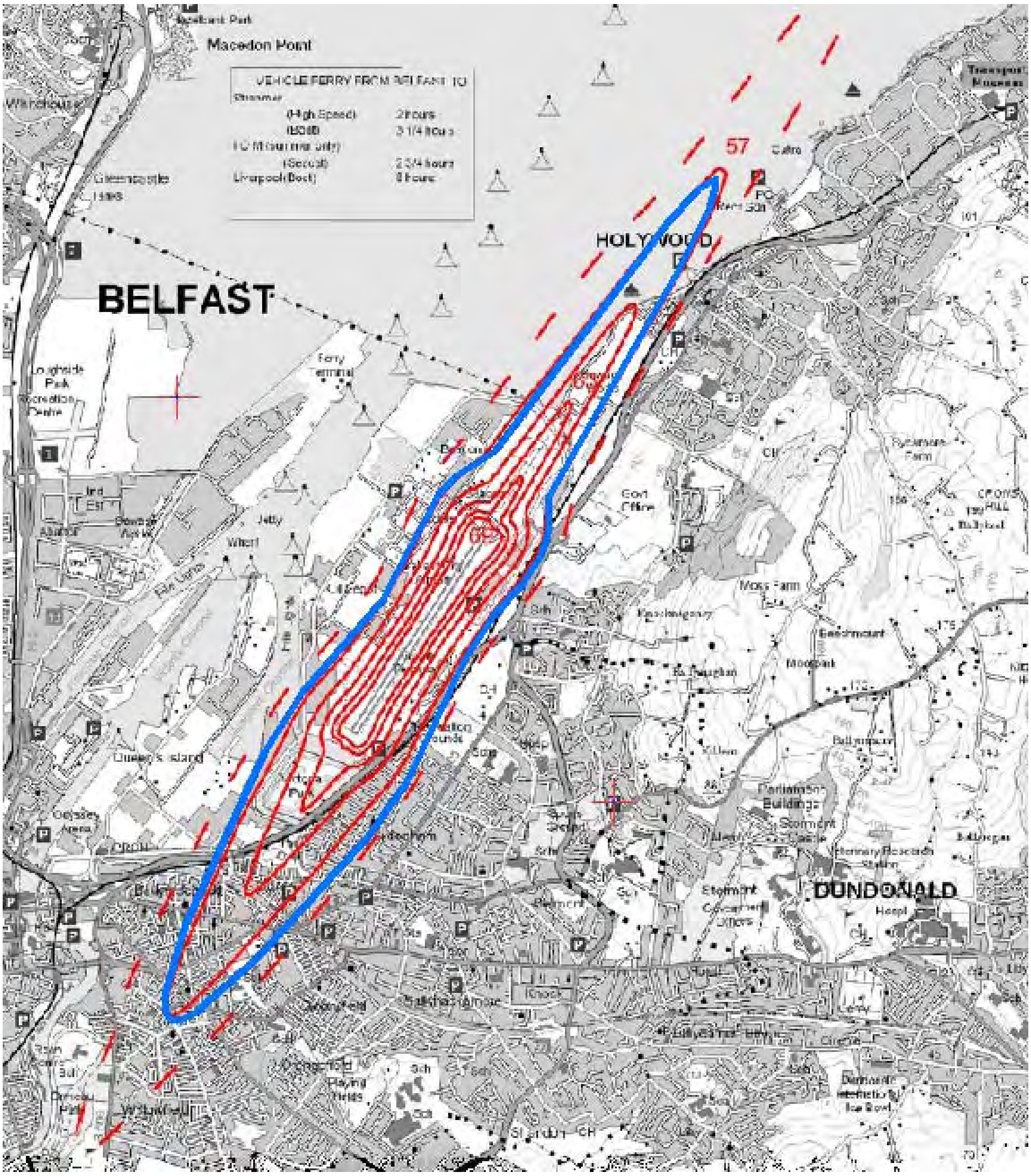
Plate 9.5 presents a comparison of the 55 dB L_{den} contours for a range of scenarios. The plate shows that the effect of applying the adjustments to the emissions is the significant increase in size of the contour. The net effect is a further increase upon the size of the Round One contour. Much of the reason for this increase is due to the adjustments resulting in an increase in the effective number of modelled movements.

Plate 9.5 Comparison of 55 dB L_{den}



To ensure that the size of the contour is reasonable, the project team have compared the $L_{Aeq, 16hr}$ outputs with those prepared by BAP for the purposes of producing Summer 2011 contours. The plate presented the BAP summer 2011 contours and a annual average 57 dB $L_{Aeq, 16hr}$ contour (in blue) as prepared by the project team. The plate shows that the general shape of these contours is comparable. The plate shows that the annual average contour is slightly larger to the south-west. This is due to the modal split over the 2011 calendar year resulting in a greater proportion of departures to the south-west than during the summer period. In general, the similar size and shape of the contours draws confidence that the model is producing very similar outputs.

Plate 9.5 Comparison of 57 $L_{Aeq, 16hr}$



As a sensibility check, the non-adjusted Round Two 55 dB L_{den} contour (in blue) was compared to the BAP Summer 2011 contours in Plate 9.6.

