R E G I O N A L
M O D E L L I N G
S Y S T E M

RM Spec5 Zone System Development Specification Report – Tender Issue

Údarás
Náisiúnta Iompair
National Transport Authority

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Foreword

The NTA has developed a Regional Modelling System (RMS) for Ireland that allows for the appraisal of a wide range of potential future transport and land use alternatives. The RMS was developed as part of the Modelling Services Framework (MSF) by the National Transport Authority (NTA), SYSTRA and Jacobs Engineering Ireland.

The National Transport Authority's (NTA) Regional Modelling System comprises the National Demand Forecasting Model, five large-scale, technically complex, detailed and multi-modal regional transport models and a suite of Appraisal Modules covering the entire national transport network of Ireland. The five regional models are focussed on the travel-to-work areas of the major population centres in Ireland, i.e. Dublin, Cork, Galway, Limerick, and Waterford.

The development of the RMS followed a detailed scoping phase informed by NTA and wider stakeholder requirements. The rigorous consultation phase ensured a comprehensive understanding of available data sources and international best practice in regional transport model development.

The five discrete models within the RMS have been developed using a common framework, tied together with the National Demand Forecasting Model. This approach used repeatable methods; ensuring substantial efficiency gains; and, for the first time, delivering consistent model outputs across the five regions.

The RMS captures all day travel demand, thus enabling more accurate modelling of mode choice behaviour and increasingly complex travel patterns, especially in urban areas where traditional nine-to-five working is decreasing. Best practice, innovative approaches were applied to the RMS demand modelling modules including car ownership; parking constraint; demand pricing; and mode and destination choice. The RMS is therefore significantly more responsive to future changes in demographics, economic activity and planning interventions than traditional models.

The models are designed to be used in the assessment of transport policies and schemes that have a local, regional and national impact and they facilitate the assessment of proposed transport schemes at both macro and micro level and are a pre-requisite to creating effective transport strategies.

1 Introduction

1.1 Regional Modelling System

The NTA has developed a Regional Modelling System for the Republic of Ireland to assist in the appraisal of a wide range of potential future transport and land use options. The regional models are focused on the travel-to-work areas of the major population centres of Dublin, Cork, Galway, Limerick, and Waterford. The models were developed as part of the Modelling Services Framework by the NTA, SYSTRA and Jacobs Engineering Ireland.

An overview of the 5 regional models is presented below in both Table 1.1 and Figure 1.1.

Table 1.1 Regional Models and their Population Centres

Model Name	Code	Counties and population centres
West Regional Model	WRM	Galway, Mayo, Roscommon, Sligo, Leitrim, Donegal
Eastern Regional Model	ERM	Dublin, Wicklow, Kildare, Meath, Louth, Wexford, Carlow, Laois, Offaly, Westmeath, Longford, Cavan, Monaghan
Mid-West Regional Model	MWRM	Limerick, Clare, Tipperary North
South East Regional Model	SERM	Waterford, Wexford, Carlow, Tipperary South
South West Regional Model	SWRM	Cork and Kerry

