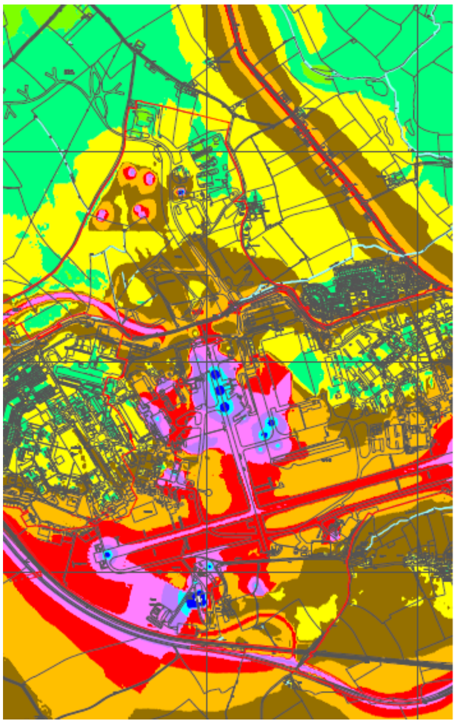
Department of Environment Northern Ireland

Provision of Second Round Noise Maps for Northern Ireland

3D Modelling Report



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3D Modelling Report

27 July 2012

AMEC Environment & Infrastructure
UK Limited

Executive Summary

This document outlines the processes which have been adopted to develop the 3D modelling environment used within the Round Two END assessment of airport, roads, railways and industrial sources within Northern Ireland.

This document aims to give the Northern Ireland Department of the Environment (DoE), Northern Ireland Department for Regional Development (DRD) Roads Service, Translink and Belfast City/ International airports, an understanding of the model development process including data capturing and processing, development of the LimA 3D 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. This includes highlighting that the Round Two data capture for all noise sources covers a total area of 5056 km^2, an increase of 132% on the area modelled in Round One.

The subsequent section (Section 3) considers the scope of the Round One mapping datasets and considers their ability to be used as a basis for development of effective input layers for the Round Two modelling process. The report also highlights in Section 4, the various updates which have taken place to key datasets used in the assessment. These include updates to the OSNI orthophotography, OSNI DTM terrain model and OSNI large scale mapping database. The report also details testing of the CEH Land Cover 2007 as ground cover input layer for Round Two.

From this basis, Sections 5 to 11 describe the GIS based processing steps which have taken to produce the Final Modified Data Input (FDMI) layers for subsequent integration into the LimA 3D modelling environment. These layers are: Buildings, Digital Terrain, Bridges, Barriers and Ground Cover. This work has been focused on developing datasets which reflect the established data specifications used during Round One. These specifications are provided in full in Appendix A.

The report concludes in Section 12 by outlining the specific QA processes which have been used to integrate each of the FDMI layers into the LimA noise model used for the subsequent modelling process.

Contents

Glossary

Term	Definition
Agglomeration	Major Continuous Urban Area as set out within the Regulations
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
INM	Integrated Noise Model

Term	Definition
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}) = $L_{Aeq,12h(07:00\ to\ 19:00)}$
Noise Level - L_e - Evening	L_e (or $L_{evening}$) = $L_{Aeq,4h(19:00\ to\ 23:00)}$
Noise Level - L_n - Night	L_n (or L_{night}) = $L_{Aeq,8h(23:00\ to\ 07:00)}$
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
Round Two	Round Two noise modelling for the European Noise Directive (Northern Ireland) - 2012

Term	Definition
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 Component 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; and
- 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; and

- All agglomerations with more than 100,000 inhabitants.

Under the Regulations, this contract aims to establish estimates of the total number of people 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. Noise exposure statistics required in L_{den} 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 and the estimated total number of people living in each of these areas will be established 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}. The results of the noise mapping will be used to inform and update noise action plans drafted by each competent authority.

Under the contract, noise level exposure statistics were also required for other supplementary noise indicators which are incumbent within national noise policy guidance.

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

- Review of the necessary Competent Authority data to ensure completeness (including a data Quality Assurance);
- Identification of gaps in order to define any further information requirements;
- Modifying and/or collecting further information through contractor survey (data cleaning and manipulation);
- Collation of the data into relevant datasets; and
- Preparation of Stage 1 report.
- Appraisal of data provided by DoE (and other stakeholders) with gaps identified with Quality Assuring of the data.

The following tasks were undertaken within Stage 1 of the contract:

- 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; and

- Storage and backup of electronic data.

1.2 Purpose of this Report

This report details the processes used to develop 3D modelling datasets for the mapping of noise levels for major roads and railways across Northern Ireland; and airport, industry, road and railway sources within the Belfast agglomeration. The aim of this report is to provide the Competent Authorities with an understanding of the processes involved in the development of 3D modelling datasets which have used to support the assessment of noise for the second round of mapping.

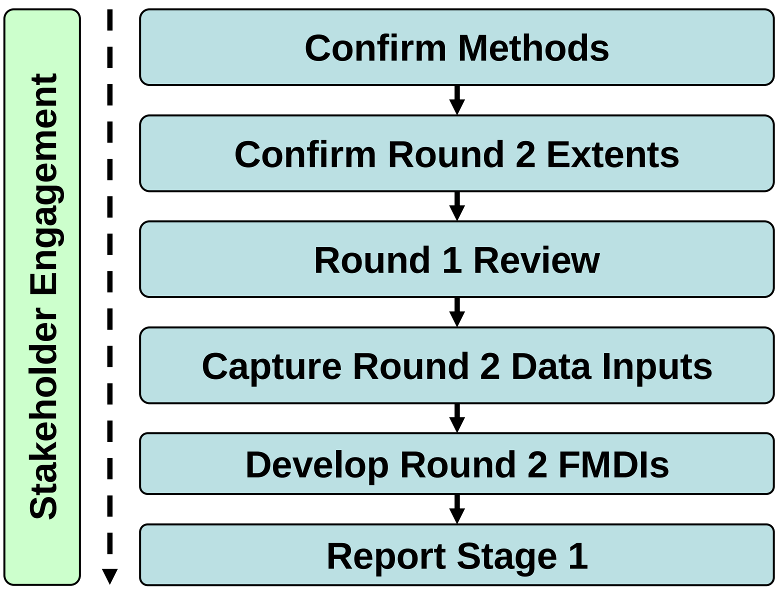
1.3 Overview of the Second Round Approach

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 are 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 3D modelling are discussed in relation to both the approach undertaken in Round One and the methodology adopted for Round Two.

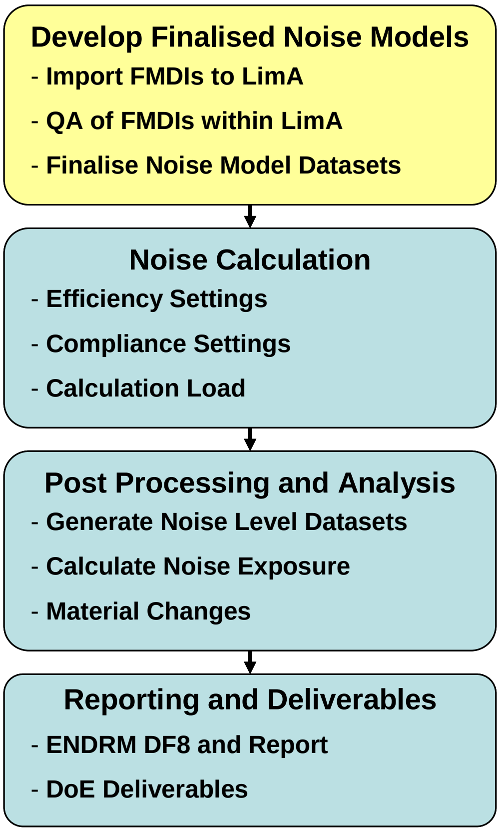
1.3.2 Stage 2

The aim and scope of Stage 2 was:

- 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. Data Capture Extents

Under the Environmental Noise Regulations (Northern Ireland) 2006, Round Two noise maps must encompass 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; and
- 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 area for each of the noise sources. Maps showing the geographical extent of the areas are also provided in Plates 2.1 – 2.4.

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.

Using the Belfast agglomeration as a basis, a Round Two data capture extent was created. This was developed by applying a 3km corridor to the boundary of the Belfast agglomeration and subsequently clipped against the Northern Ireland coastline. The resulting data capture area of 596km^2 is shown in Plate 2.1. This area is the same geographical area as used for round one mapping exercise.

2.2 Airport Modelling Extent

At the start of the Round Two, contact was established between AMEC and Belfast City and Belfast International Airports. Subsequent discussions with representatives of the airports confirmed that there have not been any significant physical changes or changes to airspace or runway operations at either airport since 2006. The location of the two airports is shown on Plate 2.1.

2.3 Industry Modelling Extent

The 104 industrial (industry, waste and harbour) sites considered in Round One were reviewed at the start of Round Two. This process included assessing the location, extent and (where possible) the operational activities of each of the Round One sites. An additional 14 sites which potentially required mapping under the END requirements were provided to AMEC by DoE.

Each of the 119 target sites were then identified and mapped using available OSNI aerial photography/ mapping and online review of Google Earth and StreetView imagery. Any premises which were not identifiable (i.e. demolished sites) during this process were removed from the list of target sites. After completing this initial assessment, detailed maps of each location were created and provided to DoE Northern Ireland and Belfast Ports and Harbour Authority for review and comment.

This process led to eight being removed from the target list and a final dataset of 111 sites which has been used in the final modelling process. The location and extent of these sites within the Belfast agglomeration are shown in Plate 2.2.

2.4 Major Roads Modelling Extent

The major roads to be mapped in this study were identified by linking road flow information supplied by the Northern Ireland Roads Service with road centrelines produced by OSNI. Detailed roads information is provided in the road modelling report.

Using these datasets, all major roads with more than 3 million vehicles were identified using GIS queries. A second GIS process was then used to define a 3km wide corridor around each of the selected roads. These buffered areas comprise the final major road mapping extent and is shown in Plate 2.3.

The data capture area covered by major roads outside the agglomeration was 4,460km^2. This compares to the 1,582km^2 mapped in Round One.

2.5 Major Railway Modelling Extent

At the start of the Round Two, Translink confirmed that there had been no major changes to the railway network in Northern Ireland since 2006 and that all of Northern Ireland’s major rail network falls within the Belfast Agglomeration. As a consequence the stretches of rail network mapped and considered during the first round have been used as the basis for the data capture process. The extent of the data capture area for the major railways is shown in Plate 2.4.

2.6 Round One and Round Two Data Capture Extents

Table 2.1 provides a summary of the extent of the data capture areas used for the Round One and Round Two mapping exercises. This highlights that total data capture area for Round Two is over double the size of the data capture area used for Round One. This reflects the changes in the requirements of the ENDS directive and the inclusion of additional major roads with more than 3 million vehicle passages per year.

Table 2.1 Round One and Round Two - Extent of Data Capture Area

Noise Source	Round One (km^2)	Round Two (km^2)	Increase in Area (km^2)	Percentage Increase	Round Two Area as a Percentage of Northern Ireland
Agglomeration (including airports, industry and railway sources)	596	596	0	0%	4.3%
Major roads (outside the Belfast agglomeration	1,582	4,460	2,878	182%	32.2%
Total area	2,178	5,056	2,878	132%	36.5%

Plate 2.1 Belfast Agglomeration showing Locations of Belfast City and International Airports and Major Roads

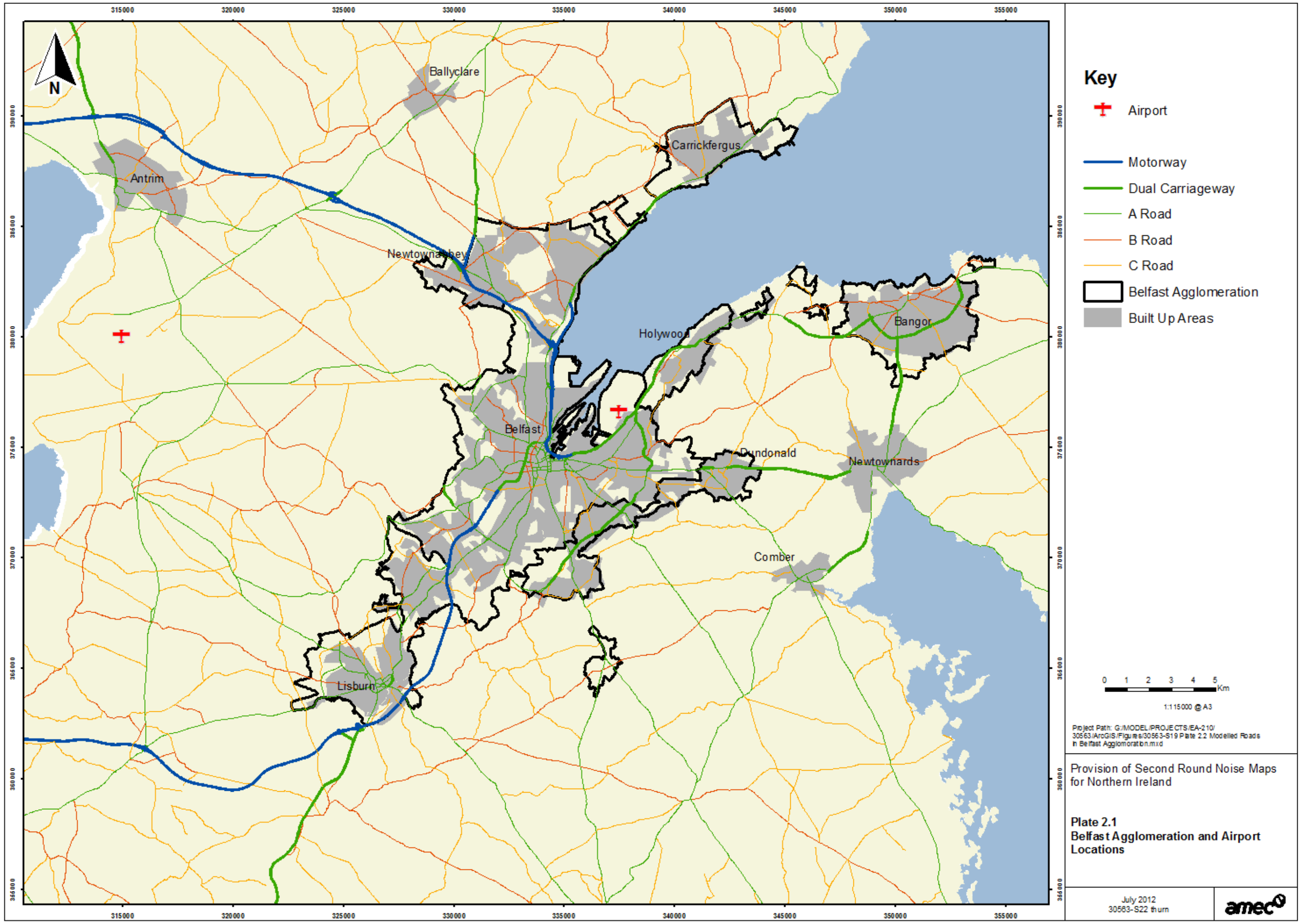


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Plate 2.2 Location of Industrial Sites Modelled within the Belfast Agglomeration

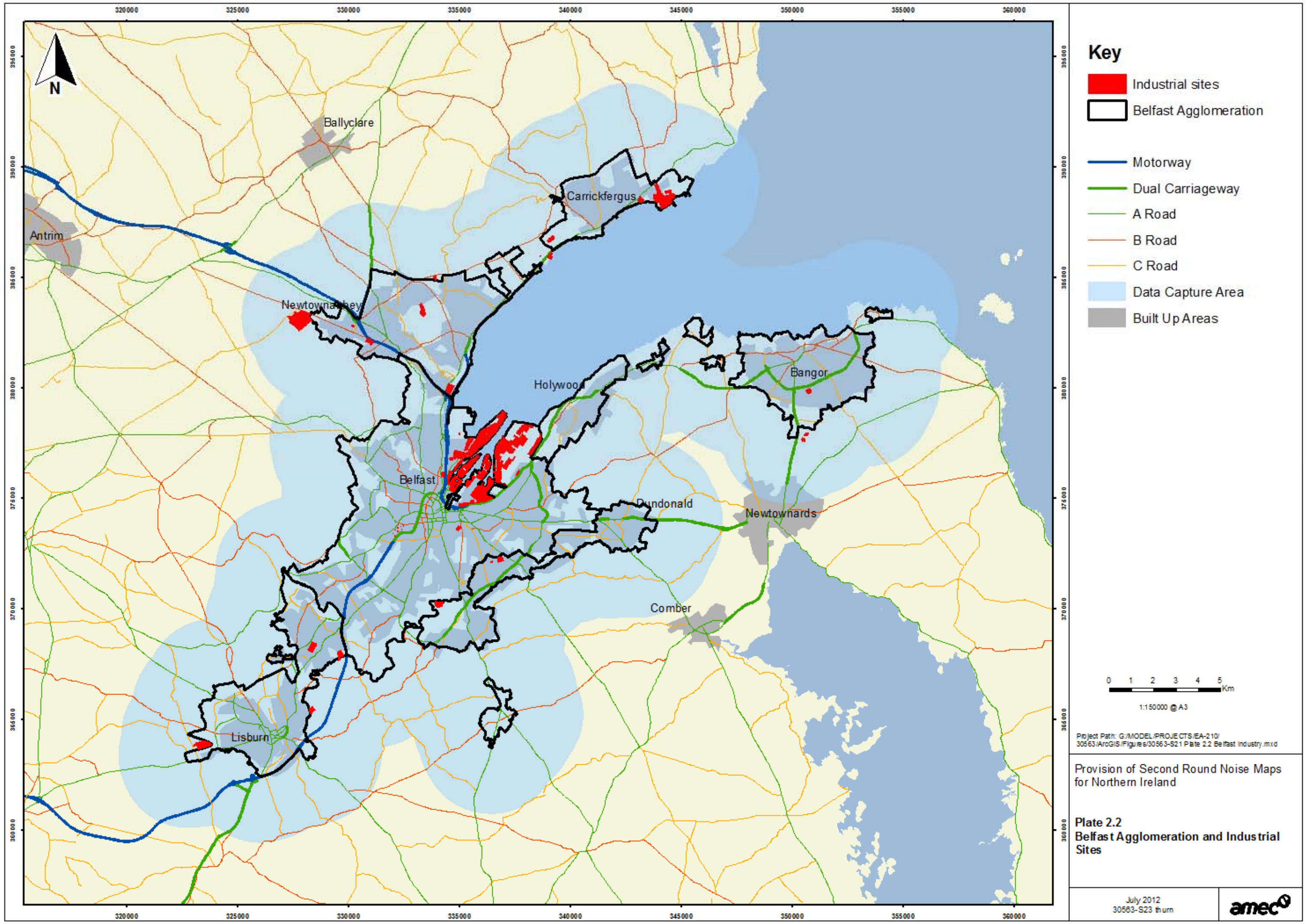

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Plate 2.3 Location of Major Roads Modelled outside the Belfast Agglomeration