Plate 9.6 Sense Check of Contours

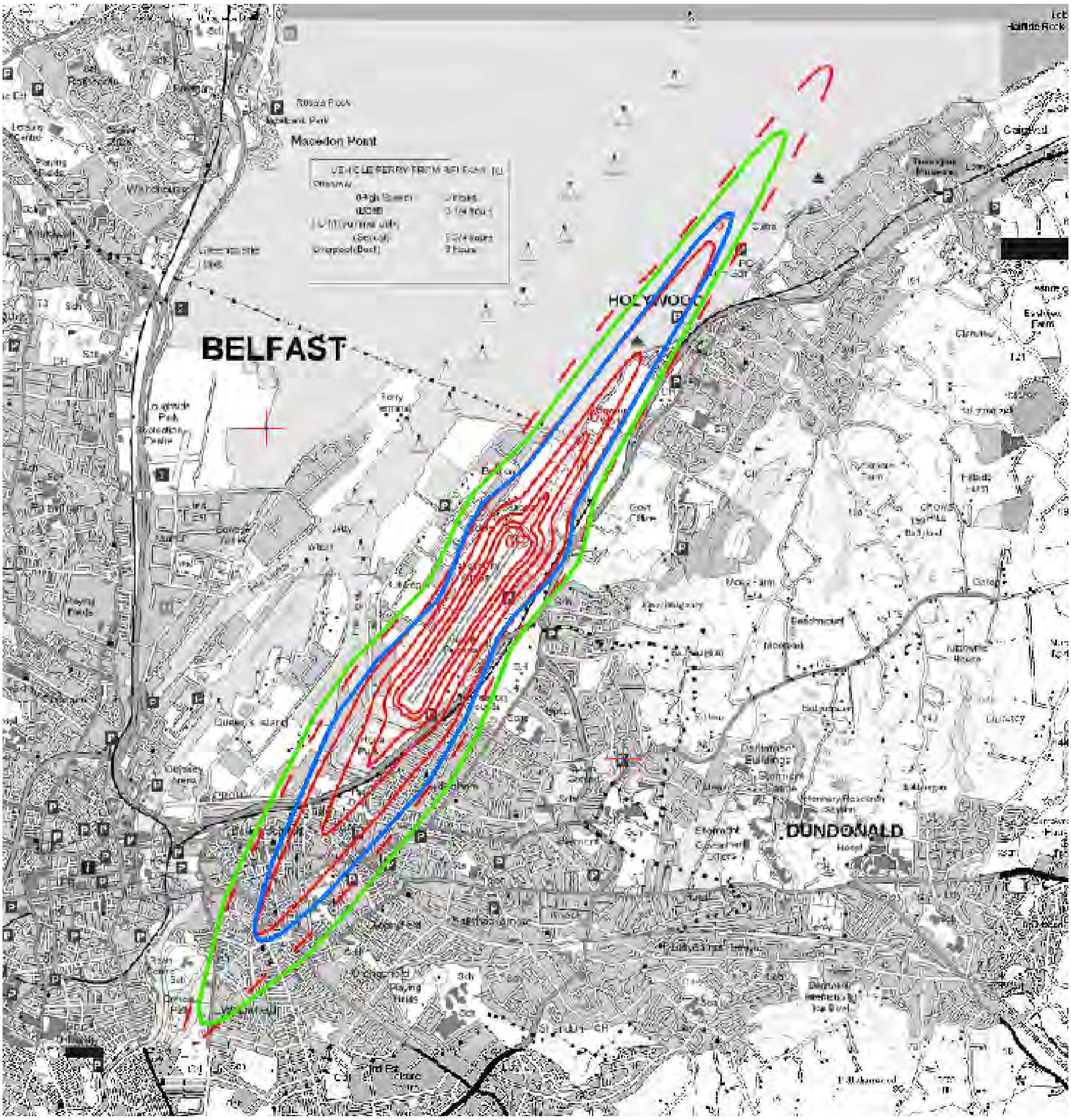


Plate 9.6 also presents the 55 dB L_{den} contour (in green) with emission adjusted. Both contours are presented against the 2011 Summer contours. This shows that the non-adjusted 55 dB L_{den} contour is similar in size to the Summer 2011 57 dB $L_{Aeq, 16hr}$ contour however the adjusted 55 dB L_{den} contour is more akin to the Summer 2011 54

dB $L_{Aeq, 16hr}$ contour. In almost all cases for busy commercial airports, the 55 dB L_{den} contour should always be larger than the 57 dB $L_{Aeq, 16hr}$ contour and should be of an order of the 54 dB $L_{Aeq, 16hr}$. This was recently stipulated in Department for Transport (DfT) Draft Aviation Policy Framework consultation. Annex D of the Draft consultation sets out relative comparisons between summer average 54 and 57 dB $L_{Aeq, 16hr}$ and annual average 55 dB L_{den} contours in which it states that the 55 dB L_{den} contour is *"larger than 57 dB $L_{Aeq, 16hr}$"* and *"Also larger than 54 dB $L_{Aeq, 16h}$ at airports with many night flights"*.

This supports the use of the Round Two noise contours which have been produced using adjustment to INM emissions in order to ensure consistency with the airports routine annual production of average summer day contours.

The use of verification adjustments for Round Two mapping at BCA makes a true comparison with Round One very difficult. For this comparison to occur, Round One would need to be remodelled to incorporate the adjustments outlined in Section 5.9. It is recommended that this exercise is undertaken and preferably completed and reported prior to the issuing of the Round Two contours and associated population statistics.

9.6 Conclusions

The comparisons presented in Chapter 9 have shown that the use of adjustments to INMs aircraft noise emissions models has resulted in a step change in noise exposure between Round One and Round Two. The comparisons do however demonstrate that regardless of this step change, increases in air traffic movements at BCA, particularly during evening and night-time periods is a major contributing factor responsible for the overall size of the Round Two END noise contours.

Appendix A
Modelled Aircraft Movements

Table A1 24-Hour Movements

Aircraft Type	INM Aircraft	INM / User Aircraft Substitute / Verification?	Annual Movements	Annual Average Daily Movements
Bombardier (Canadair) CL-600-2B16 Challenger 604	CL600	C	4	0.011
1125 Astra M	IA1125	C	2	0.005
200 Super King Air L	BEC200	S	26	0.071
400A Beechjet (400XP)	BEC400	C	10	0.027
Airbus A319	See Section 5.9	V	3615	9.904
Airbus A320	See Section 5.9	V	4	0.011
Airbus A320	See Section 5.9	V	837	2.293
Airbus A321	See Section 5.9	V	18	0.049
ATR 72	ATR72	C	4	0.011
BAe -146	BAE146	C	7	0.019
BAe Jetstream 41	BAEJ41	S	2	0.005
BAe-125-700 M	BAE125	C	24	0.066
BAe-3100 Jetstream 31	BAEJ31	S	156	0.427
BD-100 Challenger 300 M	BD100	S	8	0.022
BD-700 Global Express M	BD700	S	2	0.005
Beech 1900	BEC190	S	2	0.005
Beech 95 Travel Air	BEC95	S	57	0.156
Beech King Air 100	BEC100	S	2	0.005
Beech King Air 300	BEC300	S	4	0.011