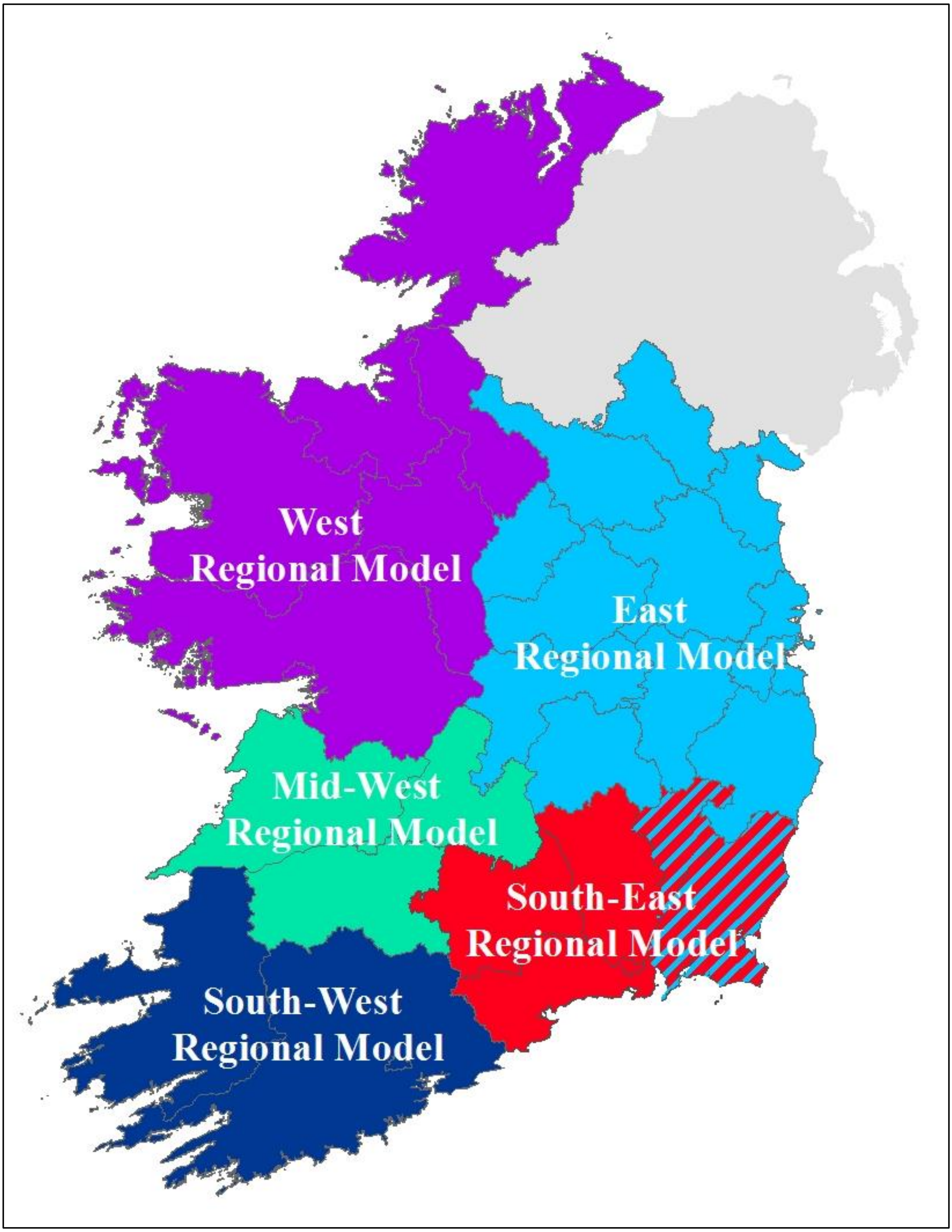

Figure 1.1 Regional Model Areas

The 5 regional transport models comprising the NTA's Regional Modelling System (RMS) all use a consistent approach to zonal development process. An important objective of the RMS Zone Specification is that its principles can be applied to any regional model area to act as an overarching road model development guide prior to calibrating to local data.

Four scoping reports were used as the basis for the specification of the update of the Regional Modelling System, which are as follows:

- RMS Scope 1 NTA Modelling Needs Review;
- RMS Scope 2 Greater Dublin Area Model Review;
- RMS Scope 3 Transport Modelling Best Practice Review; and
- RMS Scope 4 Modelling Data Review

1.2 RMS Model Structure

The Regional Modelling System is comprised of three main components, namely:

- The National Demand Forecasting Model (NDFM);
- 5 Regional Models; and
- A suite of Appraisal Modules.

The modelling approach is consistent across each of the regional models. The general structure of the regional models is shown below in Figure 1.2. The main stages of the regional modelling system are described below.

1.2.1 National Demand Forecasting Model (NDFM)

The NDFM is a single, national system that provides estimates of the total quantity of daily travel demand produced by and attracted to each of the 18,488 Census Small Areas. Trip generations and attractions are related to zonal attributes such as population, number of employees and other land-use data. See the NDFM Development Report for further information.

1.2.2 Regional Models

A regional model is comprised of the following key elements:

Trip End Integration

The Trip End Integration module converts the 24-hour trip ends output by the NDFM into the appropriate zone system and time period disaggregation for use in the Full Demand Model (FDM).