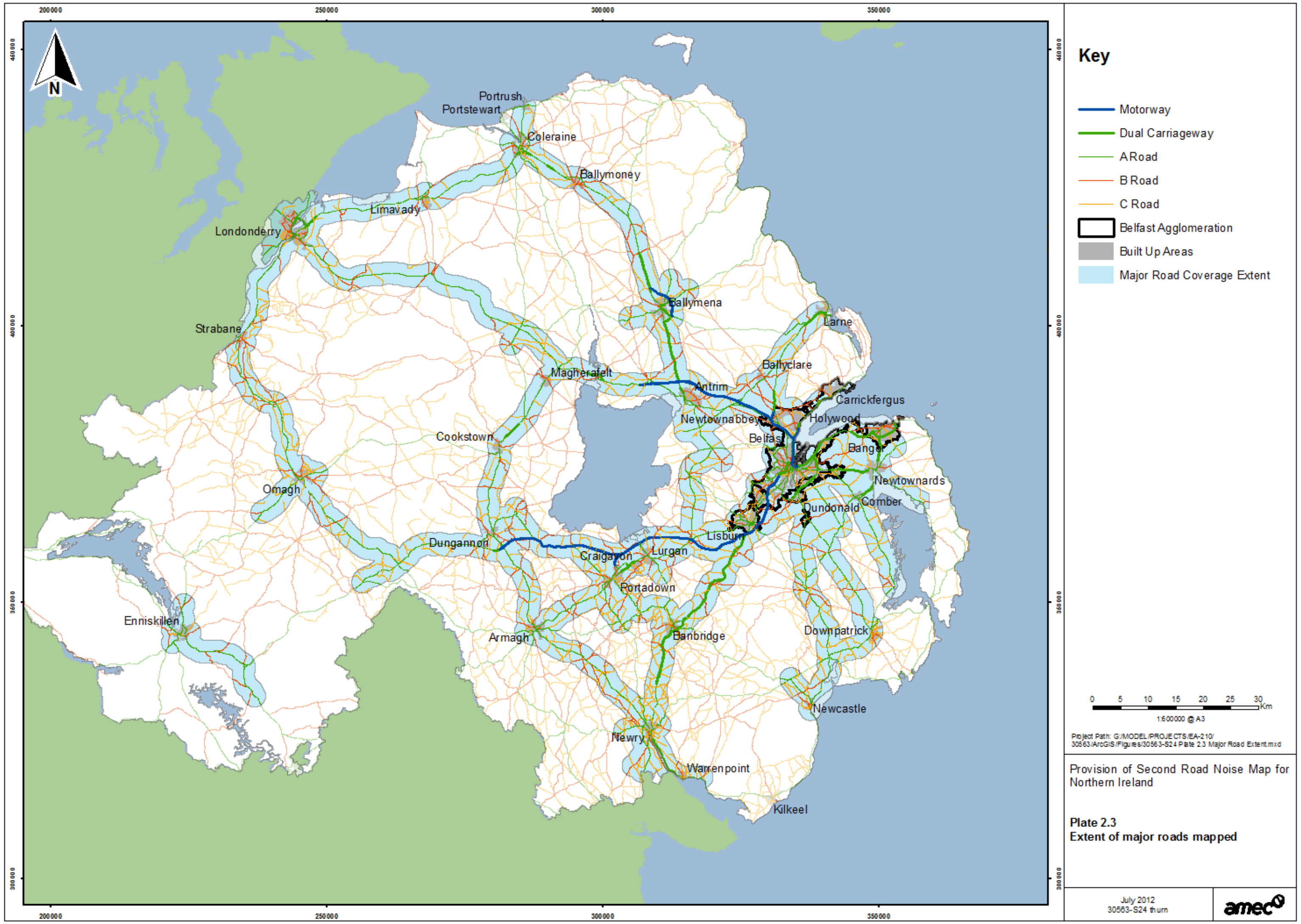
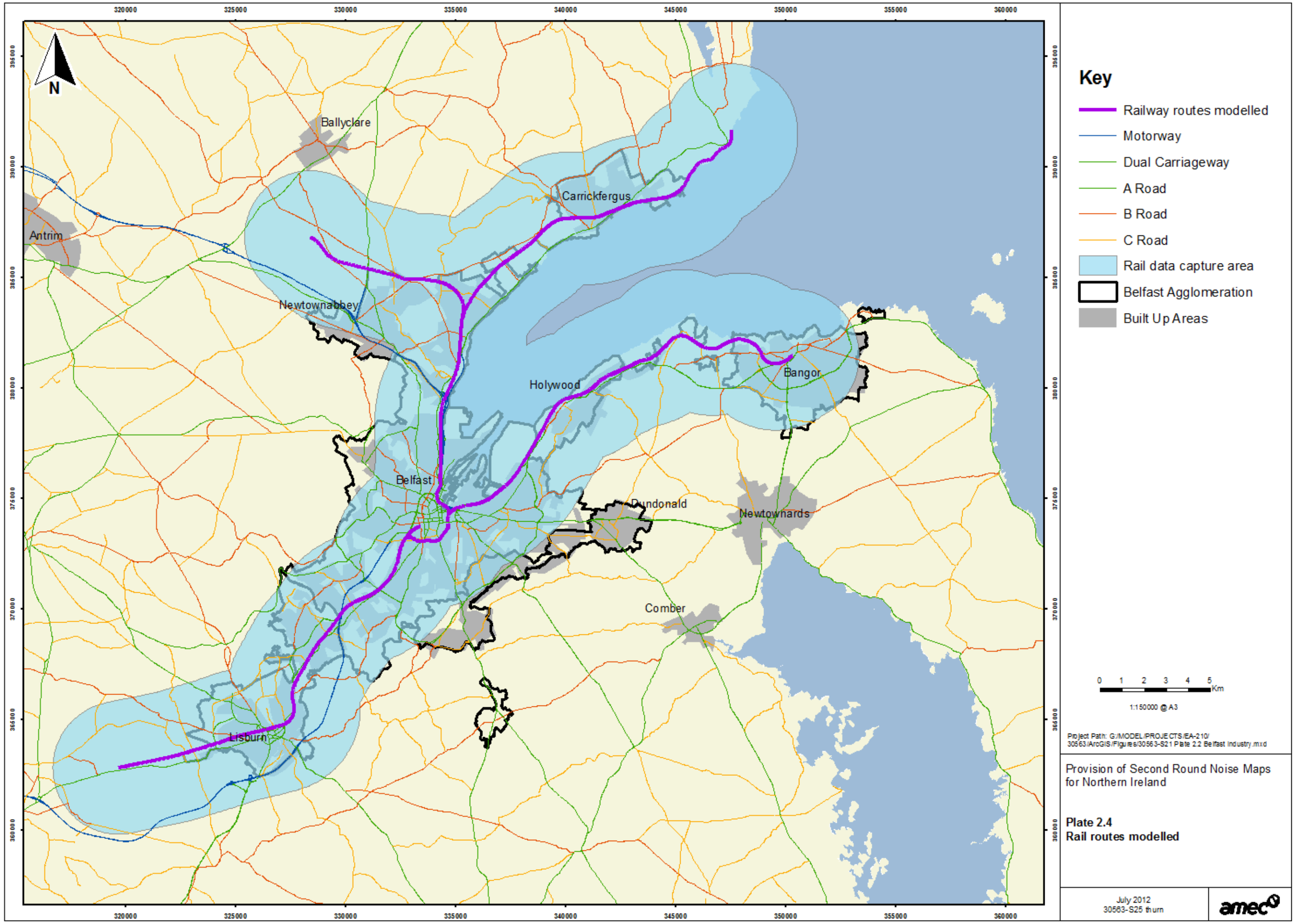


Plate 2.4 Location of Major Railway Routes Modelled inside the Belfast Agglomeration



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3. Confirmation of Calculation Methods

The 3D modelling environment was used for the assessment of road, railway and industrial noise. For these noise sources, the noise calculations require an understanding of topographic conditions in order to calculate attenuations of noise during propagation from source to receiver. These attenuations include corrections due to distance, ground conditions and acoustic screening from natural terrain and manmade features such as cuttings and embankments, buildings and barriers.

In the noise software environment, noise calculations obtain information leading to these corrections from the 3D model. It is therefore important that the information contained within the 3D modelling environment satisfies the requirements of the noise calculations methods. Furthermore the information held within the 3D modelling environment must also satisfy the requirements of the noise calculation and GIS software methods. These requirements often relate to object definition and cartographic rules.

This section outlines the noise calculation and software methods which have influenced the preparation of the 3D modelling.

3.1 Noise Calculation Methods

Under the Regulations the assessment methods prescribed for the mapping of road traffic, railway and industrial noise sources are outlined in Table 3.1. It is confirmed from the review of Round One that the same methods were adopted and applied during Round One. For Round One, the methods outlined in Schedule 2 were adopted and/or supplemented by additional guidance.

For road traffic noise, the assessment for Round One was undertaken with reference to the following:

- Roads: Calculation of Road Traffic Noise (CRTN) (UK) – adapted version comprising:
  - Department of Transport publication, *'Calculation of Road Traffic Noise'*, HMSO, 1988 ISBN 0115508473; and
  - Defra, Method for Converting the UK Road Traffic Noise Index LA10,18h to the EU Noise Indices for Road Noise Mapping, st/05/91/AGG04442, 24th January 2006.

Table 3.1 Methods of Assessment as Outlined in Schedule 2 of the Regulations (Road, Rail, Airport and Industry)

Assessment method for road traffic noise indicators

6. For road traffic noise indicators the assessment method "Calculation of road traffic noise" (Department of Transport, 7 June 1988, HMSO)(b) shall be used, adapted using the report "Method for converting the UK traffic noise index LA10,18h to EU noise indices for road noise mapping" (DEFRA, 24 January 2006)(c).

Assessment method for railway noise indicators

7. For railway noise indicators the assessment methods—

(a) "Calculation of railway noise" (Department of Transport, 13th July 1995, HMSO)(d); and

(b) (in relation to railways to which it is expressed to apply) "Calculation of railway noise 1995 Supplement No. 1 Procedure for the calculation of noise from Eurostar trains class 373" (Department for Transport, 20 October 1996, Stationery Office)(e);

shall be used, adapted as shown in Figure 6.5 of the report "Rail and wheel roughness – implications for noise mapping based on the Calculation of Railway Noise procedures" (DEFRA March 2004)(f).

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.

Assessment methods for industrial noise indicators and port noise indicators

9.—(1) For industrial noise indicators and port noise indicators the propagation assessment method described in "ISO 9613-2:1996 Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of Calculation" (International Standards Organisation, 1996)(a) shall be used in accordance with paragraph 2.5 of the Annex in the Recommendation.

(2) Suitable noise emission data (input data) for "ISO 9613-2:1996 Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation" can be obtained either from measurements carried out in accordance with one of the following methods:

(a) "Acoustics. Determination of sound power levels of multisource industrial plants for evaluation of sound pressure levels in the environment. Engineering method" (BS ISO 8297:1994, British Standards Institute)(b);

(b) "Acoustics. Determination of sound power levels of noise sources using sound pressure. Engineering method in an essentially free field over a reflecting plane" (BS EN ISO 3744:1995, British Standards Institute)(c);

(c) "Acoustics. Determination of sound power levels of noise sources using sound pressure. Survey method using an enveloping measurement surface over a reflecting plane" (BS EN ISO 3746:1996, British Standards Institute)(d);

or by using Toolkit 10 of the "Good Practice Guide for Strategic Noise Mapping and the Production of Associated Data on Noise Exposure Version 2, Position Paper Final Draft" (European Commission Working Group Assessment of Exposure to Noise, 13 January 2006)(e).

For railway noise, the assessment for Round One was undertaken with reference to the following:

- Railways: Calculation of Railway Noise (CRN) (UK) - adapted version comprising:
  - Calculation of Railway Noise (Department of Transport, 13th July 1995, HMSO);
  - Calculation of Railway Noise 1995 Supplement No. 1 Procedure for the calculation of noise from Eurostar trains class 373" (Department for Transport, 20th October 1996, Stationery Office);
  - "Rail and wheel roughness – implications for noise mapping based on the Calculation of Railway Noise procedure" (Defra, March 2004);
  - "Additional railway noise source terms for "Calculation of Railway Noise 1995" (Defra, May 2004); and

- Supplementary information regarding noise emissions and railway roughness corrections for the Northern Irish rail fleet as provided by DeltaRail during Round One.

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) 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) as implemented in INM version 7 onwards.

The main change between the Second and Third Edition of the method is the inclusion of additional functions and attenuations for bank angles, and the inclusion of new flight procedures and updated thrust reverser components. These 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.

For industrial noise, the assessment for Round One was undertaken with reference to the following:

- ISO 9613 Interim is described within the following documents:
  - ISO 9613-2: ‘Acoustics — Attenuation of sound propagation outdoors, Part 2: General method of calculation’;
  - Commission Recommended Adaptations from 2003/613/EC; and
  - The source noise levels used within the calculations should be derived via a methodology in line with the WG-AEN GPGv2 Toolkit 10.

For Round Two, there is no requirement to alter or amend the methods adopted for Round One. It has also been concluded that the adopted versions outlined above remain relevant to the delivery of the strategic noise maps under the Regulations. For Round Two, the noise calculation assessment methods described in this section were used and have informed the preparation of the 3D modelling dataset.

3.2 Software Methods

For Round One noise maps for road, railway and industrial noise sources were prepared using the LimA version 5.2 noise modelling package with geo-processing and analysis undertaken with the ESRI ArcGIS software environment.

Both software environments were retained for Round Two. The LimA version adopted for Round Two was version 8.1. Following discussions with Stapelfeldt Ingenieurgesellschaft mbH, developers of the LimA noise mapping software, it is understood that there have been no modifications to the implementation of the CRTN, CRN or ISO9613 methodologies between versions 8.1 and 5.2. It is understood that the software now offers some additional features in terms of new and additional definitions for 3D modelling objects. However it is understood that the interpretations of these objects with reference to the underlying calculation algorithms remains unchanged.

4. Dataset Specifications

The development of the 3D model dataset was undertaken with the aim of developing and finalising “Final Modified Data Inputs” (FMDIs) in accordance with a data specification satisfying the requirements of the calculation methods and software environments.

To calculate noise levels at a specific location or receptor, the following must be established:

i. The level of noise being generated at source (i.e. the noise emissions)

ii. The attenuation of noise levels during propagation from source to receiver (i.e. the propagation)

As discussed later in Section 5, the 3D model environment is used to establish the various attenuations during the propagation of noise from source to receiver and as such the 3D model environment is a noise propagation dataset. The preparation of noise emission datasets are reported in separate reports delivered under this contract.

For Round One, dataset specifications were developed for the calculation methods and software environments. As there has been no change in the calculation methods or software environments employed in Round Two the FMDI dataset specifications have been retained from Round One. These are provided in Appendix A.

4.1 Propagation Datasets

Due to the similarities in the information required in the calculation of the propagation of road traffic, railway and industrial noise, it is best practice in noise mapping to produce a single 3D model environment which can facilitate calculations of each noise source. This best practice was implemented during Round One and has been carried forward into Round Two.

Within the noise modelling software, the following datasets comprise the propagation dataset.

- **Buildings Dataset** – this dataset defines the location and the height of buildings;
- **Digital Terrain Model (DTM) Dataset** – this dataset is used to define the height and profile of the terrain upon which other objects are located. The DTM dataset can comprise of the following element:
  - Spot Heights –data representing the height of the terrain at a point;
  - Contour Lines – data presenting areas of terrain with equal height;
  - Break Lines – vector information representing the height of the terrain at specific features.
- **Barriers Dataset –** this dataset defines the location and the height of any noise barriers (i.e. barriers that present an obstacle to noise propagation);
- **Bridges Dataset –** this dataset present the location of bridges;

- **Ground Cover Dataset** – this dataset is used to define the acoustic absorbency of the ground over which noise propagates from source to receiver;

- **Meteorological Dataset** – this dataset defines the average annual meteorological conditions for parameters such as temperature, humidity and wind direction.

Appendix A presents the FMDI data specification of each dataset comprising the 3D model. The FMDI data specifications are designed to work both within the ArcGIS and LimA software environments. Both software environments are also capable of handling point, polyline and polygon objects and can process heights and elevations in several different formats.

The FMDI dataset specifications have ultimately been driven by the requirements of the LimA noise modelling environment. This means that cartographic, object and object attribution rules required within the LimA environment have been reciprocated within the ArcGIS environment.

To assist this process, the LimAarc ArcGIS extension was utilised. The LimAarc extension streamlines many of the key data interaction stages between the ArcGIS and LimA software environments, reducing the risk of human error. It also enhances key interfaces between the ArcGIS and LimA environments providing additional QA procedures within the noise mapping process.

4.2 Interim Datasets

In the development of the Round Two FMDIs, it was necessary to convert and process existing data sources to fit the FMDI specifications. For Round Two, it was also necessary to report any material changes that may, or may not have occurred between Round One and Round Two. To identify and record these material changes, it was necessary for interim datasets (i.e. those that are produced during the processing towards FMDIs) to identify where data may have changed with respect to Round One.

In the case of the 3D modelling material, changes may occur due to the construction and/or demolition of buildings. Changes may also occur as a result of changes in the DTM. As part of the development of the Round Two FMDIs, interim datasets were developed to review, where possible, any differences between the various noise propagation datasets. This has included differential testing of Round One and Round Two data sources.