Table A1 (continued) 24-Hour Movements

Aircraft Type	INM Aircraft	INM / User Aircraft Substitute / Verification?	Annual Movements	Annual Average Daily Movements
Beechcraft Beechjet 400	BEC400	S	10	0.027
Boeing 737-200	7373B2	C	2	0.005
Boeing 737-300	See Section 5.9	V	2	0.005
Boeing 737-300	See Section 5.9	V	2	0.005
Boeing 737-300	See Section 5.9	V	4931	13.510
Boeing 737-400	737400	C	166	0.455
Boeing 737-500	See Section 5.9	V	505	1.384
Boeing 737-700	737700	C	8	0.022
Boeing 737-800 (winglets)	737800	C	4	0.011
Boeing C-40 Clipper	737300	C	26	0.071
Boeing 737-4Z6 B734 27906	737400	C	2	0.005
Bombardier BD-700 Global Express	BD700	S	2	0.005
Canadair CL-600 Challenger 600	CL600	C	6	0.016
CASA C-295M	C130E	C	2	0.005
Cessna 172	CNA172	C	3	0.008
Cessna 303 Crusader	CNA303	S	4	0.011
Cessna 340A	CNA340	S	2	0.005
Cessna 425 Corsair	CNA425	S	4	0.011
Cessna 441 Conquest II	CNA441	S	2	0.005

Table A1 (continued) 24-Hour Movements

Aircraft Type	INM Aircraft	INM / User Aircraft Substitute?	Annual Movements	Annual Average Daily Movements
Cessna 510 Citation Mustang	CNA510	C	12	0.033
Cessna 525 Citation CJ1+	CNA525C	C	3	0.008
Cessna 525 CitationJet	CNA525C	C	2	0.005
Cessna 550 Citation	CNA550	S	33	0.090
Cessna 550 Citation Bravo	CNA55B	REG	2	0.005
	CNA55B	C	20	0.055
Cessna 560 Citation V	CNA560	S	2	0.005
Cessna 560XL Citation Excel	CNA560XL	C	216	0.592
	CNA560XL	REG	19	0.052
Cessna 680 Citation Sovereign	CNA560XL	C	2	0.005
Cessna 750 Citation X	CNA750	C	3	0.008
Cessna A150 Aerobat	CNA150	S	2	0.005
Cessna Citation 500 (I)	CNA500	C	1	0.003
Cessna Citation 525	CNA525C	C	20	0.055
Cessna Citation II	CNA550	S	2	0.005
Cessna Citation Sovereign 680	CNA680	C	4	0.011
Cessna Citation Ultra 560	CNA560U	C	12	0.033
Cessna T206H Turbo Stationair	CNAT20	C	11	0.030

Table A1 (continued) 24-Hour Movements

Aircraft Type	INM Aircraft	INM / User Aircraft Substitute?	Annual Movements	Annual Average Daily Movements
Cessna T303 Crusader	CNAT20	C	3	0.008
	CNAT20	REG	1	0.003
Cirrus SR22	SR22	S	4	0.011
DA-42 Twinstar	DA42	S	2	0.005
Dash 8-Q300	DCH830	C	4	0.011
Dassault Falcon 2000	FAL20A	S	10	0.027
Dassault Falcon 7X	FAL900	S	6	0.016
Dassault Mystère 50	FAL50	S	2	0.005
De Havilland Canada DHC-8-400 Dash 8	See Section 5.9	V	22457	61.526
Diamond DA40	DA40	U	2	0.005
Dornier 228	DO228	C	59	0.162
Dornier 328	D328J	S	2	0.005
Eclipse 500 L	ECLIPSE500	C	2	0.005
EMB-500 Phenom 100	EMB120	C	3	0.008
Embracer 175	EMB170	S	6	0.016
EMBRAER EMB-500 Phenom 100	EMB120	C	2	0.005
EMBRAER 135	EMB135	S	6	0.016
EMBRAER 145	EMB190	S	240	0.658

Table A1 (continued) 24-Hour Movements

Aircraft Type	INM Aircraft	INM / User Aircraft Substitute?	Annual Movements	Annual Average Daily Movements
EMBRAER 195	See Section 5.9	V	4747	13.005
EMBRAER EMB-110 Bandeirante	EMB110	S	2	0.005
EMBRAER EMB-505 Phenom 100	EMB500	U	8	0.022
Embraer Phenom 500	EMB120	C	2	0.005
Gulfstream Aerospace G-IV	GIV	C	16	0.044
Gulfstream Aerospace GV-SP (G550)	GV	C	48	0.132
GULFSTREAM AMERICAN CORP. G-1159A	GULF3	S	2	0.005
Hawker-Siddeley HS-125-1	HS125	S	34	0.093
Learjet 35	LEAR35	C	2	0.005
Learjet 40	LEAR45	S	4	0.011
Learjet 45	LEAR45	S	15	0.041
Learjet 60	LEAR60	S	2	0.005
LET L-420 Turbolet	See Section 5.9	V	2368	6.488
P-180 Avanti L	P180	S	2	0.005
PA-28 L	PA28	C	4	0.011
PA-31 L	PA31	C	16	0.044
PA-46-500TP Malibu Meridian L	PA46	S	2	0.005
Pilatus PC-12	PC12	S	124	0.340

Table A1 (continued) 24-Hour Movements

Aircraft Type	INM Aircraft	INM / User Aircraft Substitute?	Annual Movements	Annual Average Daily Movements
Piper PA-31-350 Navajo Chieftain	PA31	C	7	0.019
PIPER PA-34-200T	CNAT20	C	2	0.005
Piper PA22 Colt	PA22CO	S	6	0.016
Piper PA-31T Cheyenne	PA31T	S	4	0.011
Piper PA-31T2 Cheyenne 2XL	PA31T	S	6	0.016
Piper PA34 Seneca	PA34	S	6	0.016
Piper Twin Commanche	PA30	C	4	0.011
Raytheon 360 Premier	R360	S	2	0.005
Raytheon Aircraft Co 1900D	BEC190	S	3	0.008
Rockwell Turbo Commander 690	RWCM69	S	2	0.005
Saab 340	See Section 5.89	V	492	1.348
Saab-Scania 2000	SAAB20	S	2	0.005
Swearingen Metro	SA227	S	4	0.011
	SAMER4	S	154	0.422

Table A2 Daytime Modelled Movements

Aircraft Type	INM Aircraft	INM / User Aircraft Substitute?	Annual Movements	Annual Average Daytime Movements
Bombardier (Canadair) CL-600-2B16 Challenger 604	CL600	C	4	0.011
1125 Astra M	IA1125	C	1	0.003
200 Super King Air L	BEC200	S	25	0.068
400A Beechjet (400XP)	BEC400	C	9	0.025
Airbus A319	See Section 5.9	V	2694	7.381
Airbus A320	See Section 5.9	V	4	0.011
Airbus A320	See Section 5.9	V	635	1.740
Airbus A321	See Section 5.9	V	15	0.041
ATR 72	ATR72	C	4	0.011
BAe -146	BAE146	C	7	0.019
BAe Jetstream 41	BAEJ41	S	2	0.005
BAe-125-700 M	BAE125	C	24	0.066
BAe-3100 Jetstream 31	BAEJ31	S	143	0.392
BD-100 Challenger 300 M	BD100	S	7	0.019
BD-700 Global Express M	BD700	S	1	0.003
Beech 1900	BEC190	S	1	0.003
Beech 95 Travel Air	BEC95	S	50	0.137
Beech King Air 100	BEC100	S	0	0.000
Beech King Air 300	BEC300	S	4	0.011