The Full Demand Model (FDM)

The FDM processes travel demand and outputs origin-destination travel matrices by mode and time period to the assignment models. The FDM and assignment models run iteratively until an equilibrium between travel demand and the cost of travel is achieved.

Assignment Models

The Road, Public Transport, and Active Modes assignment models receive the trip matrices produced by the FDM and assign them in their respective transport networks to determine route choice and the generalised cost for origin and destination pair.

The Road Model assigns FDM outputs (passenger cars) to the road network and includes capacity constraint, traffic signal delay and the impact of congestion. See the RM Spec 2 Road Model Specification Report for further information.

The Public Transport Model assigns FDM outputs (person trips) to the PT network and includes the impact of capacity restraint, such as crowding on PT vehicles, on people's perceived cost of travel. The model includes public transport networks and services for all PT sub-modes that operate within the modelled area. See the RM Spec 3 Public Transport Model Specification Report for further information.

Secondary Analysis

The secondary analysis application can be used to extract and summarise model results from each of the regional models.

1.2.3 Appraisal Modules

The Appraisal Modules can be used on any of the regional models to assess the impacts of transport plans and schemes. The following impacts can be informed by model outputs (travel costs, demands and flows):

- Economy;
- Safety;
- Environmental;
- Health; and
- Accessibility and Social Inclusion.

Further information on each of the Appraisal Modules can be found in the following reports:

- Economic Module Development Report;
- Safety Module Development Report;
- Environmental Module Development Report;
- Health Module Development Report; and
- Accessibility and Social Inclusion Module Development Report