5. Round Two Dataset Development

5.1 Reviewing the Round One Data Sources

Prior to the development of the Round Two datasets, the project team undertook a review of the various datasets adopted for the noise mapping as part of Round One. The review was undertaken through study of the GIS FMDIs and 3D modelling reports obtained from DoE and as produced by the previous contractor. The review process set out to identify the following:

- Round One data sources;
- Availability for Round Two over required extents;
- Where any added value or editing was present within the dataset; and
- Whether or not the data source could be improved upon or further refined for Round Two.

Table 5.1 presents a summary of this review in relation to the above points.

Table 5.1 Reviewing the Round One Datasets

Propagation Dataset	Round One Data Source	Round One Coverage relevant for Round Two Mapping	Value Adding/ Editing	Potential Improvement?
DTM Dataset	OSNI Enhanced DTM	Yes but only covering parts of the Round Two extent	Yes	Yes - parts of the DTM product have been updated since 2007/2008 using new aerial photography
Ground Cover Dataset	EEA CORINE	Yes but only covering part of the Round Two extent	Yes	Yes – consideration of the detailed CEH Land Cover Map 2007 dataset
Buildings Dataset	OSNI large scale database	Yes but only covering part of the Round Two extent	Yes	Yes
Barriers Dataset	Surveyed data	Yes but only covering part of the Round Two extent	Yes	Yes
Bridges Dataset	OSNI large scale database	Yes but only covering part of the Round Two extent	Yes	Yes
Meteorological Dataset	Belfast International Airport	No – updated 2011 data needs to be used	No	n/a

The review identified that most of the OSNI data sources available during Round One were also available for Round Two mapping over the required extents. For all 3D modelling datasets, with the exception of the meteorological dataset, the review identified that added value or manual editing had been undertaken i.e. all datasets had been subject to refinement prior to any noise modelling. This is discussed further in the following sections along with the relevance to Round Two.

5.1.1 Overview of the Round One FMDI Datasets

Two versions of the Round One FMDI datasets were provided: GIS and noise model datasets. The GIS datasets have been provided in ESRI Shapefile format with the noise model datasets provided in the proprietary formats of the LimA and INM software.

As discussed in Section 3, for Round Two the project team have retained the software environments adopted during Round One. Furthermore, as outlined Section 4, due to the retention of the software environments, the project team are also retaining the dataset specifications adopted for Round One. As a result, the Round One FMDIs can be used to assist in the development of the Round Two datasets.

Table 5.2 outlines the Round One FMDI datasets received from DoE and the corresponding LimA model layer. To enable project management in Round One, the mapping was undertaken in six project sub-areas.

Table 5.2 Overview of Round One 3D-Modelling Datasets

Project Area	DTM Dataset		Buildings	Bridges	Barriers	Ground Cover
	GEL	HIN HA 4	HIN HA 2	HIN HA 7	HIN HA 1	TOP
Area 1 – Major Roads	✓	✓	✓	✓		✓
Area 2 – Major Road	✓	✓	✓	✓		✓
Area 3 – Major Road	✓	✓	✓	✓	✓	✓
Area 4 – Major Road	✓	✓	✓	✓	✓	✓
Area 5 – Major Road	✓	✓	✓	✓	✓	✓
Area 6 – Belfast Agglomeration	✓	✓	✓	✓	✓	✓

As discussed in Section 2, the total extent to be mapped under Round Two is approximately 5,056km^2. This is over double the size of the area mapped in Round One due to the lowering of the major road threshold from 6 million vehicle passages per year to 3 million passages per year. As shown in Plate 2.3, the major road extents in Northern Ireland are no longer defined as discrete project sub-areas as assessed in Round One. Instead the extent of major roads in Northern Ireland forms a continuous dataset. As a result, the project team decided to use the Round One FMDIs developed outside of Area 6 (the Belfast Agglomeration) as a starting point for capturing the location of bridges and barriers, and therefore develop a new continuous 3D-modelling dataset for Round Two.

For the Belfast Agglomeration, the project team decided to assess the usability of the Round One datasets on a layer by layer basis. The use of the Round One FMDIs is discussed further in the remainder of this report.

5.2 Datasets Available for the Second Round of Mapping

5.2.1 OSNI Datasets

Many of the datasets used in the second round mapping exercise have been derived from OSNI spatial datasets. OSNI spatial datasets were also used in the development of the Round One FMDIs. Table 5.3 outlines the datasets which were provided (under licence) by OSNI and summarises how they have been used in the subsequent modelling processes.

Table 5.3 Overview of OSNI Datasets

OSNI Product Name	Used in Development of Round Two Datasets	Digital Format	Comment
Raster			
10k Colour	Yes	TIFF & ECW	Context and background mapping
STREET Maps	Yes	TIFF & ECW	Context and background mapping
CITY Maps	Yes	TIFF & ECW	Context and background mapping
Activity Maps	Yes	TIFF & ECW	Context and background mapping
1:50 000 Raster	Yes	TIFF & ECW	Context and background mapping
250k Raster	Yes	TIFF & ECW	Context and background mapping
1:1,000,000 Raster	Yes	TIFF	Context and background mapping
Historic	No	ECW	N/A
Orthophotography	Yes	ECW	Review of first round datasets and production of Round Two FDMI datasets
Parliamentary Constituency Maps 1995	No	JPG	N/A
Vector			
Large Scale Data	Yes	DWG/DXF/NTF	Building features extracted and used as basis for development of FDMI buildings layer
Large Scale Boundaries	Yes	SHP & TAB	Context and background mapping
OSNI Road Network	Yes	SHP	Used as basis for FDMI roads layer
1:50 000 Vector	Yes	SHP	Context and background mapping

Table 5.3 (continued) Overview of OSNI Datasets

OSNI Product Name	Used in Development of Round Two Datasets	Digital Format	Comment
EuroGlobalMap	No	PGDB & SHP	N/A
EuroRegionalMap	No	PGDB & SHP	N/A
Boundary Map	No	.shp	N/A
POINTER	Yes	CSV	Used in population analysis
Height/3D			
DTM 50 m grid	No	MDB & DBF & CSV	N//A
DTM 10 m	No	TXT	N/A
DTM enhanced	Yes	DXF / DGN	Used as basis for FDMI ground model layer
Gazetteers			
1: 250 000 Gazetteer	No	DBF / SHP / TXT	N/A
1: 50 000 Gazetteer	No	DBF / CSV / TXT	N/A
Placenames Gazeteeer	No	DBF / CSV / TXT	N/A
Raster			
10k Colour	Yes	TIFF & ECW	Context and background mapping

Further information regarding the key datasets used in the modelling process is described in the remainder of this section.

5.2.2 OSNI Large Scale Mapping Database

The OSNI large-scale mapping database consists of 17,335 individual tiles, each based on the original large-scale maps of Northern Ireland surveyed at either 1:1,250 or 1:2,500 scales. The vector mapping included in the dataset records spatial information as cartographic elements – lines, symbols, text etc. The format of the database also includes a hierarchical framework which categorises 190 features (i.e. building, wall, road edge, administrative boundary etc) types. An illustration of the format of the data is provided in Plate 5.1.

Plate 5.1 OSNI Large Scale Database – Example of this Dataset overlain on OSNI Orthophotography

The data can also be supplied in DWG, DWF or NTF format and is therefore compatible with the CAD (AutoCad), GIS (ESRI ArcGIS) and LIMA noise modelling software which has been used in the delivery of this contract. Further details are provided in the full OSNI Large-scale Product Specification V0.1 Document (2008).

OSNI have also confirmed that in recent years, additional work has been undertaken on the dataset to create polygons for cartographic objects such as buildings, streets, waterways and areas of vegetation. Additional data has been recorded about road centre lines, such as identification information, to enhance the value of the data, and to create datasets separate from the large-scale maps. The use of this dataset for the preparation of the FDMI building layer is described later in this report.

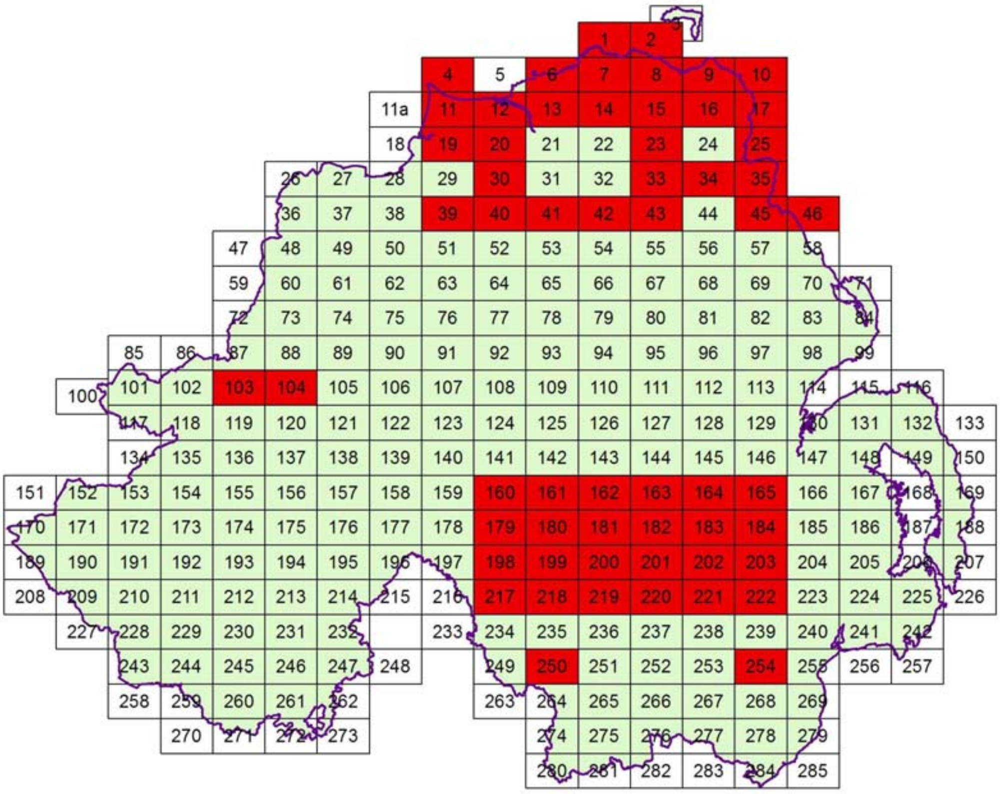
5.2.3 OSNI Enhanced DTM and Orthophotography Product

The OSNI enhanced DTM product consists of 258 individual tiles each with a geographical extent of 9.6km x 6.4km or a total geographical area 61.44km^2. The dataset was originally produced using the series 1:10,000 Orthophotography was and was flown between March 2003 and finished in 2006. Further information regarding the dataset is provided in Appendix A and the OSNI Enhanced DTM Technical Product Specification document. These two datasets are illustrated below in Plate 5.2.

Plate 5.2 OSNI Enhanced DTM and Orthophotography

Although this dataset remains valid for the majority of Northern Ireland, it should be noted that 58 tiles were updated in 2007/08 following the Round One mapping exercise. The tiles which have been updated are shown in Plate 5.3. These changes have been considered during the subsequent development of the Round Two FDMI ground model dataset.

Plate 5.3 OSNI Enhanced DTM Product – Tiles Updated Since 2006



5.2.4 Producing the FDMI Datasets

Using the datasets listed in Table 5.3, a variety of GIS methods have been used to create the final Stage 1 FMDI layers and ultimately develop the 3D LimA modelling environment for this contract. These GIS processes are described in detail in Sections 6 to 11, with the subsequent QA processes used in LimA described in Section 12 of this report.

6. Buildings Dataset

6.1.1 Background to the Creation of the Round Two Building Dataset

The most detailed dataset representing building objects across Northern Ireland is the OSNI large scale digital mapping database. This dataset consists of 1:1250 and 1:2500 scale vector mapping which records cartographic elements – lines, symbols, text etc. – with related attributes. The format of the database includes hierarchical framework which categorises the type of feature (building, wall, road edge, administrative boundary etc). This dataset was used during Round One as the basis for modelling buildings within the ground model.

In recent years, additional work has been undertaken on the dataset to create polygons for cartographic objects such as buildings, streets, waterways and areas of vegetation. Additional data has been recorded about road centre lines, such as identification information, to enhance the value of the data, and to create datasets separate from the large-scale maps.

Although these are important developments it is also important to note that, within the OSNI dataset, building footprints are split across tile boundaries and therefore not available as single polygons. This issue is inherent in design of the OSNI Large scale product, and the requirement to supply large scale mapping as a tiled dataset. Unfortunately the dataset does not currently store unique feature ID which enables adjacent polygons to be combined into one building.

These characteristics were noted during Round One but it was determined that a semi-manual process to rectify this issue was beyond the scope of the project. The split polygons were therefore included in the FMDIs and ultimately led to some increases in processing times for model calculations and duplications within the population analysis.

6.1.2 Developing the Round Two Dataset

At the outset of the Round Two, the structure of the OSNI large scale dataset was reviewed to identify the number and structure of objects defined as buildings. This work included consideration of the data specification of the Round One datasets as outlined in Table A.5 in Appendix A. This work also reconfirmed the presence of split building footprints across tile boundaries. The work highlighted that, without further processing, around 1,375,258 building objects covering the modelled extents would need to be included within the ground models. The specific codes extracted from the OSNI dataset are provided in Appendix B.

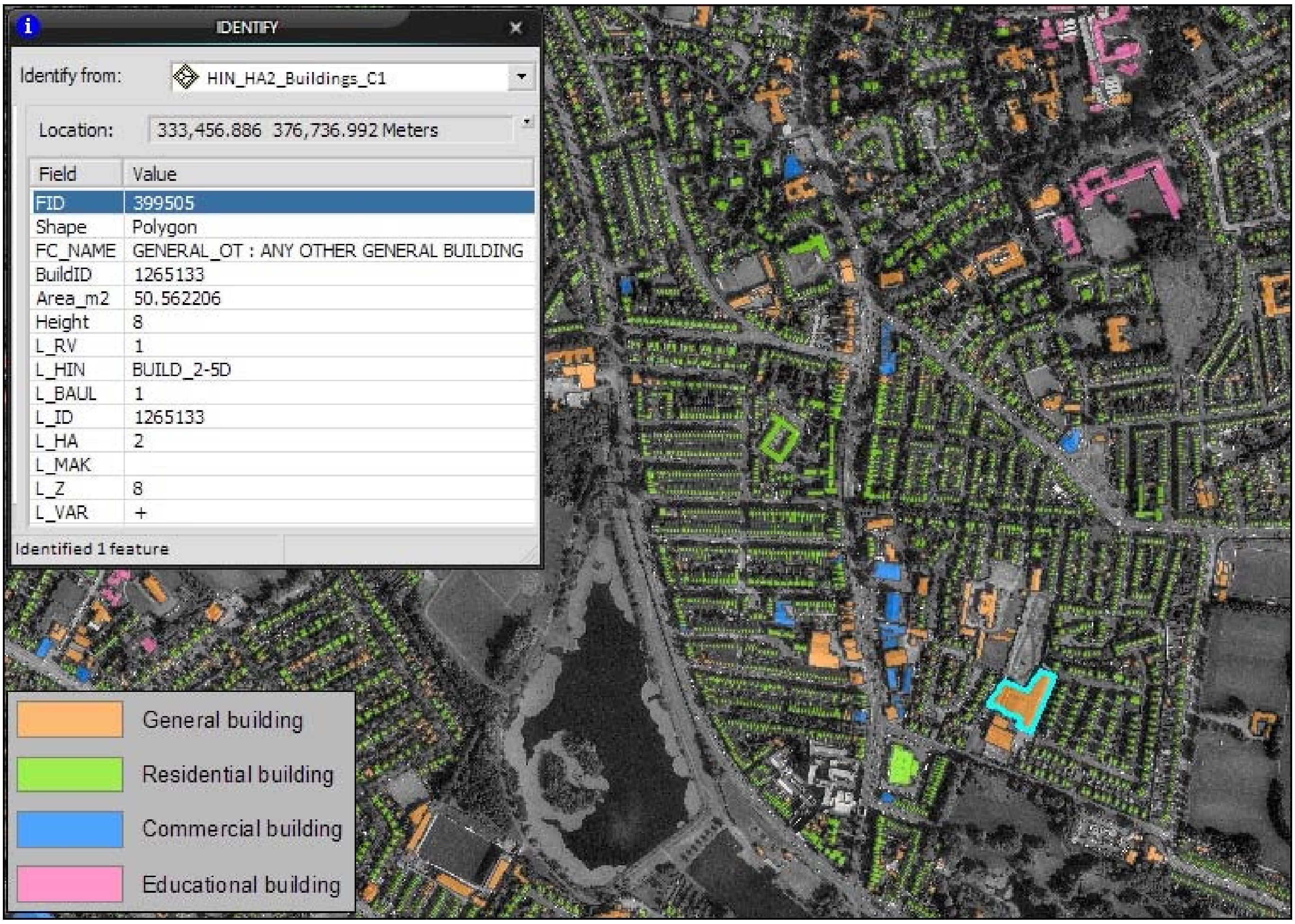
The project team decided to explore the potential to use ESRI GIS processing steps to remove the splits in the building objects, reducing the number of building objects and ultimately improving the ground models, reducing model processing time and improving the quality of the population exposure statistics. The specific steps used in the process are provided in Appendix B. Using the processing steps outlined in Appendix B, the number of building objects was reduced to 1,326,308 objects. This represents the removal of 48,950 objects or 3.5% of the original OSNI large scale database.

Once processed, all buildings were assigned a default height of 8m and assigned an attribution specification in accordance with the specification outlined in Table A.5 of Appendix A.

During Round One, a survey team recorded building heights above a default standard height of 8m. These building heights were present within the Round One buildings FMDI. Using the Round One dataset, a spatial join was executed to ensure that building heights captured during the Round One survey exercise were transferred to the final Round Two FDMI dataset.

An illustration of the structure and content of the final Round Two FDMI dataset is provided below in Plate 6.1.

Plate 6.1 Final Round Two FDMI Buildings Layer



7. Digital Terrain Model (DTM) Dataset

7.1 Review of the Round One DTM Dataset

The Round One DTM dataset was based on OSNI's Enhanced DTM product which consists of breaklines and spot height objects. The data specification for this dataset is outlined in Tables A.2-A.4 in Appendix A.