Table A2 (continued) Daytime Modelled Movements

Aircraft Type	INM Aircraft	INM / User Aircraft Substitute?	Annual Movements	Annual Average Daytime Movements
Beechcraft Beechjet 400	BEC400	S	10	0.027
Boeing 737-200	7373B2	C	0	0.000
Boeing 737-300	See Section 5.9	V	2	0.005
Boeing 737-300	See Section 5.9	V	2	0.005
Boeing 737-300	See Section 5.9	V	3979	10.901
Boeing 737-400	737400	C	142	0.389
Boeing 737-500	See Section 5.9	V	485	1.329
Boeing 737-700	737700	C	0	0.000
Boeing 737-800 (winglets)	737800	C	4	0.011
Boeing C-40 Clipper	737300	C	11	0.030
Boeing 737-4Z6 B734 27906	737400	C	2	0.005
Bombardier BD-700 Global Express	BD700	S	1	0.003
Canadair CL-600 Challenger 600	CL600	C	6	0.016
CASA C-295M	C130E	C	2	0.005
Cessna 172	CNA172	C	3	0.008
Cessna 303 Crusader	CNA303	S	4	0.011
Cessna 340A	CNA340	S	2	0.005
Cessna 425 Corsair	CNA425	S	4	0.011
Cessna 441 Conquest II	CNA441	S	2	0.005

Table A2 (continued) Daytime Modelled Movements

Aircraft Type	INM Aircraft	INM / User Aircraft Substitute?	Annual Movements	Annual Average Daytime Movements
Cessna 510 Citation Mustang	CNA510	C	11	0.030
Cessna 525 Citation CJ1+	CNA525C	C	3	0.008
Cessna 525 CitationJet	CNA525C	C	2	0.005
Cessna 550 Citation	CNA550	S	30	0.082
Cessna 550 Citation Bravo	CNA55B	REG	2	0.005
	CNA55B	C	17	0.047
Cessna 560 Citation V	CNA560	S	2	0.005
Cessna 560XL Citation Excel	CNA560XL	C	196	0.537
	CNA560XL	REG	16	0.044
Cessna 680 Citation Sovereign	CNA560XL	C	2	0.005
Cessna 750 Citation X	CNA750	C	3	0.008
Cessna A150 Aerobat	CNA150	S	2	0.005
Cessna Citation 500 (I)	CNA500	C	1	0.003
Cessna Citation 525	CNA525C	C	20	0.055
Cessna Citation II	CNA550	S	2	0.005
Cessna Citation Sovereign 680	CNA680	C	2	0.005
Cessna Citation Ultra 560	CNA560U	C	10	0.027
Cessna T206H Turbo Stationair	CNAT20	C	10	0.027

Table A2 (continued) Daytime Modelled Movements

Aircraft Type	INM Aircraft	INM / User Aircraft Substitute?	Annual Movements	Annual Average Daytime Movements
Cessna T303 Crusader	CNAT20	C	3	0.008
	CNAT20	REG	1	0.003
Cirrus SR22	SR22	S	4	0.011
DA-42 Twinstar	DA42	S	2	0.005
Dash 8-Q300	DCH830	C	4	0.011
Dassault Falcon 2000	FAL20A	S	10	0.027
Dassault Falcon 7X	FAL900	S	6	0.016
Dassault Mystère 50	FAL50	S	2	0.005
De Havilland Canada DHC-8-400 Dash 8	See Section 5.9	V	17910	49.068
Diamond DA40	DA40	U	2	0.005
Dornier 228	DO228	C	53	0.145
Dornier 328	D328J	S	2	0.005
Eclipse 500 L	ECLIPSE500	C	2	0.005
EMB-500 Phenom 100	EMB120	C	2	0.005
Embracer 175	EMB170	S	4	0.011
EMBRAER EMB-500 Phenom 100	EMB120	C	2	0.005
EMBRAER 135	EMB135	S	4	0.011
EMBRAER 145	EMB190	S	224	0.614

Table A2 (continued) Daytime Modelled Movements

Aircraft Type	INM Aircraft	INM / User Aircraft Substitute?	Annual Movements	Annual Average Daytime Movements
EMBRAER 195	See Section 5.9	V	3841	10.523
EMBRAER EMB-110 Bandeirante	EMB110	S	2	0.005
EMBRAER EMB-505 Phenom 100	EMB500	U	7	0.019
Embraer Phenom 500	EMB120	C	2	0.005
Gulfstream Aerospace G-IV	GIV	C	15	0.041
Gulfstream Aerospace GV-SP (G550)	GV	C	45	0.123
GULFSTREAM AMERICAN CORP. G-1159A	GULF3	S	2	0.005
Hawker-Siddeley HS-125-1	HS125	S	34	0.093
Learjet 35	LEAR35	C	2	0.005
Learjet 40	LEAR45	S	3	0.008
Learjet 45	LEAR45	S	14	0.038
Learjet 60	LEAR60	S	2	0.005
LET L-420 Turbolet	See Section 5.9	V	2180	5.973
P-180 Avanti L	P180	S	0	0.000
PA-28 L	PA28	C	2	0.005
PA-31 L	PA31	C	16	0.044
PA-46-500TP Malibu Meridian L	PA46	S	2	0.005
Pilatus PC-12	PC12	S	117	0.321

Table A2 (continued) Daytime Modelled Movements

Aircraft Type	INM Aircraft	INM / User Aircraft Substitute?	Annual Movements	Annual Average Daytime Movements
Piper PA-31-350 Navajo Chieftain	PA31	C	7	0.019
PIPER PA-34-200T	CNAT20	C	2	0.005
Piper PA22 Colt	PA22CO	S	6	0.016
Piper PA-31T Cheyenne	PA31T	S	3	0.008
Piper PA-31T2 Cheyenne 2XL	PA31T	S	6	0.016
Piper PA34 Seneca	PA34	S	5	0.014
Piper Twin Commanche	PA30	C	4	0.011
Raytheon 360 Premier	R360	S	2	0.005
Raytheon Aircraft Co 1900D	BEC190	S	3	0.008
Rockwell Turbo Commander 690	RWCM69	S	2	0.005
Saab 340	See Section 5.9	V	492	1.348
Saab-Scania 2000	SAAB20	S	2	0.005
Swearingen Metro	SA227	S	4	0.011
	SAMER4	S	154	0.422