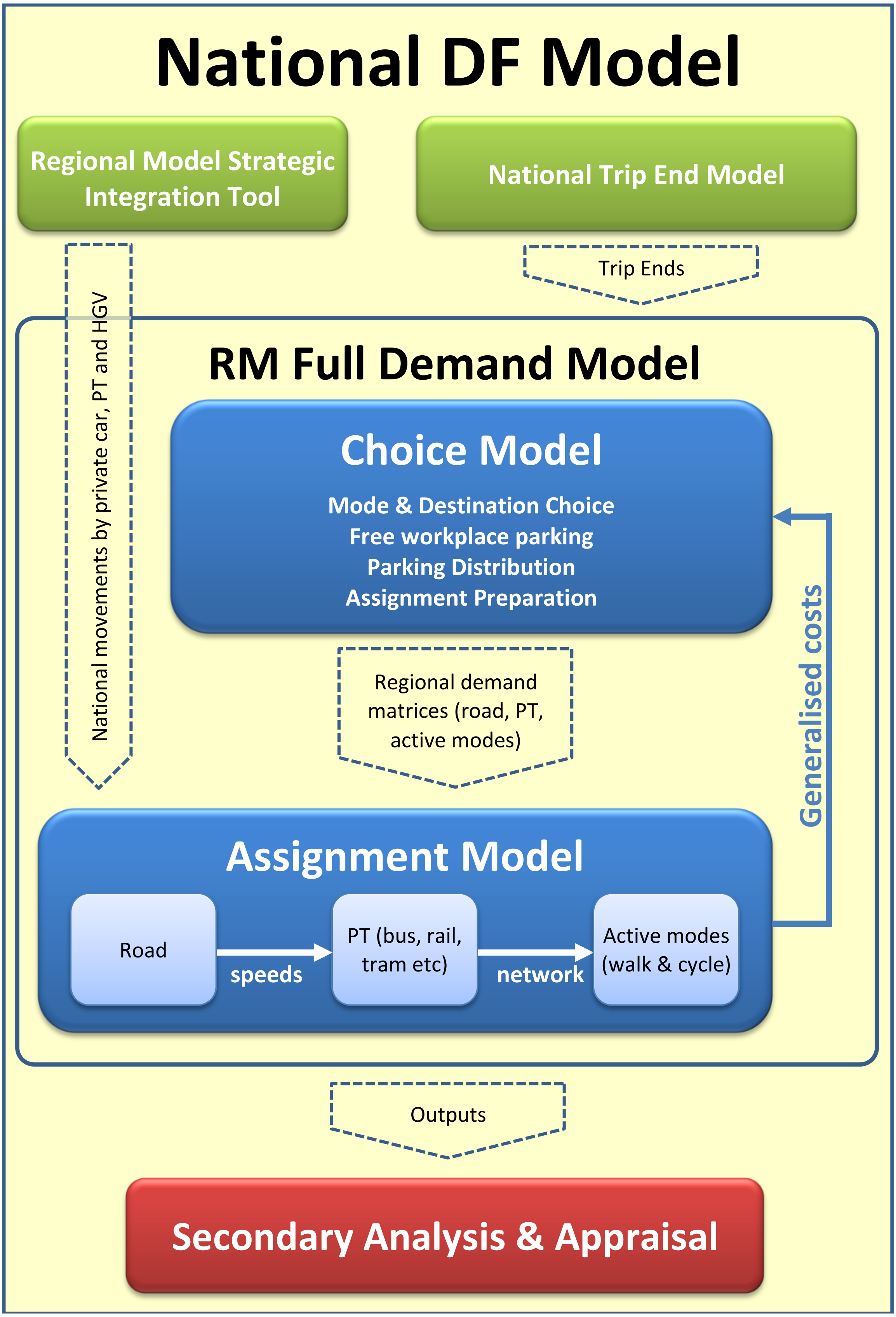

Figure 1.2 RMS Model Structure

1.3 Purpose of this Report

The purpose of this note is to provide a methodology to define consistent zoning systems for each regional model, based on experience gained during the development of the Eastern Regional Model zoning. This note presents a discussion on the data sources used in the ERM zone delineation, sets out criteria on which zones will be delineated in all regional models, and outlines a series of repeatable methods designed to save time for future zoning development and give consistency among all NTA transport models.

1.4 The Delineation Process

The zone delineation process aims to create a zone system which allows us to accurately model travel demand in the model area concerned. The process involves taking Census Small Areas (CSAs –the smallest spatial level that data are available) and manipulating zone boundaries to create zones that take account of physical boundaries (motorways, rivers etc.), and represent homogenous land use types and activity.

The process has been split into two main steps i.e. Preparation Work and Zone Delineation. Within these steps, the process is broken down into chronologically organized tasks which are described in greater detail throughout this report. Figure 1.3 below sets out the zone delineation process with arrows representing the chronological order of tasks. The process is iterative in order to achieve an acceptable balance between the various zone delineation conditions.