The project team reviewed work undertaken during Round One by the previous contractor which assessed the Enhanced DTM dataset against an alternative OSNI equal height contour product. The outcome of this work recommended the use of the Enhanced DTM due to it yielding a very similar terrain profile to the contour product whilst significantly improving calculation times. The work also argued that the Enhanced DTM provides greater compliance with the requirements of the noise mapping software and calculation standards. Based on this outcome, the project team decided to retain the OSNI Enhanced DTM for Round Two.

Although the OSNI Enhanced DTM was used as the basis of the DTM dataset in Round One, the dataset was subject to several modifications and refinements to make it fit for purposes. These refinements included:

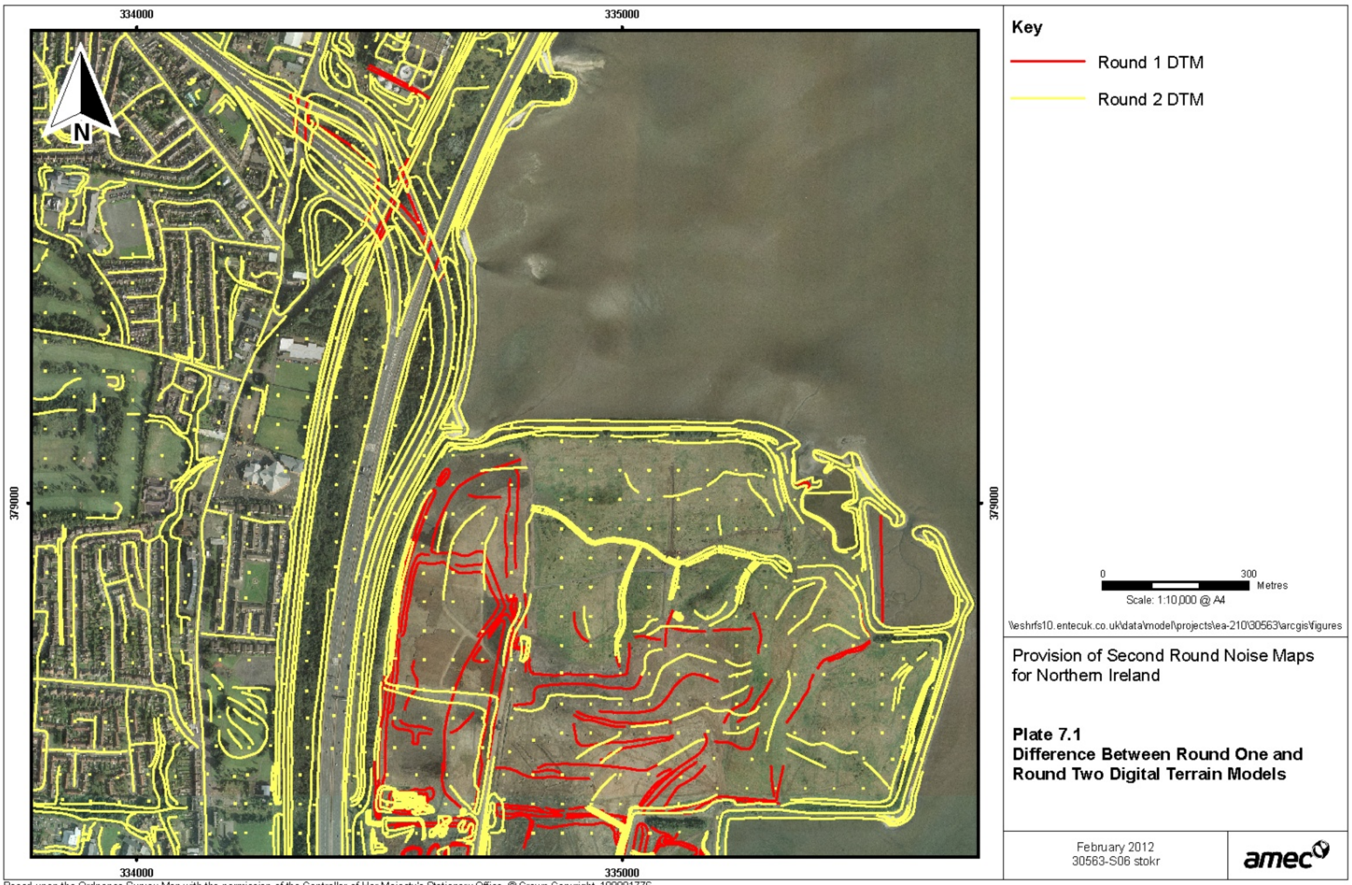
- Editing to support the inclusion of bridge objects;
- Removal of spot heights within 50m of any modelled road centreline to ensure stability in calculated road gradients; and
- Object simplifications to ensure compliance with topographic rules within the LimA calculation core.

The project team identified that all of the above refinements would be required for the development of the Round Two DTM dataset.

7.2 Reuse of the Round One DTM Dataset

As part of the review process, the project team considered the feasibility of reusing the Round One DTM datasets which correspond with the Round Two extents. The project team first assessed differences between the Round One FMDI DTM dataset and the latest OSNI Enhanced DTM. The comparison was made by generating a gridded version of both datasets and comparing heights. Due to edits made in the Round One FMDI DTM, the comparisons were made in locations where manually editing was unlikely to have occurred. This comparison identified several differences in the position and height of breakline and spot height objects as illustrated in Plate 7.1.

Plate 7.1 Comparison between Round One and Round Two OSNI Enhanced DTM Products



The information presented in Plate 7.1 led the project team to conclude that inserting the Round One DTM dataset into the latest OSNI Enhanced DTM could lead to discontinuities particularly at the boundaries of any insertions. This also suggested that reusing the Round One DTM dataset could lead to oversights in areas where genuine changes in the terrain had occurred from, for example, road building.

Following this review, it was decided that the Round Two DTM dataset should be developed purely from the latest OSNI Enhanced DTM. This was considered to provide the best approach in ensuring consistency and currency with the latest OSNI dataset however it was accepted that this approach could lead to changes between Round One and Round Two noise levels in areas where editing was required. To minimise this risk, the project team decided to use the Round One DTM dataset as a target and guide for any manual editing in shared areas.

7.3 Round Two Dataset Development

The Round Two DTM dataset has been developed from the latest OSNI Enhanced DTM with manual editing and refinements to ensure that the dataset meets the requirements of the LimA calculation core and also accommodates bridge objects and road upgrade projects. The Round One DTM dataset and the Round One Bridge Dataset have been used to assist this process.

In summary, the development of the Round Two DTM dataset was undertaken as follows:

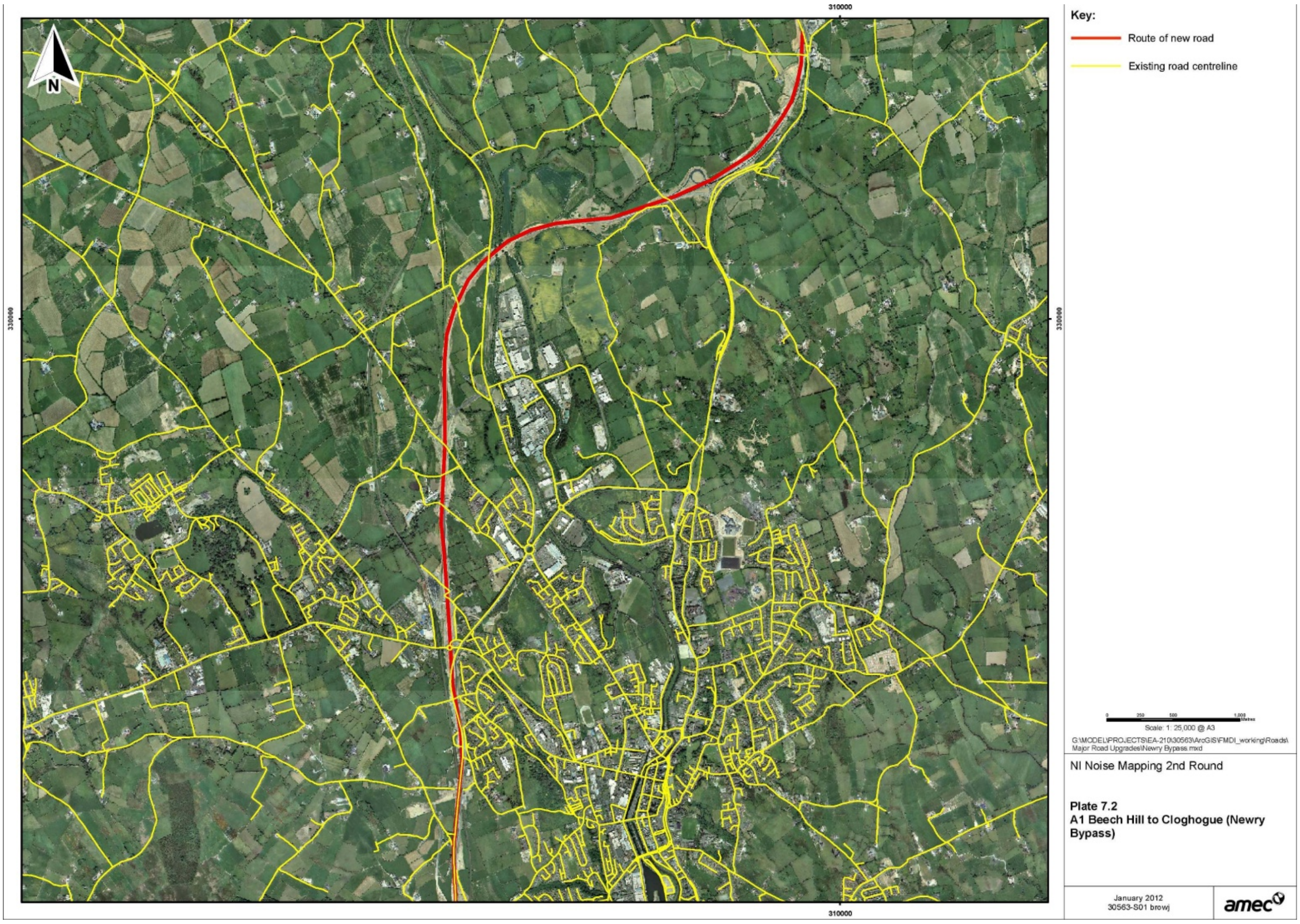
- Clipping of the full dataset to the Round Two modelling extents;
- Topographic refinements applied to meet the basic topographic requirements of the LimA calculation core;
- Manual editing of the data to accommodate bridge objects. This process is discussed fully in Section 8;
- Basic editing to incorporate road upgrade projects. This is discussed fully in Section 7.3.1 below;
- Removal of spot heights within 50m of modelled road centrelines;
- Application of attribution rules as outlined in Appendix A.

Additional work was also undertaken to incorporate new roads which have been developed since Round One but which were not represented in the OSNI DTM dataset. The processes used to address these features are outlined in Section 7.3.1.

7.3.1 Road Upgrade Projects

Through discussion with Roads Service, on-line research and reviewing aerial imagery, it was discovered that the OSNI Enhanced DTM did not fully encompass road upgrade projects completed and operational in 2011. Plate 7.2 presents an example of road upgrade project active in 2011 but not incorporated within the OSNI Enhanced DTM.

Plate 7.2 Example of Road Upgrade Project Active in 2011 but not incorporated within the OSNI Enhanced DTM



In total, 15 road upgrade projects developed 2007 were identified through on-line research, with several confirmed by Roads Service and aerial imagery as being Major Roads. Only a limited number of improvement schemes were identified within the Belfast agglomeration. The list of these schemes is presented below in Table 7.1. The priority column indicates the relative importance of each scheme (in terms of size; likely impact upon noise levels and adjacency to nearby population). The primary focus of the work has been placed on the routes assigned a priority code of 1 and 2.

Table 7.1 Major Road Developments in Northern Ireland since 2007

Scheme ID	Name	Priority
1	Westlink and M1 Upgrade Belfast	1
2	A1 Beech Hill to Cloghogue (Newry Bypass)	1
3	A1 Beech Hill to Cloghogue (Newry Bypass)	1
4	A2 dualling Maydown to City of Derry airport	2
5	A4 Dualling - Dungannon to Ballygawley	2
6	A26 Ballee Road East to M2 link	2
7	A20 Newtownards southern relief road	2
8	A29 realignment, Carland	3
9	A4 A5 realignments - Annaghilla and Tullyvar	3
10	A4 A5 realignments - Annaghilla and Tullyvar	3
11	A20 Frederick Street Link, Newtownards	3
12	A515 Skeoge Link Londonderry	3
13	A1 grade separated junction - Dromore Road, Hillsborough	4
14	A48 Six Road Ends upgrade, near Bangor	4
15	A1 Grade separated junction at Cascum Road, Banbridge	4

From reviewing the capture dates of the OSNI DTM and through discussions with Roads Service, it was apparent that data obtained from road traffic counters in the areas of the road upgrade projects would include these projects. As such, it was recommended by Road Service that these roads should be modelled and captured in the configurations representative of the road traffic counter data. This has therefore resulted in a requirement to investigate amendment to both the OSNI Enhanced DTM and the corresponding OSNI road centreline dataset. This section discusses the editing of the OSNI Enhanced DTM.

Where road upgrade projects were identified, the project team undertook a review of aerial imagery and the OSNI Enhanced DTM with respect to the location of the road upgrade project. In parallel, the LimA calculation core was used to calculate road gradients at 1m intervals along the routes of the upgrade projects. This procedure provided information regarding the slope of the road along its route. From this, the project team identified that for large road upgrade projects, gradients for some sections of road appeared sensible for a road carriageway. In other areas, gradients were considered excessive. By reviewing the aerial imaginary, OSNI Enhanced DTM and the road gradients, the project team identified that for many larger road upgrade projects, the OSNI Enhanced DTM has in part captured the new or altered carriageway as demonstrated in Plate 7.3.

Plate 7.3 Example of a Part-captured Road Upgrade Project in the OSNI Enhanced DTM

As can be seen within Plate 7.3, sections of the road upgrade project in red appear to have been captured within the DTM whereas sections in blue do not.

From this analysis the project team determined several options for the modelling of the road upgrade projects.

- Option 1 – Model the terrain as defined in the Enhanced DTM without edits;
- Option 2 – Buffer or digitise around the upgrade projects in their entirety and clip out DTM to create a relatively smooth surface for the road to be modelled;
- Option 3 – Where OSNI Enhanced DTM is incomplete and does not capture the completed upgrade project, use LimA special features to auto generate during calculation a smoothed terrain and shallow cutting equivalent to those at the start and end of the road upgrade project;
- Option 4 – Manually edit the OSNI Enhanced DTM where it is incomplete and does not capture the completed upgrade project to create a smoothed terrain and shallow cutting equivalent to those at the start and end of the road upgrade project.

Through the gradient work undertaken by the project team, Option 1 was discounted as this would lead to significant variations in road traffic noise emissions due to significant variations in calculated road gradients and result in irregular noise contours. Option 2 was also discounted as this would lead in most cases to roads running on a level surface which may not reflect the upgrade project. This option would also remove any existing capture of the upgrade project within the DTM.

Option 3 was given consideration through testing. The project team identified that this option was feasible but due to the terrain modelling being undertaken automatically during calculation, there was no guarantee that auto-generated terrain would be plausible until the completion of the calculations. Although testing could be undertaken prior to calculations in these areas, the team demonstrated that no terrain auto-generation settings could create a reasonable carriageway.

As Option 3 was discounted the project team identified that only way model these upgrade project with a reasonable level of confidence was to undertake manually edits of the OSNI Enhanced DTM. These edits were undertaken in LimA environment and found to take in the order of around four hours to complete for each area. Where road upgrade projects were incomplete, the project team have inserted new breaklines into the DTM using information, such as depth of cutting and carriageway widths to continue the carriageway within the terrain model.

8. Bridges Dataset

Three key tasks were undertaken within the second round of modelling to develop an enhanced bridges dataset for use within the LimA modelling process. The specific steps in this process were:

- Review of the bridge objects captured in Round One;
- Use of GIS methods to identify potential target locations for new bridge digitisation;
- Capture of bridge objects in target locations and editing of the ground model layer in these locations.

The remainder of this section outlines the work undertaken to produce the final Round Two bridges dataset.

8.1.1 Review of the Round One Bridge Dataset

A review of the Round One bridge datasets was undertaken at the commencement of the Round Two mapping exercise. This included a review of the spatial coverage of the dataset and the attribute fields used. The full data specification for this dataset is outlined in Table A.8 in Appendix A.

No amendments were made to the existing objects and the dataset of 201 bridge objects created during the Round One mapping exercise was used as the basis for the subsequent digitisation exercise undertaken in Round Two.

8.1.2 Identification of New Bridge Target Locations

A number of GIS techniques were used to identify potential target locations for the capture of new bridge objects. This semi-automated approach was taken due to the size of the modelling areas to be assessed and the number of road and rail objects involved.

The first step in the assessment process was the extraction of all motorway, dual-carriageway, A-Road and B road features, water and railway features which fall within the modelling areas. These features were subjected to a series of GIS spatial queries to identify unique combinations of intersections. This process resulted in the identification of over 11,000 individual intersections across the Round Two modelling area.

To provide a more manageable dataset, a subsequent GIS process was used to combine adjacent intersections which shared similar road characteristics. This was a particular issue at roundabouts and complex road junctions which might be defined by multiple intersections but where only one bridge object was potentially required.

Using this processing step, a final set of target locations was created and which formed the basis of the subsequent manual review and assessment exercise. The breakdown of the target locations identified is shown in Table 8.1.

Table 8.1 Number of Target Locations identified for Bridge and Ground Modelling Review

	Motorway	Dual Carriageway	A-Roads	Railway	Rivers	Total
Motorway	14					**14**
Dual Carriageway	7	7				**14**
A Road	34	230	61			**325**
B Road	15	25	295			**325**
C Road	25	42	452			**519**
Other	6	146				**152**
All major roads				35		**35**
All major roads					479	**479**
Total	**101**	**450**	**808**	**35**	**479**	**1873**

Each of these 1873 target locations were reviewed manually to assess the requirement for the creation of a new bridge object and/or editing of the ground model using the available OSNI enhanced ground model information (breaklines and spot heights) and the OSNI aerial photography dataset.

Many of the target locations (1167 or 62%) were subsequently dropped as digitisation of a bridge object was not considered necessary. These situations included simple road junctions; at ground level roundabouts and roads crossing small river/ stream features. The remaining locations (793 or 38%) were considered in detail in the final phase of the assessment.