Table A3 Evening Modelled Movements

Aircraft Type	INM Aircraft	INM / User Aircraft Substitute?	Annual Movements	Annual Average Evening Movements
1125 Astra M	IA1125	C	1	0.003
200 Super King Air L	BEC200	S	1	0.003
400A Beechjet (400XP)	BEC400	C	1	0.003
Airbus A319	A319-131	C	836	2.290
Airbus A320	A320-232	C	185	0.507
Airbus A321	A321-232	C	3	0.008
BAe-3100 Jetstream 31	BAEJ31	S	13	0.036
BD-100 Challenger 300 M	BD100	S	1	0.003
BD-700 Global Express M	BD700	S	1	0.003
Beech 1900	BEC190	S	1	0.003
Beech 95 Travel Air	BEC95	S	5	0.014
Beech King Air 100	BEC100	S	2	0.005
Boeing 737-200	7373B2	C	2	0.005
Boeing 737-300	See Section 5.9	V	809	2.216
Boeing 737-400	See Section 5.9	V	22	0.060
Boeing 737-500	See Section 5.9	V	20	0.055
Boeing 737-700	737700	C	7	0.019
Boeing C-40 Clipper	737300	C	15	0.041

Table A3 (continued) Evening Modelled Movements

Aircraft Type	INM Aircraft	INM / User Aircraft Substitute?	Annual Movements	Annual Average Evening Movements
Cessna 510 Citation Mustang	CNA510	C	1	0.003
Cessna 550 Citation	CNA550	S	3	0.008
Cessna 550 Citation Bravo	CNA55B	C	3	0.008
Cessna 560XL Citation Excel	CNA560XL	C	19	0.052
Cessna 560XL Citation Excel	CNA560XL	REG	2	0.005
Cessna Citation Sovereign 680	CNA680	C	2	0.005
Cessna Citation Ultra 560	CNA560U	C	2	0.005
Cessna T206H Turbo Stationair	CNAT20	C	1	0.003
De Havilland Canada DHC-8-400 Dash 8	See Section 5.9	V	4105	11.247
Dornier 228	DO228	C	6	0.016
EMB-500 Phenom 100	EMB120	C	1	0.003
Embracer 175	EMB170	S	2	0.005
EMBRAER 135	EMB135	S	2	0.005
EMBRAER 145	EMB190	S	16	0.044
EMBRAER 195	See Section 5.9	V	723	1.981
EMBRAER EMB-505 Phenom 100	EMB500	U	1	0.003
Gulfstream Aerospace G-IV	GIV	C	1	0.003
Gulfstream Aerospace GV-SP (G550)	GV	C	3	0.008

Table A3 (continued) Evening Modelled Movements

Aircraft Type	INM Aircraft	INM / User Aircraft Substitute?	Annual Movements	Annual Average Evening Movements
Learjet 40	LEAR45	S	1	0.003
Learjet 45	LEAR45	S	1	0.003
LET L-420 Turbolet	See Section 5.9	V	188	0.515
P-180 Avanti L	P180	S	2	0.005
PA-28 L	PA28	C	2	0.005
Pilatus PC-12	PC12	S	7	0.019
Piper PA-31T Cheyenne	PA31T	S	1	0.003
Piper PA34 Seneca	PA34	S	1	0.003
Swearingen Metro	SA227	S	2	0.005
Swearingen Metro	SAMER4	S	7	0.019

Table A4 Night-Time Modelled Movements

Aircraft Type	INM Aircraft	INM / User Aircraft Substitute?	Annual Movements	Annual Average Night-time Movements
Airbus A319	See Section 5.9	V	85	0.233
Airbus A320	See Section 5.9	C	17	0.047
Beech 95 Travel Air	BEC95	S	2	0.005
Boeing 737-300	7373B2	C	143	0.392
Boeing 737-400	737400	C	2	0.005
Boeing 737-700	737700	C	1	0.003
Bombardier BD-700 Global Express	BD700	S	1	0.003
Cessna 560XL Citation Excel	CNA560XL	C	1	0.003
Cessna 560XL Citation Excel	CNA560XL	REG	1	0.003
De Havilland Canada DHC-8-400 Dash 8	DHC840	S	442	1.211
EMBRAER 190	EMB190	S	183	0.501

Table A5 INM Substitutions Based on Airline and Aircraft Codes from 2011 Flight Records

Airline IATA Code	Aircraft IATA Code	Airline Name	Aircraft Name	INM Aircraft	INM Substitution Type C – Core S – INM Built-in U – User REG – Various aircraft within IATA Code, looked up by aircraft registration V = Verification Adjustment	Details of Any Assumptions/ Verification
BD	319	BMI	Airbus A319	A319-131	V	Arrival movements x 1.5, Departure movements x 1.4
U2	73G	easyJet	Boeing 737300	737300	V	Arrival movements x 1.7, Departure movements x 1.7
BE	DH4	Flybe	De Havilland Canada DHC-8-400 Dash 8	SD330 Arr DHC6 Dep	V	Arrivals modelled as SD330 with movements x 1.4, Departures modelled as DHC6 with movements x 0.8
WW	733	Bmibaby	Boeing 737-300	737300	V	Arrival movements x 1.7, Departure movements x 1.7
BD	320	BMI	Airbus A320	A320-232	V	Departures modelled using Stage 2
	BE20		200 Super King Air L	BEC200	S	
NM	L4T		LET L-420 Turbolet	SD330 Arr DHC6 Dep	V	Arrivals modelled as SD330, Departures modelled as DHC6 with movements x 1.8
U2	73W	easyJet	Boeing 737-700	737700	V	Modelled with movements factored by 1.7
BE	E95	Flybe	EMBRAER EMB-190 / EMB-195 / ERJ-190 / ERJ-195	A319-131	V	Modelled as A319-131 with movements factored by 2
NM	SW4	Air Madrid	Swearingen Metro	SAMER4	S	
	H25B		BAe-125-700 M	BAE-125-400	S	Assumed to be same as BAE 125-400
LC	SF3	Logan Air	Saab 340	SF340	V	Arrival movements x 2, Departure movements x 2.5
U2	319	easyJet	Airbus A319	A319-131	V	Arrival movements x 1.5, Departure movements x 1.4