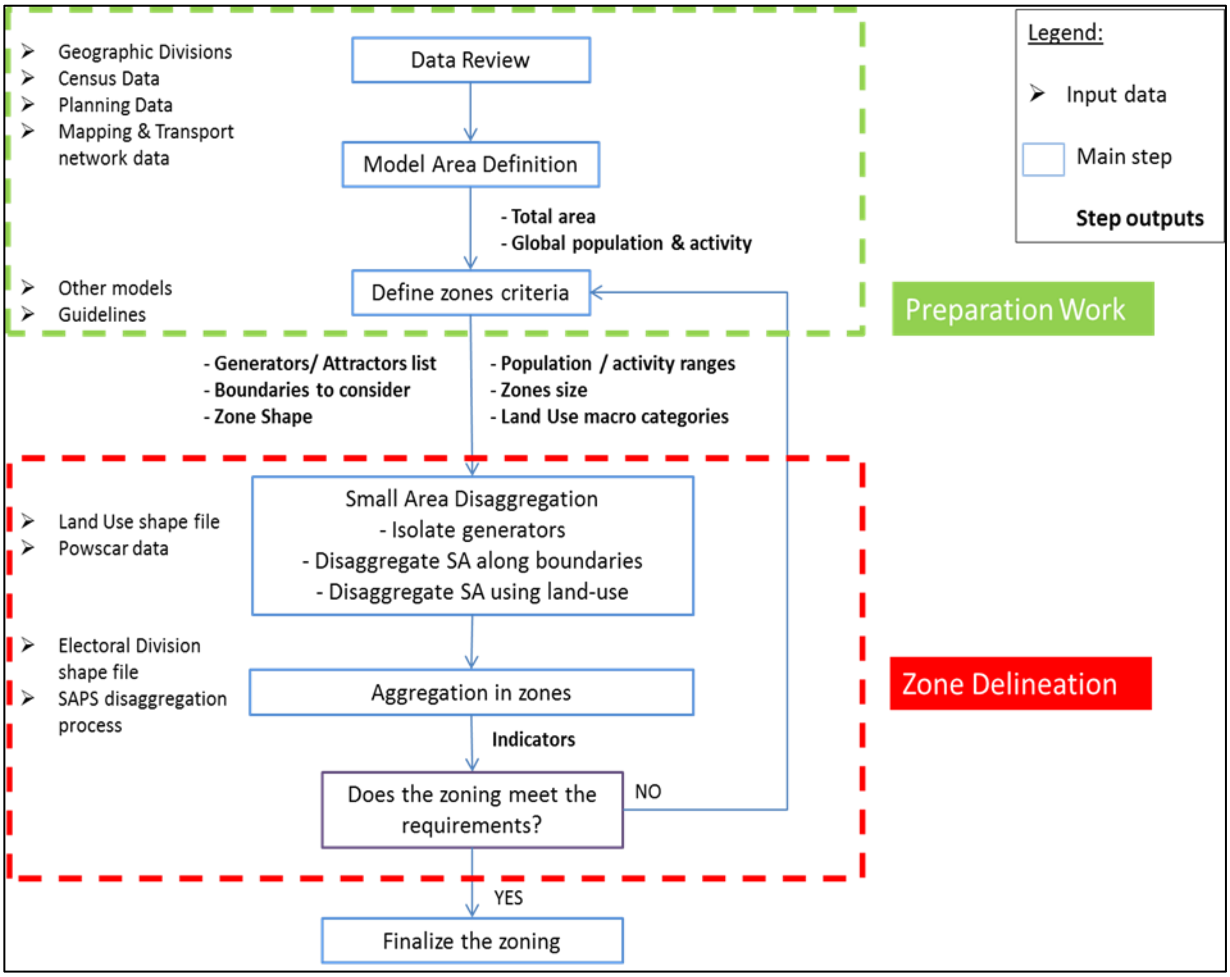

Figure 1.3 Overview of Zone Delineation Process

1.5 Consistent Modelling Methodologies

Zone development is a task common to all NTA regional transport models. To capitalise on the work done for the Eastern Regional Model (ERM) and keep consistency, this note presents a process for delineating model zones to be used across the development of all regional models.

Model zone development is influenced by a variety of considerations and inevitably a compromise has to be reached between the requirement for detailed representation of travel demand and the limitations presented by computer processing power and data availability and quality. On the one hand it is desirable to have small and detailed zones as these are likely to produce the most accurate representations of travel patterns and routeings, on the other hand the level of detail is often limited by the availability of data.

This note aims to define criteria for delineating transport model zones that will result in a zoning system that is commensurate with the requirements of the NTA regional models. As each transport model scale is different, the criteria and thresholds used in zone delineation will vary depending on regional characteristics. For example, population and job densities vary from one area to another, and therefore the admissible range of trips going from/to a zone has to be adapted so that the model area is represented by a suitable number of zones. The question of what a suitable number of zones is complex with a number of contributing factors such as travel data quantity and quality, model run time and network detail requirements.

Recommendations are also provided on the most appropriate data and software to be used in zone delineation for regional modelling.

The methodology presented is illustrated with worked examples from the delineation of ERM model zones.

This note also provides a methodology for disaggregating data below the CSA level, and should be used when developing the zoning systems for each of the regional models.

1.6 Contents of this Note

This note divides broadly into preparation work, and then the core zone delineation process, consisting of the following chapters:

- Chapter 2 RMS Criteria for Zone Delineation;
- Chapter 3 RMS Zone Development Preparation;
- Chapter 4 RMS Zone Delineation; and
- Chapter 5 Definition of Population & Employment at Sub-SA level

Firstly, Chapter 2 outlines a set of criteria that should be utilised in the zone delineation process.

Then, Chapter 3 illustrates the steps involved in preparation for completing the zone delineation process. These steps include the review of available data, the method for defining the model area and the definition of delineation criteria thresholds.

Following this preparation work, Chapter 4 describes the delineation process, consisting of two main steps. The first step is to split Small Areas (SA) that attract/generate large number of trips, taking account of physical boundaries. The second step involves aggregating these new areas to make zones that meet the specified criteria.