8.1.3 Capture of Bridge Objects in Target Locations

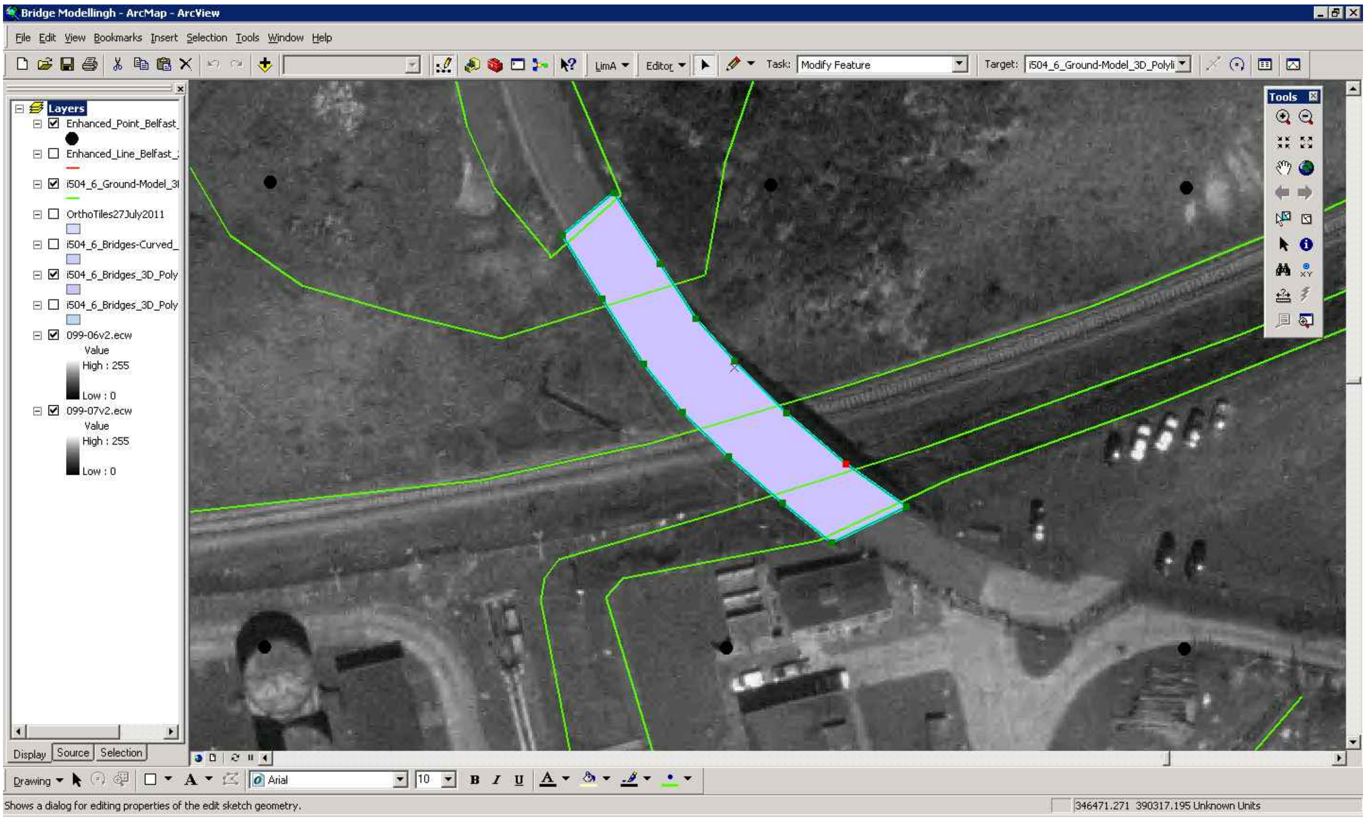
To digitise a bridge, it is important that the underlying ground model is already edited in order to support the bridge object; and the bridge object also meets the cartographic requirements of the LimA noise modelling package.

There are several rules that apply when digitising bridges for use within LimA. These are:

- The breaklines within the ground model are digitised correctly and correctly represent the ground terrain in the area of the bridge;
- A new bridge object is captured with the first and second nodes representing the bridge end;
- The bridge is digitised in a clockwise direction; and
- The bridge span should be digitised with an equal number of vertices on either side which are roughly equally spaced along the span.

Plate 8.1 presents an example of a bridge digitisation process.

Plate 8.1 Cartographic Bridge Digitisation Rules

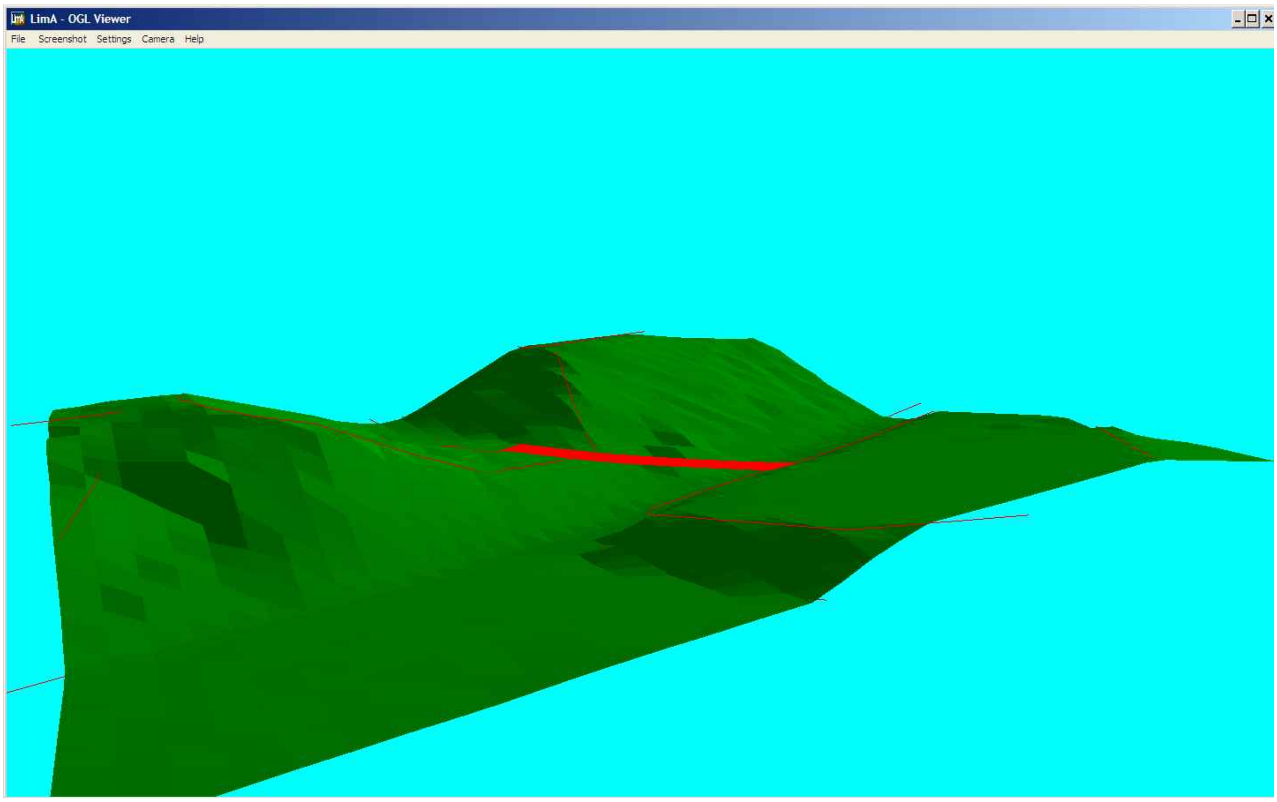


Using this process, an additional 281 objects were produced creating a final dataset of 492 bridge objects within the Round Two FDMI dataset.

Following the final validation of the bridge objects in ArcGIS, the draft FDMI dataset was imported into the LimA modelling environment to enable assignment of elevations along the bridge as derived from the ground model. These have been subsequently exported back to ArcGIS with LimA attribution in the form of a 3D shapefile.

Plate 8.2 presents an example of a fully processed bridge within the LimA environment.

Plate 8.2 Example of 3D Bridge Object represented within the LimA Modelling Environment



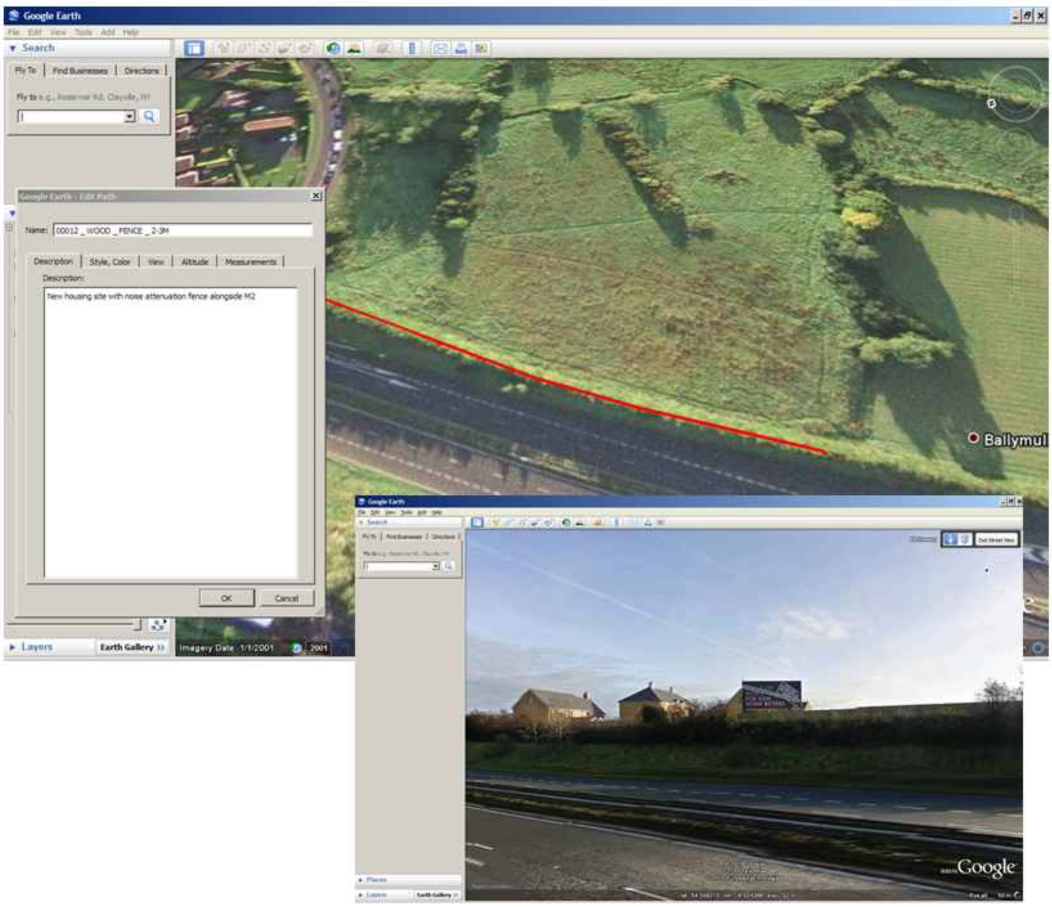
The attribution of road centrelines against the final bridge object datasets is considered in the separate road modelling report.

9. Barriers Dataset

The first round of noise mapping included a noise barrier survey, which involved the capture of key noise barriers along selected roads and railways using GIS enabled tablet PCs. The LIMA specification for this dataset is outlined in Table A.7 in Appendix A.

This dataset was reviewed during the latest round of work to assess its suitability and accuracy for use within the latest round of mapping. This was achieved by reviewing the spatial location and attribute information within the dataset against available imagery contained in Google Earth, Google Streetview and available OSNI aerial photography. Examples of the datasets used are provided in Plate 9.1.

Plate 9.1 Review of Round One Noise Barriers using Google Earth



Copyright Google - Example shows a site of a development not shown on aerial imagery but shown in Google Streetview. The Streetview shows that the development has been designed with a noise barrier along the perimeter of the site with the motorway.

This review highlighted that although many of the features captured were still relevant, a number of features were incorrectly positioned or attributes incorrectly assigned. This can in part be explained by new road construction in some areas. It is also important to emphasise that barriers were only captured in the area modelled in the Round One assessment.

With these issues in mind, a more extensive on-line data capture exercise was undertaken along each of the major routes (i.e. motorway, Dual carriageways and A Roads) within the Round Two mapping areas. For each of these routes, Google Earth and StreetView imagery was viewed and locations of new barriers captured using the tools available within Google Earth environment. Each of these new barriers captured were stored within a Google Earth KMZ format file and were assigned a unique feature ID. Additional attributes (i.e. estimated height, construction materials etc) were captured in a separate database file and subsequently joined to the spatial data within ESRI ArcGIS.

This information was subsequently imported into ESRI ArcGIS and the dataset reprojected from the standard WGS84 projection used by Google Earth to the required Irish Grid 65 projection system. This final reprojection process ensured that the final noise barriers were located correctly for final import into the LIMA noise modelling environment.

10. Ground Cover Dataset

This section details the development of the FDMI ground cover dataset. The data specification for this dataset is outlined in Table A.8 in Appendix A.

10.1.1 Review of the Round One Ground Cover Dataset

During the development of the Round One Ground Cover dataset, two datasets were considered. These were:

- OSNI Large scale dataset; and
- European Environment Agency CORINE Land Cover 2000 dataset.

The OSNI Large scale dataset consists of 1:1250 and 1:2500 scale vector mapping and is designed so that features within the dataset can be stored alongside information categorising them by type e.g. buildings. During the development of the Round One dataset, polygon features relating to ground surfaces were extracted from the OSNI Large scale dataset. Each object was given a “L_G” attribute to represent its acoustic absorbency.

Each object was then either designated as either ‘hard’ (L_G = 0) or ‘soft’ (L_G = 1) ground depending upon the type of surface it represented. In general, areas of grass were considered ‘soft’ ground types whereas areas of pavement or road were considered ‘hard’ ground types. For Round One, this was considered the most accurate method of representing ground cover based on the datasets available to the project team at the time.

The EEA CORINE dataset is a European-wide vector land parcel product derived from satellite imagery. CORINE was developed in order to establish a computerised inventory on land cover and is used for making environmental policy as well as for other such as regional development and agriculture policies. Unlike the Large scale dataset, CORINE is coarse (resolution around 100m) and generalizes areas by land use instead of surface type. These land uses were assigned L_G values.

Acoustic testing of the datasets was undertaken using road, rail and industrial noise sources within a 1km^2 calculation area within a 25km^2 test model.

For the OSNI Large scale dataset, the testing included an unrefined dataset and a refined version only considering objects with areas of greater than 500m^2. Using the unrefined large scale objects as a benchmark (i.e. the most accurate data available to the project team), the testing identified significant reductions in calculation times through the use of CORINE whilst ensuring the uncertainty introduced within the resultant noise levels was limited to a 2 dB(A) 95% confidence interval. This confidence interval was considered acceptable to the project team and DoE and as such, CORINE was adopted as the basis of the Round One Ground Cover dataset.

From a review of the Round One Ground Cover dataset and the CORINE land use categorisation, the ground absorption coefficients or ‘G values’ have been established against the land use categories in CORINE. These are outlined in Table 5.4. The table shows that many of the areas have absorption coefficients between 0 and 1. This reflects the mixed ground surfaces that occur in these areas. Several areas have also been assumed as either fully hard or fully soft ground types. Examples of these are typically areas of forest or continuous urban areas, respectively. In general, the assignment of the L_G values assigned to the CORINE dataset appears reasonable and any proposed changes to these values would most likely result in minor changes to calculated noise levels.

The review concluded that given the data available to the project team in Round One, the selection of CORINE as basis for modeling ground cover was appropriate. Despite this, the project team was concerned with the coarseness of the CORINE dataset and the approximation of the L_G values by land use. Furthermore, the CORINE dataset is based on aerial imagery take in or before 2000. The CORINE dataset is therefore over 10 years old and due to its age, alternative datasets should be considered.

CEH Land Cover Map 2007

Land Cover Map 2007 (LCM2007) is produced by the Centre for Ecology & Hydrology and was released in 2011. Based on 2007 data, the dataset is derived from satellite images and digital cartography and presents land cover information for the entire UK. Unlike the CORINE dataset, LCM2007 depicts areas of land surface (e.g. grasslands, rock, water etc.) rather than land uses. This means that ground absorpancy can be derived from ground surfaces rather than land uses. The spatial resolution of LCM2007 is also greater than CORINE with the dataset depicting areas of different ground cover above $25m^2$. Away from noise modelling, the dataset has uses for noise action planning as it can be used to assist in the definition of locations which may also qualify as quiet areas.

Plate 10.1 presents an example of LCM2007 in a suburban area of Belfast with Plate 10.2 presents the CORINE data for the same area. It is clear from both plates that the LCM2007 is more spatially accurate in terms of depicting areas of land types than CORINE. It can also be seen that whereas most of the area is depicted as ‘Discontinuous Urban Fabric’ in CORINE, the LCM2007 data differentiates between suburban, urban and a variety of grass and woodland land cover types in the same area.

It is considered that the LCM2007 provides an opportunity for ground cover to be modelling with a reasonable level of spatial accuracy for a range of ground cover types that are akin to ground cover types which are normally associated with acoustic absorpancy within environmental noise modelling.

An outline review of the LCM2007 data against the OSNI Large Scale ground surface polygons also demonstrated that in terms of assigning absorption coefficients, the LCM2007 should be considered more accurate than assuming either fully ‘soft’ or ‘hard’ ground types. On this basis, and given the spatial accuracy of the LCM2007 data, it should be considered a more accurate depiction of ground surface than the OSNI Large scale data.

The project team have considered the potential to use the LCM2007 as a facilitating dataset to allow absorption coefficients to be assigned to the OSNI Large scale product. Although this is possible, this is limited by the large scale dataset itself. Ground surface areas within the large scale data are part polygonised and are in many areas represented as a series of lines. For these areas to be used within the LimA environment, they must be polygon objects. Although these lines can be converted into polygon objects, the extent of this task is considered beyond the scope of this project as it would require a significant amount of manually editing of the OSNI Large scale product. For this reason, the project team decided not to investigate this further.