Table A5 (continued) INM Substitutions Based on Airline and Aircraft Codes from 2011 Flight Records

Airline IATA Code	Aircraft IATA Code	Airline Name	Aircraft Name	INM Aircraft	INM Substitution Type C – Core S – INM Built-in U – User REG – Various aircraft within IATA Code, looked up by aircraft registration V = Verification Adjustment	Details of Any Assumptions/ Verification
NM	D28	Air Madrid	Dornier 228	DO228	C	
	CNJ		Cessna 560XL Citation Excel	CNA560XL	C	
WW	735	Bmibaby	Boeing 737-500	737500	V	Arrival movements x 1.7, Departure movements x 1.9
	C525		525 Citation CJ1 L	CNA525C	C	
	PA31		PA-31 L	PA31	C	
	G5		Gulfstream Aerospace GV-SP (G550)	GV	C	
U2	320	easyJet	Airbus A320	A320-211	V	Departures modelled as Stage Length 2
	CL30		BD-100 Challenger 300 M	BD100	S	
U2	732	easyJet	Boeing 737-200	7373B2	C	Only 2 movements - majority for ex-easyjet fleet 300 series
	SW4		Swearingen Metro	SA227	S	
	C500		500 Citation 1 L	CNA500	C	

Table A5 (continued) INM Substitutions Based on Airline and Aircraft Codes from 2011 Flight Records

Airline IATA Code	Aircraft IATA Code	Airline Name	Aircraft Name	INM Aircraft	INM Substitution Type C – Core S – INM Built-in U – User REG – Various aircraft within IATA Code, looked up by aircraft registration V = Verification Adjustment	Details of Any Assumptions/ Verification
RR	H25B	Royal Air Force	BAe-125-700 M	BAE-125-400	S	Assumed to be same as BAE 125-400
	PC12		PC-12 L	PC12	S	
	PAY2		PA-31T-620 Cheyenne 2 L	PA31T	S	
	C425		425 Corsair L	CNA425	S	
	B350		300 (B300) Super King Air 350-L	BEC300	S	
	C303		T303 Crusader L	CNA303	S	
	BE30		300 Super King Air L	BEC300	S	
	C510		510 Citation Mustang L	CNA510	C	
LS	733	Jet2.com	Boeing 737-300	7373B2	V	Arrival movements x 1.7, Departure movements x 1.9
	LJ45		45 M	LEAR45	S	
	E50P		EMB-500 Phenom 100 L	EMB120	C	Assumed Embrarer 120 with Pratt & Whitely engines
	GLEX		BD-700 Global Express M	BD700	S	
	BE10		100 King Air L	BEC100	S	
	C550		550 Citation Bravo L	CNA550	S	

Table A5 (continued) INM Substitutions Based on Airline and Aircraft Codes from 2011 Flight Records

Airline IATA Code	Aircraft IATA Code	Airline Name	Aircraft Name	INM Aircraft	INM Substitution Type C – Core S – INM Built-in U – User REG – Various aircraft within IATA Code, looked up by aircraft registration V = Verification Adjustment	Details of Any Assumptions/ Verification
FR	73H	Ryanair	Boeing 737-800 (winglets)	737800	C	
	P180		P-180 Avanti L	P180	S	
NM	J31	Air Madrid	BAe BAe-3100 Jetstream 31	BAEJ31	S	
	PRM1		390 Premier 1 L	R390	S	
	G4		Gulfstream Aerospace G-IV	GIV	C	
	C560		560 Citation 5 Ultra Encore M	CNA560U	C	
	C680		680 Citation Sovereign M	CNA680	C	
	PA34		PA-34 Seneca L	PA34	S	
BD	321	BMI	Airbus A321	A321-232	V	Departures modelled as Stage Length 2
	PA30		PA-30 Twin Comanche L	PA30	C	
	BE40		400 Beechjet M	BEC400	S	
	73W		Boeing 737-700	737700	C	Assumed easyjet
	C25A		525A Citation CJ2 L	CNA525C	C	
	73G		Boeing C-40 Clipper	737300	C	

Table A5 (continued) INM Substitutions Based on Airline and Aircraft Codes from 2011 Flight Records

Airline IATA Code	Aircraft IATA Code	Airline Name	Aircraft Name	INM Aircraft	INM Substitution Type C – Core S – INM Built-in U – User REG – Various aircraft within IATA Code, looked up by aircraft registration V = Verification Adjustment	Details of Any Assumptions/ Verification
NM	BE20	Air Madrid	200 Super King Air L	BEC200	S	
	DA42		DA-42 L	DA42	S	
BD	ER4	BMI	EMBRAER EMB-145 / ERJ-145	EMB190	S	
JP	319	Adria Airways	Airbus A319	A319-131	V	Arrival movements x 1.5, Departure movements x 1.4
	SR22		SR-22 L	SR22	S	
	J31		BAe BAe-3100 Jetstream 31	BAEJ31	S	
	A340		Cessna 340A	CNA340	S	
	ASTR		1125 Astra M	IA1125	C	
	P46T		PA-46-500TP Malibu Meridian L	PA46	S	
	EA50		Eclipse 500 L	ECLIPSE500	C	
	PA28		PA-28 L	PA28	C	
CJ	E90	China Northern Airlines	EMBRAER EMB-190 / EMB-195 / ERJ-190 / ERJ-195	EMB190	S	

Table A5 (continued) INM Substitutions Based on Airline and Aircraft Codes from 2011 Flight Records

Airline IATA Code	Aircraft IATA Code	Airline Name	Aircraft Name	INM Aircraft	INM Substitution Type C – Core S – INM Built-in U – User REG – Various aircraft within IATA Code, looked up by aircraft registration V = Verification Adjustment	Details of Any Assumptions/ Verification
BD	733	BMI	Boeing 737-300	737300	V	Arrival movements x 1.7, Departure movements x 1.7
	PAY3		PA Cheyenne 3 L	PA31T	S	
	C172		P-172 L	CNA172	C	
	LJ40		40 M	LEAR45	S	The Learjet 40 is derived from the Learjet 45, but with a shorter fuselage (by 24.5 inches/60 cm), and is powered by two Honeywell TFE731-20AR engines. These are known as the "AR" engines.
	C750		750 Citation X M	CNA750	C	
	BET		Beech 95 Travel Air	BEC95	S	
	H25		Hawker-Siddeley HS-125-1	HS125	S	
	LJ35		35 M	LEAR35	C	
	FA7X		Falcon 7X M	FAL900	S	Falcon 7X is a smaller version of the FAL900
	G3		GULFSTREAM AMERICAN CORP. G-1159A	GULF3	S	
	C56X		560XL Citation Excel M	CNA560	S	
	AC90		690 Turbo Commander 690 L	RWCM69	S	
	DA40		DA-40 L	DA40	U	Similar to Cessna 172