The last chapter sets out the methodology used to apportion data such as population, or trips destination, at a sub-SA level, using available data. This process is used to define zonal data.

2 RMS Criteria for Zone Delineation

2.1 Introduction

The following section sets out a set of common criteria that should be utilised for defining zone boundaries for each of the NTA regional models in line with local conditions. Zone delineation aims to create homogenous zones which exhibit internal consistency, and are compatible with the network. So for example, the number of different land use types will be limited within each zone, as different land uses are likely to exhibit differing trip characteristics.

The main criteria to be used in defining zone boundaries are as follows:

- Political geography (correspondence with Electoral Divisions);
- Population;
- Activity Levels;
- Land use;
- Special Generators / Attractor;
- Zone Size;
- Zone shape;
- Physical Barriers; and
- Intra-zonal Trips.

Decisions taken on model zones will be based on defined criteria thresholds (see Section 3.4). It will not be possible to build a zone system that meets all of the criteria, but where this is the case, justification should be provided for the choices made.

2.2 Political geography (correspondence with Electoral Divisions)

In order to allow backward comparison with previous models and censuses, it should be possible to aggregate zones to the ED level. In other words, zone boundaries should not intersect ED boundaries.

2.3 Population

Zone population is used as a criterion for disaggregating zones, as trip making is closely correlated to this variable. The criteria should specify a maximum value and this process should lead to a matrix which displays a flatter profile across zones.

2.4 Activity Levels

The activity criterion is employed to ensure that zones load and unload comparable levels of trip making onto the network. Zones with very low activity levels will increase model run times without necessarily providing any benefit to the model representation, whereas zones with a very high activity level run the risk of overloading the network in certain locations leading to excessive congestion, and the risk of model convergence problems.

Activity levels are calculated from POWSCAR data and are the sum of the origin and destination trips in the morning peak period. POWSCAR data is also used to locate and estimate jobs and education at the small area level and then at the zone level.

2.5 Land use

Zones should be disaggregated to create areas of unique land use types wherever possible. Homogenous land use and socio-economic characteristics will allow us to isolate different trip making activities into different zones.

My Plan data should be used for this stage of delineation. The My Plan dataset summarises land use, using the following macro-categories:

- Green spaces – Agriculture;
- Residential;
- Office – Commercial;
- Education – Health;
- Industry;
- Development Area;
- Tourism – Infrastructure; and
- Airport / Port.

Following discussions with the NTA, four of these land use types have been deemed “disparate”, which means they exhibit significant variations in trip making characteristics and measures should be taken to avoid including more than 1 of these land use types in the same zone. The incompatible land use types are:

- Residential;
- Industry;
- Office/Commercial; and
- Education/Health.

Zones should be split so that they do not contain more than one land use from this list. The list is intentionally concise and focuses on land uses that produce very different trip characteristics. If every separate land use was split into an area, the number of areas would soon become unmanageable, and would be impossible to group into zones. More details on applying the land use criterion are available in Section 4.2, as part of the Small Area disaggregation process.

2.6 Special Generators / Attractor

Large generators of traffic from the list of land use types below will be disaggregated into separate zones:

- Airports / Ports;
- Universities;
- Hospitals;
- shopping centres;
- large employers;
- tourist attractions; and
- industrial estates;

This separation allows these zones to be treated in a different way within the demand model. The identification of these 'Major generators' follows a two stage process. Firstly, known generators such as schools, hospitals and shopping centres are mapped. POWSCAR data is then used to identify any other major generators which are not picked up in the first stage. This involves looking for small areas which have a large number of destination trips in the morning peak. If these cannot be linked to a known major generator then they are identified and added to the list.

Major generators are then isolated in an individual zone to accurately represent their particular traffic patterns. Places to be considered as a generator/attractor are identified based on empirical evidence from the data available.

2.7 Zone Size

Zones that cover a large geographic area can lead to problems in accurately representing route choice due to limitations in the number of locations where the zone should be connected to the network. For example, in a zone which contains 3 or 4 small villages, it can be difficult to decide the best location for the zone connector(s). The issue of large zones is likely to be particularly problematic in areas where count or journey time data is being used to validate the model, or where they are in close proximity to the scheme being tested, with the issue being amplified if there is a dense road network within the zone. Further to this, larger zones will lead to complications in estimating the walk time to PT, and require detailed analysis of where the population centroid should be. It is recommended that in order to avoid long walk access legs to PT services, zone centroids should be no more than 2km from the zone boundary.