Plate 10.1 Example of LCM2007 in Belfast Suburb

Plate 10.2 Example of CORINE in Belfast Suburb

Table 10.1 CORINE Land-Use Categories and corresponding Ground Absorption Coefficients

CORINE Land Use Category	L_G (Ground Absorption Categories)
AgriculturalLandWithSignifAreasOfNaturalVeg	0.9
Airports	0.4
BareRocks	0.1
BeachesDunesSands	0.5
BroadLeavedForest	1
ComplexCultivationPatterns	0.7
ConiferousForest	1
ConinuousUrbanFabric	0
DiscontinuousUrbanFabric	0.3
DumpSites	0.7
GreenUrbanAreas	0.7
IndustrialOrCommercialUnits	0.1
InlandMarshes	0.3
IntertidalFlats	0.5
MineralExtractionSites	0.4
MixedForest	1
MoorsAndHeathland	1
MotorwaysUnderConstruction	0
NaturalGrasslands	1
NonIrrigatedArableLand	0.7
Pastures	0.7
PeatBogs	0.5
PortAreas	0.1
RoadandRailNetworks	0
SaltMarshes	0.7
SparselyVegetatedAreas	0.7
SportAndLeisureFacilities	0.7
TransitionalWoodlandShrub	1
WaterBodies	0.1
WaterCourses	0.1

10.1.2 Testing of the LCM2007 Dataset

There are two main implications of using the LCM2007 data as a basis for modeling ground cover instead of the CORINE dataset. These are:

- Impact on calculation times; and
- Changes in resultant noise levels due to changes in the modeling of ground absorption objects.

To test the implication of the LCM2007 upon the noise calculations and resultant noise level grids, the project team undertook the following:

- The identification and assignment of absorption coefficients for each LCM2007 surface type;
- Assessment of the correlation between LCM2007 surface types and the land use types in Corrine; and
- Noise model testing of the LCM2007 data with respect to CORINE.

Assigning Absorption Coefficients to LCM2007

As previously discussed, the LCM2007 data lends itself to the modeling of ground cover in environmental noise calculations due to the surfaces stored within the dataset being akin to absorptive ground types. To enable the assignment of ground absorption values to the LCM2007 dataset, the project team have reference guidance within the WG-AEN *Good Practice Guide for Strategic Noise Mapping version 2* (GPGv2); general guidance from software developers on the modeling of ground cover; and technical documentation and research on ground cover modeling from the HARMONOISE/ IMAGINE projects.

Table 10.2 presents a summary of this guidance in terms of absorption coefficient and ground cover type. Using the guidance, and through review of aerial photography of each LCM2007 ground cover type, the project team assigned absorption coefficients. It should be noted that in assigning absorption coefficients, the project team have avoided using values of 0 or 1 unless fully applicable. It is also noted from Table 10.2 that whereas the general guidance and the guidance from HARMONOISE/ IMAGINE relate to ground surfaces, the WG-AENv2 guidance relates to a combination of land uses and ground surfaces.

Table 10.2 Summary of Relevant Ground Absorption Coefficient Guidance

General Guidance from Software Developers		WG-AENv2		HARMONOISE/ IMAGINE	
Ground Cover Type	**Absorption Coefficient**	**Land Use**	**Absorption Coefficient**	**Ground Cover Type**	**Absorption Coefficient**
Pavement	0.0	Forest	1.0	Soft (Snow / Moss)	1.0
Packed Ground	0.1	Agriculture	1.0	Soft Forest Floor (dense heather or thick moss)	1.0
Water	0.0	Park	1.0	Non-compacted, loose ground (turf, grass, loose soil)	1.0
Forest Leaves	0.7 – 0.9	Heath Land	1.0	Normal non-compacted ground (forest floors, pasture fields)	1.0
Ploughed Field	0.7 – 0.9	Paving	0.0	Compacted field and gravel (compacted lawns, parks)	0.75
Lawn	0.6 – 0.8	Urban	0.0	Compacted dense ground (gravel road, parking lot)	0.3
Field Grass	0.6 – 0.8	Industrial	0.0	Hard surface (dense asphalt, concrete, water)	0.0
Fresh Snow	1.0	Water	0.0		
Crusted Snow or Ice	0.0	Residential	0.5		

The interpretation of this guidance in relation to the LCM2007 ground cover types is presented in Table 10.3 along with rationale for the assignment of the selected absorption coefficient. Where appropriate, the correlation between LCM2007 cover types and CORINE land use classifications are outlined in the Rationale.

Table 10.3 Determination of LCM2007 Ground Absorption Coefficients

LCM2007 Ground Surface Type	Selected Absorption Coefficient	Rationale
Unclassified	0.0	Aerial imagery shows that the majority of this surface type in NI is over areas of water
Broadleaved woodland	0.7	General guidance suggests 0.7 – 0.9. Review of areas modelled by CORINE suggests that these areas are mainly pastures and were modelled as 0.7. The WG-AEN and Harmonoise/ Imagine suggest absorption values of 1.0. This is considered excessive. A value of 0.7 is considered conservative and consistent with the assumptions made in CORINE
Coniferous woodland	0.7	
Arable and horticulture	0.7	
Improved grassland	0.7	Aerial imagery shows these areas to be mainly grass. General guidance suggests grass land should be modelled as 0.6 – 0.8. WG-AEN guidance suggests a value of 1.0. The Harmonoise/ Imagine guidance suggests a value of 0.7. A review of the CORINE data suggests that these grass land areas are mostly classified as pastures which were modelled as 0.7. A value of 0.7 for these grass lands is therefore considered an appropriate value.
Rough grassland	0.7	
Neutral Grassland	0.7	
Calcareous Grassland	0.7	
Acid grassland	0.7	
Fen, Marsh and Swamp	0.7	A review of aerial imagery shows these to be very much un-compacted grounds with little or few areas of water. Harmonoise/ Imagine and WG-AEN guidance suggests a value of 1.0. General guidance based on ploughed fields suggests 0.7-0.9. The team has discounted using values of 1.0 as the surface type is not fully un-compacted and there are some areas of water. This suggests a lower value. Analysis of CORINE in these areas suggests these areas were modelled as 0.7. A value of 0.7 has been adopted as a conservative assumption and to correlate with values used within CORINE.
Heather	0.7	Review of aerial imagery shows these areas to be grass land type with heather coverage. Not all areas are covered with heather.
Heather grassland	0.7	
Bog	0.5	Review of aerial imagery shows these areas to be mainly grass land with heather coverage and some standing areas of water. Grass land and heather has been taken as 0.7 however due to the potential for standing water, a value of 0.5 is consider more appropriate.
Montane Habitats	1.0	Aerial imagery shows these to be mainly dense heathland at elevated positions. There are only five areas in NI which fall within the extents to be mapped. These surfaces appear to be relatively high in absorption and there a value of 1.0 has been assigned. A review of CORINE shows that these areas were modelled as 1.0 in Round One.
Inland Rock	0.0	These surfaces are of hard ground types. Water surfaces and rocks have a very high impedance to sound and therefore reflect all most all sound incident at the surface. All guidance suggests these surfaces should be modelled as either 0.0 or 0.1. A conservative approach has been adopted and an absorption coefficient of 0.0 applied to these surface types. A review of CORINE shows that apart from large areas of water, these surfaces were not defined and such were considered as pastures and other absorptive ground covers. In these areas the Round One noise level grids are likely to have underestimated noise levels.
Saltwater	0.0	
Freshwater	0.0	
Supra-littoral Rock	0.0	
Supra-littoral Sediment	0.0	
Littoral Rock	0.0	
Littoral sediment	0.0	
Saltmarsh	0.0	

Table 10.3 (continued) Determination of LCM2007 Ground Absorption Coefficients

LCM2007 Ground Surface Type	Selected Absorption Coefficient	Rationale
Urban	0.0	Urban areas were assumed as 0.0 in CORINE however the extent and spatial accuracy of urban areas within the dataset in comparison to LCM2007 is poor. Many urban areas within the LCM2007 dataset were modelled as pastures in CORINE. Aerial imagery shows that most urban areas within the LCM2007 dataset are areas of dense housing and pavement. Grass land, open spaces and parks within urban areas are defined as other surface types such as 'improved grassland'. Guidance suggests that absorption coefficients of either 0.0 or 0.1 apply. A conservative approach has been adopted and an absorption coefficient of 0.0 applied to urban ground covers.
Suburban	0.5	Suburban ground cover areas within the LCM2007 dataset are mainly areas of residential housing which comprise of roads with grass verges and dwellings with gardens. The suburban ground surface type therefore included a mixture of ground covers. WG-AENv2 guidance suggests that for residential environments, an absorption coefficient of 0.5 should apply. HARMONOISE / IMAGINE guidance suggests that the absorption coefficient should fall between 0.3 and 0.75 as a mix of compacted lawns and compacted dense grounds. Likewise, general guidance suggested a mixture of surfaces with absorption coefficients of 0.0 for pavement and 0.6-0.8 for lawns. A value of 0.5 as suggested by the WG-AENv2 therefore appears appropriate.

Noise Model Testing of LCM2007 Dataset

To test the LCM2007 data against the CORINE data and gauge the resulting effects upon calculation times and noise levels, the project team developed noise models for three areas of Northern Ireland, each requiring calculations of road, rail and industrial noise. Each area comprised of a 36km^2 noise model with a 4km^2 calculation area. Table 10.4 outlines the four tests considered.

Table 10.4 LCM2007 Noise Model Testing Models/ Scenarios

Test	Ground Cover Test Areas	Noise Sources/ Scenarios Considered
1	Area 1 – Within Belfast Agglomeration	Major & All Roads
2	Area 2 – Within Belfast Agglomeration	Major Railways
3	Area 2 – Within Belfast Agglomeration	Industry
4	Area 3 – Outside Belfast Agglomeration	Major Roads

For each test, two ground models were prepared using CORINE and LCM2007 for ground cover. Calculations were undertaken for noise sources in each area using the same calculation server and calculation settings adopted for Round One. All calculations were allowed to complete without any other tasks being undertaken on the calculation hardware. Upon completion of the calculations, the project team used a specially developed software tool to compare the results of the calculations and identify the respective differences in noise levels between the LCM2007 and CORINE models.

To ensure that the comparison were relevant to the reporting requirements of the Directive and the Regulations, comparisons were made for locations where noise levels were above 50 dB L_{night} and 55 dB L_{den}. This approach is consummate with the testing undertaken as part of Round One.

Area 1 – All Agglomeration Roads and Agglomeration Major Roads

For Area 1, the testing indicated that calculated road traffic noise levels between the LCM2007 and CORINE are generally consistent. This is supported by 95% confidence intervals of the L_{den} and L_{night} of 1.6 dB(A) and 1.7 dB(A) respectively. This indicates that within the agglomeration, the use of CORINE as a mean of modelling ground cover was appropriate. The average change in L_{den} and L_{night} noise levels when using LCM2007 instead of CORINE is -0.3 dB(A) indicating that the use of LCM2007 has the tendency to reduce noise levels within the agglomeration. A similar trend is also observed for the major roads within the agglomeration. This is evident from the histograms presented in Plate 10.3.

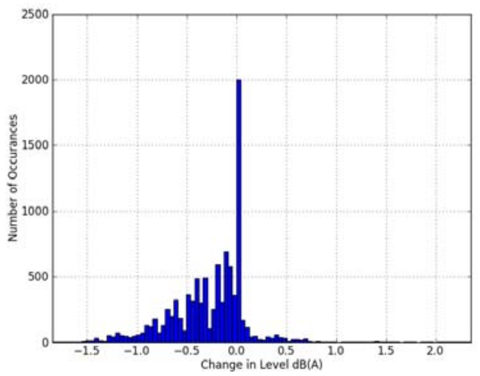
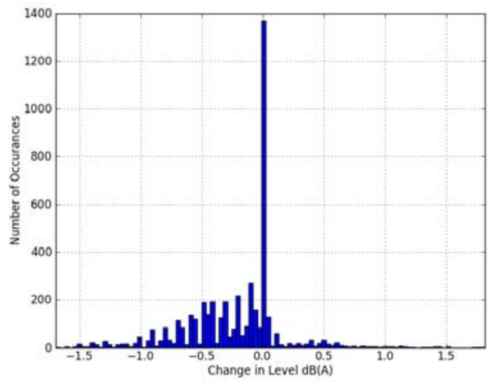
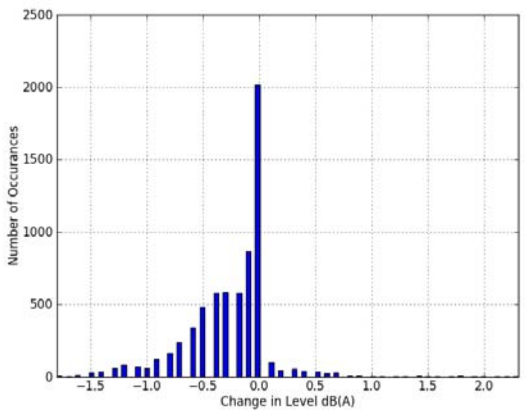
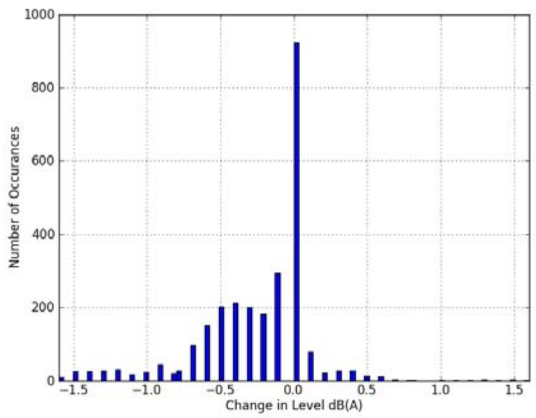
The statistics presented in Table 10.5 show that the implications of replacing CORINE with LCM2007 upon calculation times is an increase of around 8%. This is considered a marginal increase in calculation load as calculations increase on average by 0.03 seconds per point on a single processor.

It could be concluded that although there is a small increase in processing time as a result of using LCM2007 data, the calculated noise levels are likely to be more accurate due to the additional categories available to describe land cover in calculation areas and noise levels within the Belfast Agglomeration would have a tendency to reduce.

Table 10.5 Noise Level Calculation Statistics – Area 1, Road Traffic Noise (LCM2007 vs. CORINE)

Statistic	All Roads in Agglomeration		Major Roads in Agglomeration	
	L_{den}	L_{night}	L_{den}	L_{night}
Max. Increase	+2.3 dB	+2.3 dB	+1.8 dB	+ 1.6 dB
Max. Decrease	-1.9 dB	-1.8 dB	-1.7 dB	- 1.6 dB
Standard Deviation	0.4 dB	0.4 dB	0.4 dB	0.4 dB
95% Confidence Interval	1.6 dB	1.6 dB	1.8 dB	1.7 dB
Average Change	-0.3 dB	-0.3 dB	-0.2 dB	-0.3 dB
Change in Calculation Time	+ 7.8% (+ 0.03 seconds per calculation point)			

Plate 10.3 Statistical Distributions for Road Traffic Noise in Area 1

All Roads, L_{den}	All Roads, L_{night}
	
Major Roads Only, L_{den}	**Major Roads Only, L_{night}**
	

Area 2 – Agglomeration - Major and Non-Major Railways

For Area 2, the testing has indicated that calculated railway noise levels between the LCM2007 and CORINE are very consistent. The statistics in Table 10.6 show that average change is 0 dB and that noise levels fall within a 95% confidence interval of 0.5 dB for both L_{den} and L_{night}. The histograms presented in Plate 10.4 show that the use of LCM2007 instead of CORINE has a tendency to increase noise levels but these increases are in general limited to 0.2 dB.

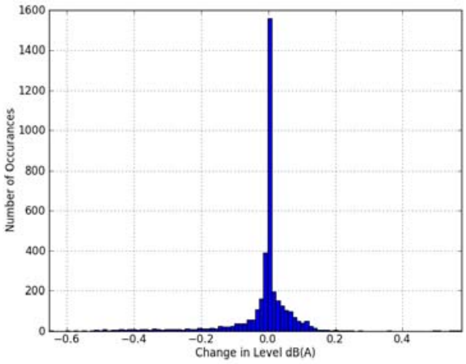
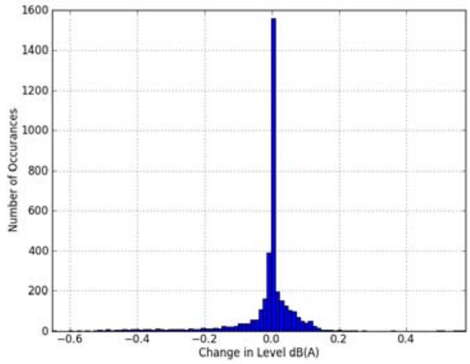
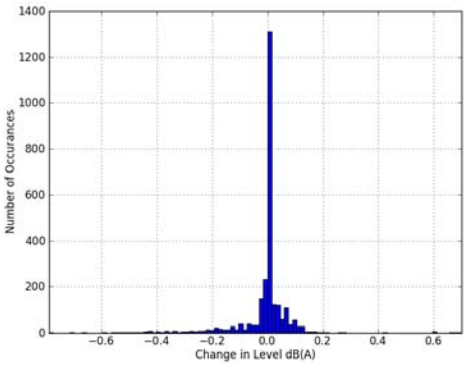
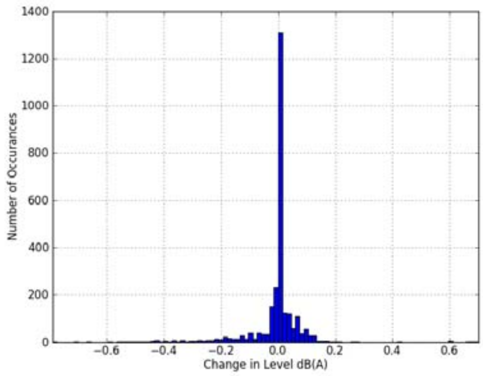
On the whole the statistics show that replacing the CORINE derived ground cover dataset with LCM2007 will have a negligible effect upon noise levels in the agglomeration. Despite this, due to the increased spatial accuracy of the LCM2007 data and the inclusion of an increased number of ground surface types, for railway noise levels, the LCM2007 dataset will result in areas where the quality and confidence of railway noise levels are improved.