Table A5 (continued) INM Substitutions Based on Airline and Aircraft Codes from 2011 Flight Records

Airline IATA Code	Aircraft IATA Code	Airline Name	Aircraft Name	INM Aircraft	INM Substitution Type C – Core S – INM Built-in U – User REG – Various aircraft within IATA Code, looked up by aircraft registration V = Verification Adjustment	Details of Any Assumptions/ Verification
BD (continued)	FA50		Mystère 50 M	FAL50	U	50% CL600 and 50% LEAR35
BE	SF3	Flybe	Saab 340	SF340	C	
GOJ	CNJ		Cessna 560XL Citation Excel	CNA560XL	C	
PVT	BET		Beech 95 Travel Air	BEC95	S	
PVT	MP2			REG	REG	MP2 CODE ALSO LOOKED UP BY REGISTRATION
EGL	MP2			REG	REG	
SYG	BET		Beech 95 Travel Air	BEC95	S	
PVT	PL2		PC-12 L	PC12	S	
BJT	GRJ		Gulfstream Aerospace GV-SP (G550)	GV	C	
CLB	BET		Beech 95 Travel Air	BEC95	S	
FLJ	JET		EMBRAER EMB-505 Phenom 100	EMB500	U	CNA525C
FLJ	CN1		Cessna A150 Aerobat	CNA150	S	
NJE	DF2		Dassault Falcon 2000	FAL20A	S	
EGL	BET		Beech 95 Travel Air	BEC95	S	
NJE	CNJ			REG	REG	LOOK UP BY REGISTRATION

Table A5 (continued) INM Substitutions Based on Airline and Aircraft Codes from 2011 Flight Records

Airline IATA Code	Aircraft IATA Code	Airline Name	Aircraft Name	INM Aircraft	INM Substitution Type C – Core S – INM Built-in U – User REG – Various aircraft within IATA Code, looked up by aircraft registration V = Verification Adjustment	Details of Any Assumptions/ Verification
PVT	CNJ			REG	REG	LOOK UP BY REGISTRATION
NJE	H25		Hawker-Siddeley HS-125-1	HS125	S	
KRH	CNJ		Cessna 560XL Citation Excel	CNA560XL	C	
GMA	JET		Dassault Falcon 2000	FAL20A	S	Mainly Business Jets - mixed fleet, only 6 movements therefore assume FALCON 2000
PVT	JET		550 Citation Bravo L	CNA550	S	Likely to be small business jets, only 10 movements, assuming Cessna 550
NJE	JET		400 Beechjet M	BEC400	C	
PVT	MP1		Gulfstream Aerospace GV-SP (G550)	GV	C	Only one of these movements under this combination has a registration which relates to a Gulfstream Aerospace GV-SP (G550)GLF5 aircraft. Therefore assume this for all others
RR	H25	Royal Air Force	Hawker-Siddeley HS-125-1	HS125	S	
RAF	H25		Hawker-Siddeley HS-125-1	HS125	S	
IRL	GRJ		Gulfstream Aerospace GV-SP (G550)	GV	C	Only 2 movements - assume Gulfstream small jet
JCB	GRJ		Gulfstream Aerospace GV-SP (G550)	GV	C	
PVT	PA1		P-172 L	CNA172	C	Only one movements - assume a small aircraft, CNA172

Table A5 (continued) INM Substitutions Based on Airline and Aircraft Codes from 2011 Flight Records

Airline IATA Code	Aircraft IATA Code	Airline Name	Aircraft Name	INM Aircraft	INM Substitution Type C – Core S – INM Built-in U – User REG – Various aircraft within IATA Code, looked up by aircraft registration V = Verification Adjustment	Details of Any Assumptions/ Verification
MT	321	Thomas Cook Airlines	Airbus A321	A321-232	V	Departures modelled as Stage Length 2
EN	E95	Air Dolomiti	EMBRAER EMB-190 / EMB-195 / ERJ-190 / ERJ-195	A319-131	V	Movements factored by 2
PVE	CN1		Cessna A150 Aerobat	CNA150	S	
PVE	BET		Beech 95 Travel Air	BEC95	S	
FLP	BET		Beech 95 Travel Air	BEC95	S	
PVE	CNJ		525A Citation CJ2 L	CNA525C	C	8x movements (all cessna, majority Cessna 525 jet)
PVE	MP1			REG	REG	SOME DONE BY REGISTRATION, ASSUMME ALL OTHER MOVEMENTS ARE THE SAME TYPE
PVE	H25		Hawker-Siddeley HS-125-1	HS125	S	
TWF	CNJ		Cessna 550 Citation Bravo	CNA55B	C	
ZT	142	Titan Airways	BAe BAe-146-200	BAE146	C	
BKK	CNJ		510 Citation Mustang L	CNA510	C	
T3	S20	Eastern Airways	Saab-Scania 2000	SAAB20	S	
PLF	MP2	Polish Air Force		REG	REG	SOME DONE BY REGISTRATION, ASSUMME ALL OTHER MOVEMENTS ARE THE SAME TYPE

Table A5 (continued) INM Substitutions Based on Airline and Aircraft Codes from 2011 Flight Records