In terms of calculation times, Table 10.6 shows that replacing the CORINE derived ground cover dataset with LCM2007 results in an increase in calculation time of 11.4%. This is considered negligible as the corresponding increase in time is less than 0.01 seconds.

Table 10.6 Noise Level Calculation Statistics – Area 2, Railway Noise (LCM2007 vs. CORINE)

Statistic	All Roads in Agglomeration		Major Roads in Agglomeration	
	L_{den}	L_{night}	L_{den}	L_{night}
Max. Increase	+0.6 dB	+0.7 dB	+0.6 dB	+0.7 dB
Max. Decrease	-0.7 dB	-0.8 dB	-0.7 dB	-0.8 dB
Standard Deviation	0.1 dB	0.1 dB	0.1 dB	0.1 dB
95% Confidence Interval	0.5 dB	0.4 dB	0.5 dB	0.4 dB
Average Change	0.0 dB	0.0 dB	0.0 dB	0.0 dB
Change in Calculation Time	+ 11.4% (+ 0.01 seconds per calculation point)			

Plate 10.4 Statistical Distributions for Railway Noise in Area 2

All Railways, L_{den}	All Railways, L_{night}
	
Major Railways Only, L_{den}	**Major Railways Only, L_{night}**
	

Area 2 – Agglomeration - Industry

For Area 2, the testing has also indicated that calculated industrial noise levels between the LCM2007 and CORINE again are very consistent. The statistics in Table 10.7 show that average change is -0.1 dB(A) and that noise levels fall within a 95% confidence interval of 0.2 dB for both L_{den} and L_{night}. The histograms presented in Plate 10.5 show that the use of LCM2007 instead of CORINE has does not appear to have a tendency to either increase or decrease noise levels.

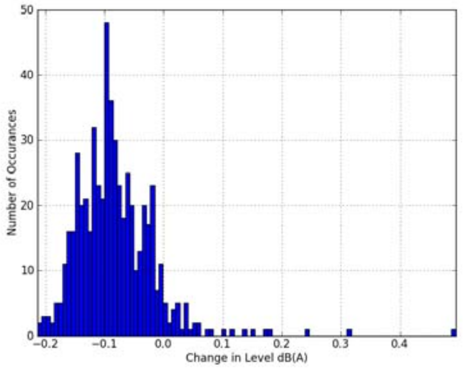
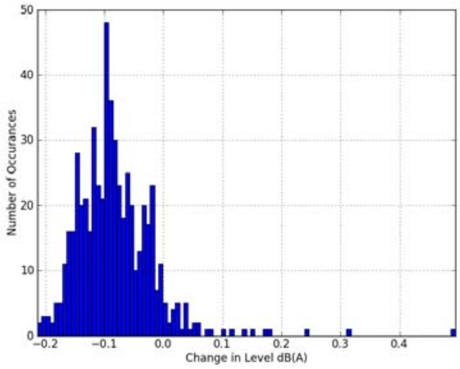
On the whole the statistics show that replacing the CORINE derived ground cover dataset with LCM2007 will have a negligible effect upon industrial noise levels in the agglomeration. Despite this, due to the increased spatial accuracy of the LCM2007 data and the inclusion of an increased number of ground surface types will result in areas where the quality and confidence of industrial noise levels are improved.

In terms of calculation times, Table 10.7 shows that replacing the CORINE derived ground cover dataset with LCM2007 results in a decrease in calculation times of 75%. This is equates to calculation time that are a quarter of that of the CORINE dataset. It is understood that this is due to the use of the 0.7 default ground type within the calculation settings which, for the ISO-9613 calculation kernel reduces the interrogation of the ground cover dataset with regards to the acoustic absorbance of the ground cover at distances in the source, middle and receiver regions of the propagation logic. In this context, the LCM2007 derived dataset results in a significant improvement in calculations times.

Table 10.7 Noise Level Calculation Statistics – Area 2, Industrial Noise (LCM2007 vs. CORINE)

Statistic	Industry Noise Sources in Agglomeration	
	L_{den}	L_{night}
Max. Increase	0.5 dB(A)	0.5 dB(A)
Max. Decrease	-0.2 dB(A)	-0.2 dB(A)
Standard Deviation	0.1 dB(A)	0.1 dB(A)
95% Confidence Interval	0.2 dB(A)	0.2 dB(A)
Average Change	-0.1 dB(A)	-0.1 dB(A)
Change in Calculation Time	- 75.5% (- 2.48 seconds per calculation point)	

Plate 10.5 Statistical Distributions for Industrial Noise in Area 2

All Railways, L_{den}	All Railways, L_{night}
	

Area 3 – Major Roads outside the Agglomeration

For Area 3, the testing indicated that calculated road traffic noise levels between the LCM2007 and CORINE are generally consistent. This is supported by 95% confidence intervals of the L_{den} and L_{night} of 2.2 dB(A) and 2.3

dB(A) respectively. This again suggests that choice of CORINE as a mean of modelling ground cover and the selected absorption coefficients were appropriate. The average change in L_{den} and L_{night} noise levels when using LCM2007 instead of CORINE for the major roads is 0.1 dB(A) indicating that the use of LCM2007 instead of CORINE has a negligible effect for the majority of calculated results, as demonstrated by the histograms presented in Plate 10.6.

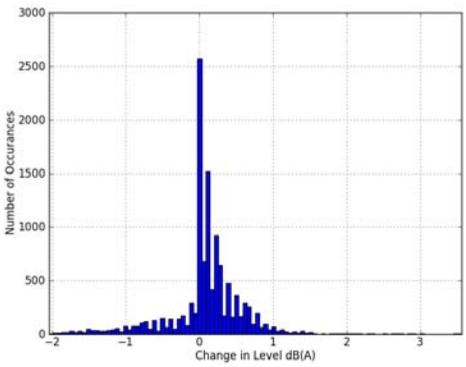
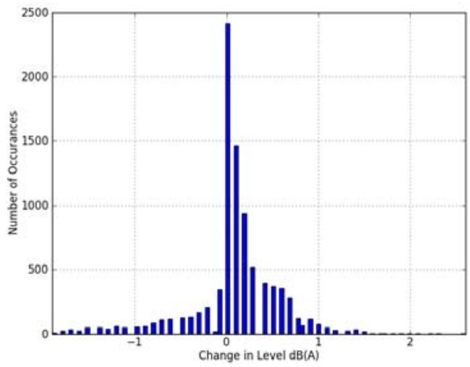
Unlike roads within the agglomeration, as tested in Area 1, the results show a slight tendency to increase noise levels rather than reduce them. This is due to the LCM2007 data depicting areas of hard ground outside of agglomerations which were not captured by the CORINE dataset.

The statistics presented in Table 10.8 show that the using LCM2007 instead of CORINE results in an increase of calculation times by around 14%. This is considered a marginal increase in calculation load as calculations increase on average by 0.02 seconds per point on a single processor.

Table 10.8 Noise Level Calculation Statistics – Area 3, Road Traffic Noise (LCM2007 vs. CORINE)

Statistic	Major Roads outside Agglomeration	
	L_{den}	L_{night}
Max. Increase	+3.6 dB	+2.6 dB
Max. Decrease	-2.0 dB	-1.9 dB
Standard Deviation	0.5 dB	0.5 dB
95% Confidence Interval	2.3 dB	2.2 dB
Average Change	0.1 dB	0.1 dB
Change in Calculation Time	+ 14% (+ 0.02 seconds per calculation point)	

Plate 10.6 Statistical Distributions for Road Traffic Noise in Area 3

Major Roads, L_{den}	Major Roads, L_{night}
	

10.1.3 Recommendations

The results presented in previous sections demonstrate that for all noise sources under assessment, the replacement of the CORINE derived ground cover dataset with an LCM2007 derived ground cover dataset results in mainly localised improvements to noise level results. A review of the LCM2007 data has shown that the spatial accuracy of the LCM2007 data is much improved in comparison to CORINE in that smaller areas of hard and soft ground such as urban green areas can be captured and fully considered. This will improve the quality of the noise level outputs. The LCM2007 data is more current than the CORINE data therefore allow new suburban areas to be captured.

Although the noise level testing has identified that CORINE is a good substitute for a pure land cover dataset, the opportunity to improve noise level results using a dataset which is more current, which considers discrete areas of land cover and is more spatially accurate must be seriously considered. The testing has revealed that in general, the LCM2007 derived data results in increases in calculation times of up to 15%. In terms of time, this results in increases of less than 0.03 seconds per calculation point. This is considered a negligible increase and as such it is recommended that LCM2007 is used as basis of modelling acoustic ground cover in Northern Ireland.

10.1.4 Dataset Development

To process the LCM2007, the project team first executed a field join between the LCM2007 ground surface classifications and the ground absorption coefficient values, as outlined in Table 10.3. A ‘dissolve’ was then performed on the LCM2007 dataset for neighboring features with shared ground absorption coefficients. This ensured that areas with the same ground absorption coefficient were modeled as a single object. Following the dissolve, it was identified that the majority of the Round Two extents has ground absorption values of 0.7. A decision was therefore taken to ensure that the default ground absorption value in the noise calculation was 0.7 and for the ground cover dataset to include only surfaces that did not have ground absorption coefficients of 0.7.

11. Meteorological Dataset

Meteorology data is required for industrial noise calculation in accordance with the ISO 9613-2 methodology. Three pieces of meteorology data are required in order to satisfy the requirements of the ISO 9613-2. These are:

- Wind Direction and Occurrence;
- Air Temperature; and
- Relative Humidity.

For Round Two, meteorology data from a weather station located at Belfast Aldergrove was provided. Data was also obtained from Belfast Aldergrove during Round One. For Round Two, data was provided for the 2011 calendar year. This data include a wind rosette, along with average temperate and humidity. Using this data, it was possible to derive 2011 average temperatures, humidity and wind speeds for day, evening, night-time and 24-hour periods. These averages are outlined in Table 11.1 below.

Table 11.1 2011 Meteorological Statistics – Temperature and Humidity

	Day (0700-1900hrs)	Evening (1900-2300hrs)	Night (2300-0700hrs)	24-Hour
Average Temperature (Degrees Celsius)	10.7 °C	9.2 °C	8.1 °C	9.6 °C
Average Relative Humidity (%)	76.9 %	82.5 %	86.9 %	81.2 %
Average Wind Speed (ms^{-1})	4.0 ms^{-1}	3.4 ms^{-1}	3.2 ms^{-1}	3.6 ms^{-1}

The wind rosette obtained from Belfast Aldergrove provides an indication of wind direction in compass bearings with a separation of approximately 22.5 degrees. In order to allow the modelling of prevailing wind directions within the LimA environment, it has been necessary to interpolate the wind rosette in to intervals of 10 degrees. This process has also required a reinterpretation of the wind rosette so that the occurrence of a certain prevailing wind direction is presented as a percentage. Using the reinterpreted wind rosette, the LimA software was used to convert the rosette into ISO 9613-2 compliant C0 factors for each 10 degree interval using a conversion algorithm.

12. QA of Round Two Datasets

12.1 Introduction

This section details the Quality Assurance procedures implemented upon the 3D modelling dataset. As discussed in Sections 6-11, all datasets were developed in the GIS environment in accordance with the various LimA object dataset schemas associated with each model layer. This approach was taken to reduce the processing required within the LimA software environment and seeks to ensure that datasets are in compliance with the LimA software.

The Quality Assurance of the Round Two datasets marks the transition from the GIS environment to the LimA software environment and marks the beginning of Stage 2 of the project. The QA procedures aim to identify whether the various GIS datasets comprising the 3D modelling environment have been developed to specification. It also aims to ensure that calculations will run without error and that any issues encountered with the 3D modelling layers are identified before calculation and corrected as required.

The QA procedures adopted by the project team broadly reflect those implemented for Round One however developments within the LimA software itself has allowed many of these procedures to become automated and further refined. Like the approach adopted in Round One, all QA procedures have been undertaken with the assistance of electronic proformas. These proformas ensure that all steps within each stage of the QA procedures are adhered to in sequence and are correctly implemented. The proformas also allow version control, file paths and corrective actions to be formally issued between the noise calculation and GIS teams. Plate 12.1 presents an example proforma.

Plate 12.1 Example QA Proforma

Stage 3A QA - Integrity Checks in LimA Modelling Env.

Project Title	Northern Ireland Second Round Noise Mapping
Project Number	30563
Project Sub-Area	A2
LimA Server Project Path	\\emanlima1\LimAjobs\30563\DATA_TESTING

Note: Scroll over the QA Check to review checking requirements. Perform Checks from Left to Right

Shapefile Data Inputs								
Data Layer	File	CHECK 1 OK?	CHECK 2 OK?	CHECK 4 OK?	CHECK 7 OK?	Renumber ELEs	SAVE	Pass / Fail?
~~HIN_HA1~~	~~No Data Layer for Project Sub-Area~~		n/a		n/a			
HIN_HA2	\\emanlima1\LimAjobs\30563\DATA_TESTINGA2\MODEL\HIN_HA2\A2_HIN_HA2_03.BN	Yes	Yes	Yes	n/a	Yes	Yes	Pass
HIN_HA4	\\emanlima1\LimAjobs\30563\DATA_TESTINGA2\MODEL\HIN_HA4\A2_HIN_HA4_02.BN	Yes	n/a	Yes	n/a	Yes	Yes	Pass
HIN_HA7	\\emanlima1\LimAjobs\30563\DATA_TESTINGA2\MODEL\HIN_HA7\A2_HIN_HA7_02.BN	Yes	Yes	Yes	Yes	Yes	Yes	Pass
GEL	\\emanlima1\LimAjobs\30563\DATA_TESTINGA2\MODEL\GEL\A2_GEL_01.BNA	Yes	n/a	Yes	n/a	Yes	Yes	Pass
~~BRL~~	~~No Data Layer for Project Sub-Area~~		n/a		n/a			
~~RDL~~	~~No Data Layer for Project Sub-Area~~		n/a		n/a			
~~IND~~	~~No Data Layer for Project Sub-Area~~				n/a			

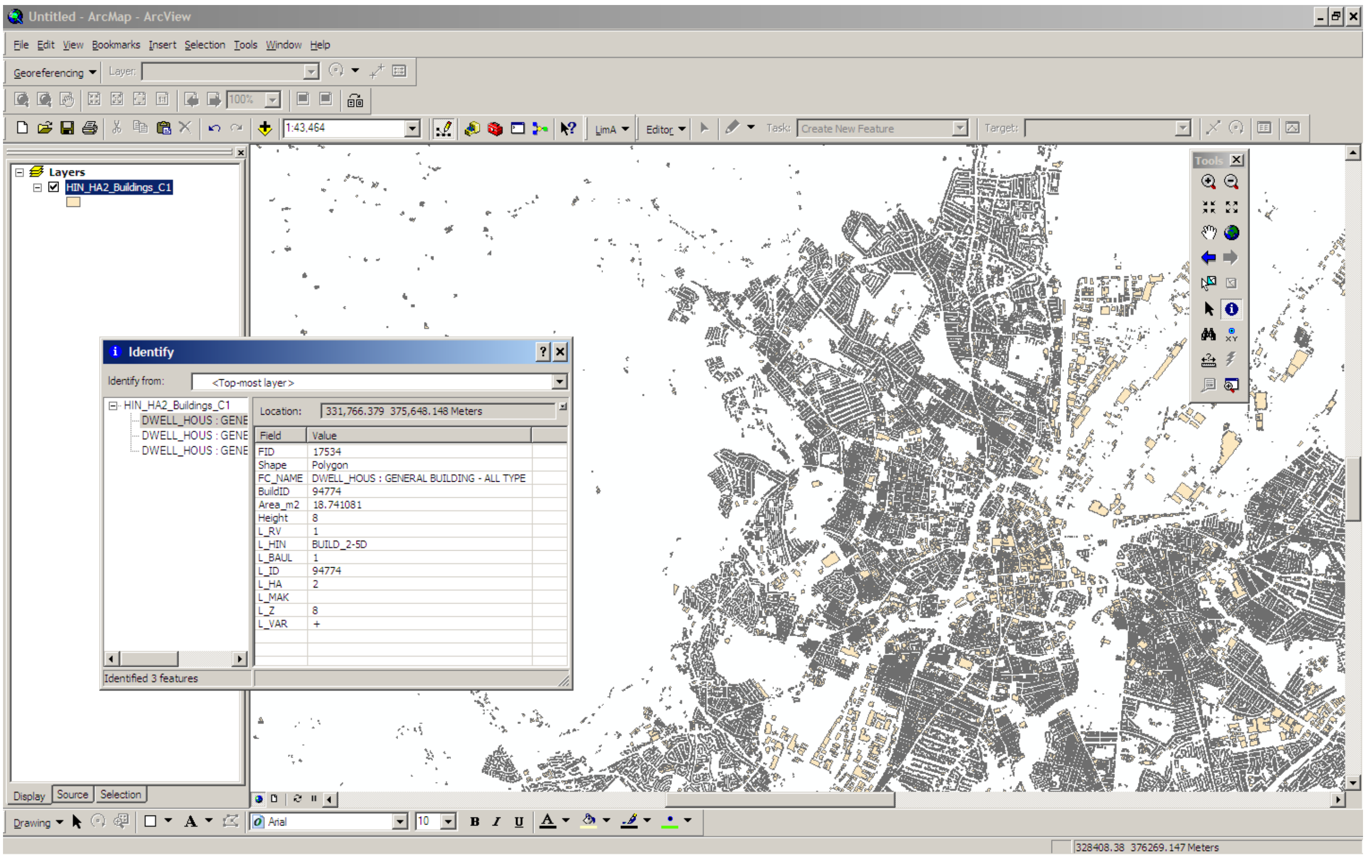
Corrective Actions		Description
Data Layer	File Path	
~~HIN_HA1~~	~~No Data Layer for Project Sub-Area~~	
HIN_HA2	\\emanlima1\LimAjobs\30563\DATA_TESTINGA2\SOURCE\HIN_HA2\A2_HIN_HA2_03.S	Doubles identified and elements renumbered, saved as rev03
HIN_HA4	\\emanlima1\LimAjobs\30563\DATA_TESTINGA2\SOURCE\HIN_HA4\A2_HIN_HA4_02.S	All clean - saved rev02
HIN_HA7	\\emanlima1\LimAjobs\30563\DATA_TESTINGA2\SOURCE\HIN_HA7\A2_HIN_HA7_02.S	All clean - saved rev02
GEL	\\emanlima1\LimAjobs\30563\DATA_TESTINGA2\SOURCE\GEL\A2_GEL_01.SHP	All clean - saved rev02

The QA procedure comprises of a four stage process. The first three stages of the QA procedure are implemented on a layer by layer basis. The fourth and final stage of the QA procedures requires the interaction of all 3D modelling layers to ensure that the noise model is correctly compiled.