Airline IATA Code	Aircraft IATA Code	Airline Name	Aircraft Name	INM Aircraft	INM Substitution Type C – Core S – INM Built-in U – User REG – Various aircraft within IATA Code, looked up by aircraft registration V = Verification Adjustment	Details of Any Assumptions/ Verification
LNX	BET		Beech 95 Travel Air	BEC95	S	
PVE	MP2		Cessna T206H Turbo Stationair	CNA20T	C	
PVE	PL2		PC-12 L	PC12	S	
BE	D38	Flybe	Dornier 328	D328J	S	
3W	MP1	Euromanx Airways		ATR72	C	Could be any one of these 3 aircrafts (ATR 72-201, Dash 8-Q200, Dash 8-Q300). Assume ATR72
MCD	PAT		Piper PA-31T2 Cheyenne 2XL	PA31T	S	
MCE	CNJ		Cessna 560XL Citation Excel	CNA560XL	C	
TYW	CNJ		Cessna 550 Citation Bravo	CNA55B	C	
WW	734	Bmibaby	Boeing 737-400	737400	C	
PVE	GRJ		Gulfstream Aerospace G-IV	GIV	C	
PVE	LRJ		40 M	LEAR45	S	Assumed LEAR45
BFO	MP2		Canadair CL-600 Challenger 600	CL600	C	
PVT	LRJ		40 M	LEAR45	S	Assumed LEAR45
PVT	PA2		Piper Piper light aircraft - twin piston engines	PA22CO	S	

Table A5 (continued) INM Substitutions Based on Airline and Aircraft Codes from 2011 Flight Records

Airline IATA Code	Aircraft IATA Code	Airline Name	Aircraft Name	INM Aircraft	INM Substitution Type C – Core S – INM Built-in U – User REG – Various aircraft within IATA Code, looked up by aircraft registration V = Verification Adjustment	Details of Any Assumptions/ Verification
CRX	CNJ		Cessna 560XL Citation Excel	CNA560XL	C	
RR	141	Royal Air Force	BAe BAe-146-100	BAE146	C	BAE146-1 assumed to be same as -2
PVT	GRJ		Gulfstream Aerospace G-IV	GIV	C	
HGR	CNJ		Cessna 525 CitationJet	CNA525C	C	
PVE	CCJ		Canadair CL-600 Challenger 600	CL600	C	
3W	MP2	Euromanx Airways	Dash 8-Q300	DHC830	C	Airline ceased in 2008, record shows on DASH-8 planes
VJS	LRJ		Learjet 60	LEAR60	S	Fleet 2x LR40 10xLR60
3W	PAG	Euromanx Airways	Dash 8-Q300	DHC830	C	Airline ceased in 2008, record shows on DASH-8 planes
VJS	CCJ		Canadair CL-600 Challenger 600	CL600	C	
T3	J41	Eastern Airways	BAe BAe-4100 Jetstream 41	BAEJ41	S	
PVE	JET		Gulfstream Aerospace G-IV	GIV	C	
PVE	CCX		Bombardier BD-700 Global Express	BD700	S	
PVT	734		Boeing 737-400	737400	C	

Table A5 (continued) INM Substitutions Based on Airline and Aircraft Codes from 2011 Flight Records

Airline IATA Code	Aircraft IATA Code	Airline Name	Aircraft Name	INM Aircraft	INM Substitution Type C – Core S – INM Built-in U – User REG – Various aircraft within IATA Code, looked up by aircraft registration V = Verification Adjustment	Details of Any Assumptions/ Verification
PVT	CCX		Bombardier BD-700 Global Express	BD700	S	
CRX	CN7		Cessna 560XL Citation Excel	CNA560XL	C	
PVE	CNT		425 Corsair L	CNA425	S	
PVT	CNT		425 Corsair L	CNA425	S	
CEG	BET		Beech 95 Travel Air	BEC95	S	
FXT	CNJ		Cessna 550 Citation Bravo	CNA55B	C	
FLJ	MP2		EMB-500 Phenom 100 L	EMB120	C	Assumed Embrarer 120 with Pratt & Whitely engines
BE	L4T	Flybe	LET L-420 Turbolet	DHC6	C	Assumed to be same as DHC6
DUK	JET	Luxemburg Air Ambulance		REG	REG	LOOK UP BY REGISTRATION
PVE	BE1		Beech 1900	BEC190	S	
NJE	GRJ		Gulfstream Aerospace GV-SP (G550)	GV	C	
PVT	CN7		Cessna 560XL Citation Excel	CNA560XL	C	
PVE	DF7		Falcon 7X M	FAL900	REG	LOOK UP BY REGISTRATION
GMA	H25		Hawker-Siddeley HS-125-1	HS125	S	

Table A5 (continued) INM Substitutions Based on Airline and Aircraft Codes from 2011 Flight Records

Airline IATA Code	Aircraft IATA Code	Airline Name	Aircraft Name	INM Aircraft	INM Substitution Type C – Core S – INM Built-in U – User REG – Various aircraft within IATA Code, looked up by aircraft registration V = Verification Adjustment	Details of Any Assumptions/ Verification
LNX	ER3		EMBRAER EMB-135 / ERJ-135	EMB135	S	
EDC	ER3		EMBRAER EMB-135 / ERJ-135	EMB135	S	
T7	BEH	Twin Jet	Beech 1900	BEC190	S	
LNX	CNJ			CNA560XL	C	
SYG	PA2		Piper Piper light aircraft - twin piston engines	PA22CO	S	
JFY	MP2		Canadair CL-600 Challenger 600	CL600	C	
NJE	DF7		Falcon 7X M	FAL900	REG	LOOK UP BY REGISTRATION
PVE	PAG			REG	REG	LOOK UP BY FLIGHT NUMBER
PVE	CN7		750 Citation X M	CNA750		
MGB	BET		Beech 95 Travel Air	BEC95	S	
LH	CNJ	Lufthansa	Cessna 525 Citation CJ1+	CNA525C	C	
PVT	DF7		Falcon 7X M	FAL900	REG	LOOK UP BY REGISTRATION
SDL	EMB		EMBRAER EMB-110 Bandeirante	EMB110	S	
PGL	LRJ		45 M	LEAR45	S	

Table A5 (continued) INM Substitutions Based on Airline and Aircraft Codes from 2011 Flight Records

Airline IATA Code	Aircraft IATA Code	Airline Name	Aircraft Name	INM Aircraft	INM Substitution Type C – Core S – INM Built-in U – User REG – Various aircraft within IATA Code, looked up by aircraft registration V = Verification Adjustment	Details of Any Assumptions/ Verification
PYN	MP2			REG	REG	LOOK UP BY REGISTRATION
LH	JET	Lufthansa		REG	REG	LOOK UP BY REGISTRATION
BE	E75	Flybe	Embracer 175	EMB170	S	Assumed Embracer 170
GMA	BET		Beech 95 Travel Air	BEC95	S	
XJC	CNJ	Xclusive Jet Charter	550 Citation Bravo L	CNA550	S	Airline has CJ2 and II
RE	AT7	Aer Arann	ATR ATR 72	ATR72	S	