12.2 Stage 1 of the QA Process

Stage 1 of the QA procedure is a check of the datasets in the GIS environment by a member of the noise calculation team prior to import into the LimA environment. The purpose of this stage is to ensure that the data has been correctly prepared in terms of spatial extent, object type and attribution and is generally suitable for importation into the LimA environment.

Plate 12.2 GIS Dataset checking in ArcGIS Prior to Import into LimA



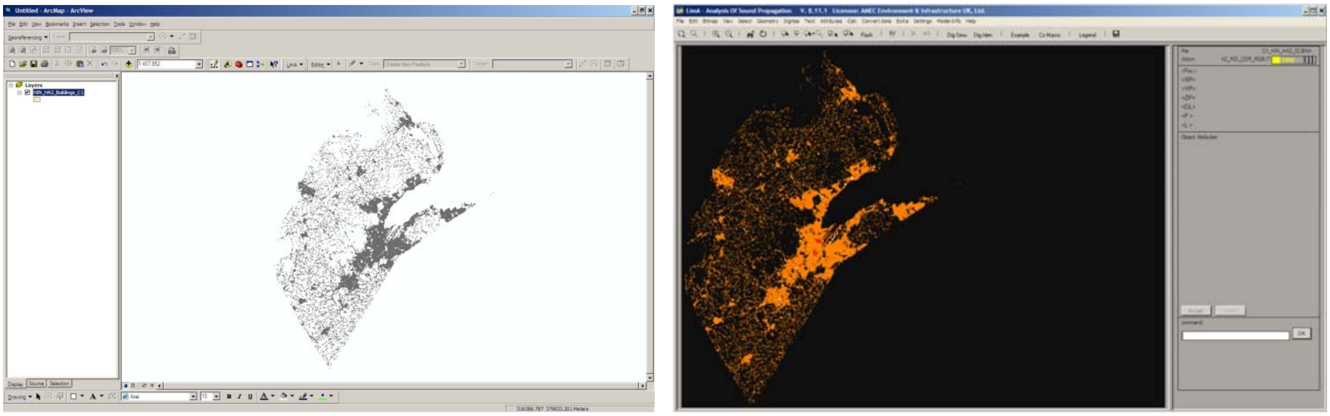
12.3 Stage 2 of the QA Process

Stage 2 of the QA procedure is the importation of the GIS model layers into the LimA environment. All data is exported from the GIS environment in Shapefile format and imported into the LimA environment in the software's proprietary BNA file format. The importation process is a one-to-one conversion and is illustrated in Plate 12.3.

This means that all objects in GIS must be stored as single feature and should have unique identification numbers. As part of the importation, LimA warns of any objects which do not meet this requirement or have significant non-compliant topographies.

The QA process in Stage 2 requires the documentation of any errors during importation and feedback to the GIS project team when any errors are encountered with corrective actions.

Plate 12.3 Data in ArcGIS and LimA Environments Respectively



12.4 Stage 3A of the QA Process

Stage 3A incorporates the testing of the imported datasets within the LimA modeling environment. The LimA modeling environment has several built in check procedures which look for topographic and attribution issues and/or errors. Each type of 3D modeling layer has a different series of checks that it must undergo. For example, bridge objects have a check designed specifically for their object type.

Once imported the QA procedure requires each LimA modeling object (e.g. bridge, building etc.) to undergo a series of checks. These checks include:

- Object integrity checks (i.e. does the object meet its topographic definitions);
- Attribution checks (i.e. are the attributes populated appropriately);
- Object definitions checks; and
- Duplicable object checks.

Where errors are identified by the check procedures, LimA marks the objects for correction. Depending upon the number of corrections required the QA procedures allows these to be undertaken within LimA or alternatively passed back to the GIS team with a set of corrective actions. All amendments are documented within the proformas.

12.5 Stage 3B of the QA Process

Stage 3B of the QA procedure reflects those undertaken in Stage 3A except these checks are undertaken within the LimA calculation environment. Each layer is subject to LimA's 'Model Check' procedure. When performed on a layer-by-layer basis, this check highlights any object attribution or topographic errors that are not highlighted within the LimA modelling environment. These include:

- Incorrect object attribution (i.e. are the attributes populated appropriately);
- Duplicable object checks; and
- Incorrect or incompatible topographies (e.g. polylines with incomparable vertex spacing).

The checks undertaken as part of LimA's 'Model Check' function are more rigorous that than those undertaken in Stage 3A within the LimA modeling environment. These checks ensure that each model layer is error free prior to Stage 4.

12.6 Stage 4 of the QA Process

Stage 4 is the most involved stage of the QA process. Stage 4 is a QA of the interaction of the various model datasets comprising the noise model. The Stage 4 QA process is broken into several small stages as outlined in Table 12.1.

Table 12.1 Tests undertaken in Stage 4 of the QA Process

Test	Model Layers	Description
T1	HIN HA 4, GEL, HIN HA 7	Bridges interact correctly with the DTM
T2	HIN HA 4, GEL, HIN HA 2	Buildings interact correctly with the DTM
T3	HIN HA 4, GEL, HIN HA 1	Barriers interact correctly with the DTM
T4	HIN HA 4, GEL, HIN HA 2, HIN HA 7, HIN HA 1, TOP	Bridge, Barrier and Building interact correctly with the DTM and Ground Cover
T5	As T4 and Noise Source Dataset	Check Complete Ground Model interaction with Noise Sources

Each test culminates in the complete QA of the ground model within the LimA calculation environment using the 'Model Check' feature.

In Test T1, the noise calculation team review the digitisation of each bridge and their 3D positioning as outlined in Section 8. Each bridge is reviewed in 3D and corrected if necessary. Bridges which are incorrectly digitised are automatically flagged by the LimA calculation core however incorrect position is not. A manual check is therefore the only mean of ensuring that bridges have been correctly digitised.

In Test T2, the ‘Model Check’ functions evaluates the height of flat topped buildings based on the relative height of the building and the height of the terrain at the start point of the building object. The key output of the check is the identification of buildings which have relative heights which fall below the surrounding terrain. This is possible in locations where buildings are located on sloping terrain.

Where this occurs, it is necessary to reposition the start point of the building object to another location which ensures that the top of the building object is above the terrain at all locations. For Round One, these errors had to be correctly manually. Due to the increased extents in Round Two, the project team worked with Stapelfeldt to develop an automated solution which corrects the start position of the building objects where the building falls below the terrain.

For Test T3, each barrier was reviewed in 3D to ensure that it is correctly aligned with respect to the DTM. Where alignments appear incorrect, these are corrected within the software. Where barriers are positioned on bridges, these must also be reviewed to ensure that they sit correctly on the bridge structure and the adjoining terrain. Each barrier is reviewed in 3D and correctly appropriately.

For Test T4, all ground model layers are interacted together. The output from the LimA ‘Model Check’ function is reviewed to ensure that the interaction of objects does not result in any additional errors. Areas are selected from the model and 3D views generated which are reviewed manually. These areas are selected in the location of bridges and barriers.

For Test T5, all ground model layers are interacted with the source datasets. For the road and railway datasets, the model is reviewed in 3D in areas where roads or railways sources interact with bridges to ensure that the sources are correctly position above or below the bridge objects. If corrections are required, these are made within the LimA modelling environment.

Appendix A
3D Modelling Dataset Specifications

Table A.1 Overview of Applicable 3D-Modelling Datasets in LimA

Layer Overview	Spatial Reference	Object Dimensions	Elevation Reference	Elevation Reference Position	Elevation Definition	Unit	LimA Object Type
DTM Spot Heights	Vector	2.5D/3D Points	Absolute	AMSL	Constant per object	Metre (m)	**GEL**
DTM Contour Lines	Vector	2.5 D Polylines	Absolute	AMSL	Constant per object	Metre (m)	**GEL**
DTM Breaklines	Vector	3D Polylines	Absolute	AMSL	Height per vertex	Metre (m)	**HIN HA 4**
Ground Cover	Vector	2D Polygons	NA	NA	NA	NA	**TOP**
Buildings	Vector	2.5D Polygons	Relative	Roof height (relative to AMSL)	Constant per object	Metre (m)	**HIN HA 2**
Bridges	Vector	3D Polygons	Absolute	AMSL	Height per vertex	Metre (m)	**HIN HA 7**
Barriers e.g. Noise barriers, retaining walls	Vector	2.5D/3D Polylines	Relative or absolute	Barrier height (AMSL or Relative to AMSL)	Constant per object or height per vertex	Metre (m)	**HIN HA 1**
Meteorology Wind Direction	Vector	NA	NA	NA	NA	NA	**N/A**
Meteorology Wind speed	NA	NA	NA	NA	NA	m/s	
Meteorology Air Temperature	NA	NA	NA	NA	NA	Celsius	
Meteorology Relative humidity	NA	NA	NA	NA	NA	%	

Note: All vector polygon and polyline objects should not have vertices with a separation distances less than 0.05m. Elevations should not be different at identical horizontal positions.

Table A.2 Spot Height Elevation (GEL Object)

Field/ Attribute Name	Full Description	Data Type	Status	Properties		Special Values
L_GEL	Spot Height in Metres AMSL	Floating Point	Calculated / Data Input	Default Value	0.00	None
				Min. Value	-9999.99	
				Max. Value	9999.99	
L_VAR	Calculation Variant	String	Software Function	Default Value	+	None
				Max. Length	20	

Table A.3 Equal Height Contour Elevation (GEL Object)

Field/ Attribute Name	Full Description	Data Type	Status	Properties		Special Values
L_GEL	Equal Height in Metres AMSL	Floating Point	Calculated / Data Input	Default Value	0.00	None
				Min. Value	-9999.99	
				Max. Value	9999.99	
L_VAR	Calculation Variant	String	Software Function	Default Value	+	None
				Max. Length	20	

Table A.4 Breaklines (HIN HA 4 Object)

Field/ Attribute Name	Full Description	Data Type	Status	Properties		Special Values
L_HIN	Object Name	String	Data Input	Default Value	EMB_EDGE	
				Max. Length	20	
L_ID	Unique ID Number	Double	Data Input	Unique ID		
				Max. Length	20	
L_HA	Object Type	Integer	Data Input	Default Value	4	
				Max. Length	2	
L_BAUL	Screening Effect	Floating Point	Data Input	Default Value	1	
				Precision	1 d.p.	
				Max. Length	6	

Table A.4 (continued) Breaklines (HIN HA 4 Object)

Field/ Attribute Name	Full Description	Data Type	Status	Properties		Special Values
L_RV	Reflection Loss	Floating Point	Data Input	Default Value	1	
				Precision	1 d.p.	
				Max. Length	10	
L_MAK	Material	String	Data Input	Default Value	-	
				Max. Length	20	
L_Z	Height of Object in AMSL	String	Calculated	Default Value	A	
				Max. Length	20	
L_VAR	Calculation Variant	String	Software Function	Default Value	+	None
				Max. Length	20	

Table A.5 Buildings (HIN HA 2 Object)

Field/ Attribute Name	Full Description	Data Type	Status	Properties		Special Values
L_HIN	Object Name	String	Data Input	Default Value	BUILD_2-5D	None
				Max. Length	20	
L_ID	Unique ID Number	Double	Data Input	Unique ID		None
				Max. Length	20	
L_HA	Object Type	Integer	Data Input	Default Value	2	None
				Max. Length	2	
L_BAUL	Screening Effect	Floating Point	Data Input	Default Value	1	None
				Precision	1 d.p.	
				Max. Length	6	
L_RV	Reflection Loss	Floating Point	Data Input	Default Value	1	None
				Precision	1 d.p.	
				Max. Length	10	
L_MAK	Material	String	Data Input	Default Value	-	None
				Max. Length	20	

Table A.5 (continued) Buildings (HIN HA 2 Object)

Field/ Attribute Name	Full Description	Data Type	Status	Properties		Special Values
L_Z	Height of Object in AMSL	String	Calculated	Default Value	8.00	None
				Min Value.	0.00	
				Max Value	9999.99	
				Precision	2 dp	
				Max. Length	10	
L_VAR	Calculation Variant	String	Software Function	Default Value	+	None
				Max. Length	20	

Table A.6 Barriers (HIN HA 1 Object)

Field/ Attribute Name	Full Description	Data Type	Status	Properties		Special Values
L_HIN	Object Name	String	Data Input	Default Value	BARRIER_2-5D	None
				Max. Length	20	
L_ID	Unique ID Number	Double	Data Input	Unique ID		None
				Max. Length	16	
L_HA	Object Type	Integer	Data Input	Default Value	1	None
				Max. Length	2	
L_BAUL	Screening Effect	Floating Point	Data Input	Default Value	1	None
				Precision	1 d.p.	
				Max. Length	6	
L_RV	Reflection Loss	Floating Point	Data Input	Default Value	1	None
				Precision	1 d.p.	
				Max. Length	10	
L_MAK	Material	String	Data Input	Default Value	-	None
				Max. Length	20	
L_Z	Height of Barrier in meters relative to ground / object	String	Calculated	Default Value	2 D	None
				Example: 4.5m high barrier at the roadside should be attributed as "4.5 D"		
				Max. Length	10	

Table A.6 (continued) Barriers (HIN HA 1 Object)

Field/ Attribute Name	Full Description	Data Type	Status	Properties		Special Values
L_VAR	Calculation Variant	String	Software Function	Default Value	+	None
				Max. Length	20	

Table A.7 Bridges (HIN HA 7 Object)

Field/ Attribute Name	Full Description	Data Type	Status	Properties		Special Values
L_HIN	Object Name	String	Data Input	Default Value	BRIDGE_3D	None
				Max. Length	20	
L_ID	Unique ID Number	Double	Data Input	Unique ID		None
				Max. Length	16	
L_HA	Object Type	Integer	Data Input	Default Value	7	None
				Max. Length	2	
L_BAUL	Screening Effect	Floating Point	Data Input	Default Value	1	None
				Precision	1 d.p.	
				Max. Length	6	
L_RV	Reflection Loss	Floating Point	Data Input	Default Value	1	None
				Precision	1 d.p.	
				Max. Length	10	
L_MAK	Material	String	Data Input	Default Value	-	None
				Max. Length	20	
L_Z	Height of Bridge in meters AMSL	String	Calculated	Default Value	A	None
				Max. Length	10	
L_VAR	Calculation Variant	String	Software Function	Default Value	+	None
				Max. Length	20	

Table A.8 Ground Cover (TOP Object)

Field / Attribute Name	Full Description	Data Type	Status	Properties		Special Values
L_TOP	Object Name	String	Data Input	Default Value	GROUND_COVER	None
				Max. Length	20	
L_ID	Unique ID Number	Double	Data Input	Unique ID		None
				Max. Length	16	
L_G	Reflection Factor	Floating Point	Data Input	Default Value	0	None
				Precision	1	
				Max. Length	6	
L_VAR	Calculation Variant	String	Software Function	Default Value	+	None
				Max. Length	20	

Appendix B
GIS Building Processing Steps

ArcGIS Processing Steps - Buildings

The following list outlines the GIS processing used to remove splits in the original OSNI building objects.

- ArcGIS query used to extract the building features from the OSNI large scale dataset. The query used is outlined below:

  - "FC_NAME" = 'ANTIQ_BLD : ANTIQUITY BUILDINGS' OR "FC_NAME" = 'BLDFURN_OT : TYPES OF BUILDING FURNITURE' OR "FC_NAME" = 'BUILD_OTH : ANY OTHER TYPE OF BUILDING' OR "FC_NAME" = 'COMM_OTH : ANY OTHER TYPE OF COMMUNAL BU' OR "FC_NAME" = 'COMMERCE_B : GENERAL BUILDING ASSOCIATED' OR "FC_NAME" = 'COMMUNAL_B : COMMUNAL BUILDINGS TOP LEVE' OR "FC_NAME" = 'DWELL_HOUS : GENERAL BUILDING - ALL TYPE' OR "FC_NAME" = 'EDUCATE_B : COMMUNAL BUILDING FOR EDUCAT' OR "FC_NAME" = 'GENERAL_OT : ANY OTHER GENERAL BUILDING ' OR "FC_NAME" = 'GLASS_B : GLASS BUILDINGS' OR "FC_NAME" = 'GOV_OFFICE : COMMUNAL BUILDING FOR GOVER' OR "FC_NAME" = 'HEALTH_B : COMMUNAL BUILDINGS ASSOCIATED' OR "FC_NAME" = 'INDUSTRY_B : GENERAL BUILDING ASSOCIATED' OR "FC_NAME" = 'LAW_ADMIN : COMMUNAL BUILDING FOR LAW AD' OR "FC_NAME" = 'RECREAT_B : COMMUNAL BUILDING FOR RECREA' OR "FC_NAME" = 'RELIGION_B : COMMUNAL BUILDING ASSOCIATE' OR "FC_NAME" = 'SERVICES_B : COMMUNAL BUILDING FOR PUBLI'

- ArcGIS query used to select building polygons within 1m of a tile boundary and then separate these objects into a new file;

- Convert the selected polygons into polylines and then calculate COGO Inverse statistics. This splits each polyline into separate vertices and assign an angle value;

- Polylines with an angle value of 0, 90, 180 or 270 were selected using a simple ArcGIS query. From that selection anything intersecting the OS gridlines were deleted;

- The lines were repaired by using ET GeoWizards - Clean Polylines, Remove Dangling Nodes and Fix Pseudo Nodes tools;

- The selected buildings were then dissolved using the FC_NAME field and repaired using ET GeoWizards’ Clean Polygons;

- The repaired lines from were then used to resplit the polygons. This ensured that houses were kept as separate entities;

- The split polygons were integrated back into the original dataset and a final repair was performed;

- Buildings from the first round of noise mapping with a height less than or greater than 8 were then selected using an attribute query and these heights joined to the new buildings, where they matched (i.e. still existed and shared the same shape). All other heights were given a default value of 8m;

- Using these processing steps, the final FDMI buildings dataset had 1,326,309 features.