2.8 Zone shape

Irregular shaped zones can lead to an unrealistic 'overloading' of trips onto certain parts of the network. This can either be caused by the use of only a single centroid connector where in reality trips would access / egress from the network in many locations, or a zone being coded with multiple centroid connectors but assignment traffic only using one of these connections (often the connector with the shortest length, or the one closest to popular origins and destinations).

Particular attention should be given to zones where multiple zone connectors would be needed to accurately model traffic movements. In these circumstances consideration should be given to disaggregating zones so they can be represented with a single connector. Having zones connected to the network at as few locations as possible is also likely to lead to improved model convergence.

2.9 Intra-zonal Trips

A large zone, or zone with a significant mix of residential and employment land use, can produce a large number of intra-zonal trips which will not be assigned to the network and therefore, can lead to an underestimation of flow, congestion and delay on the network.

This indicator is calculated using POWSCAR data as the ratio of intra-zonal trips over the sum of trips attracted and produced by the zone. A threshold (5% as a rule of thumb) is then applied to determine the proportion of intra-zonal trips allowed within each zone.

2.10 Physical Barriers

Infrastructure and natural features which present a barrier to movement should be considered alongside the zone plan. Major transport facilities such as motorways, railways or canals and physical geography features such as steep slopes and wetlands shouldn’t cross any model zone, and instead should be used to form the boundaries of zones.

3 RMS Zone Development Preparation

3.1 Overview

As outlined previously in Section 1.4 (and Figure 1.3), the overall zone delineation process, at a high level, contains two main steps, namely:

- Preparation Work; and
- Zone Delineation.

The preparation work for the delineation process consists of 3 main steps:

- Data Review;
- Model Area Definition; and
- Criteria Definition.

The following section outlines these three processes, including a review of the data that should be utilised in zone delineation, the methodology of defining the model area based on available data/defined objectives and the definition of criteria thresholds.

3.2 Data Review

3.2.1 Introduction

In order to produce an accurate representation of demand, the definition of the model zone system should take into consideration a variety of data sources. Data ranges from mapping, which is used to identify physical boundaries, to Census data, which will directly feed into the creation of base year demand matrices, to planning data, covering existing land use and future development, which needs to be considered in the base year to facilitate testing of future year scenarios.

The data described in the following section include:

- Geographic Divisions (Census boundaries)
  - Electoral Divisions (EDs)
  - Small Areas (SAs)
- Census data
  - Place of Work and School Census of Anonymised Records (POWSCAR);
  - Small Area Population Statistics (SAPS);
- Planning data
  - Geodirectory[1];
  - MyPlan[2];
  - Land use data
- Mapping and transport network data

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[1] geo located addresses across Ireland – maintained by An Post - www.geodirectory.ie
[2] local plan information in Ireland - Department of Environment, Community and Local government - www.myplan.ie

- Model road and public transport networks
- GIS mapping

3.2.2 Geographic Divisions

Census statistics are presented at a range of spatial levels by the Central Statistics Office (CSO – www.cso.ie). This section explains the two main levels of geographical information utilised in the zone delineation process.

Electoral Divisions (EDs)

Electoral Divisions are a territorial division of Ireland into 3,440 areas. CSO defines an ED as the "smallest legally defined administrative areas in the State for which Small Area Population Statistics (SAPS) are published from the Census". As population will be a critical input into the demand model, it is important to be able to map model zones to EDs.

Year of data: 2011

Quality of data: Excellent

Completeness: All Small Areas are linked to an Electoral Division

Coverage: Republic of Ireland

Small Areas

The CSO divided the Republic of Ireland into approximately 18,500 Small Areas (SA) for the 2011 Census. Each SA contains an average 80 to 100 households which are used as the reporting areas for national datasets such as POWSCAR. SAs are sub-divisions of EDs, which means that an ED might contain several SAs, however a SA cannot span more than one ED. Figure 3.1 shows SAs in Dublin City.

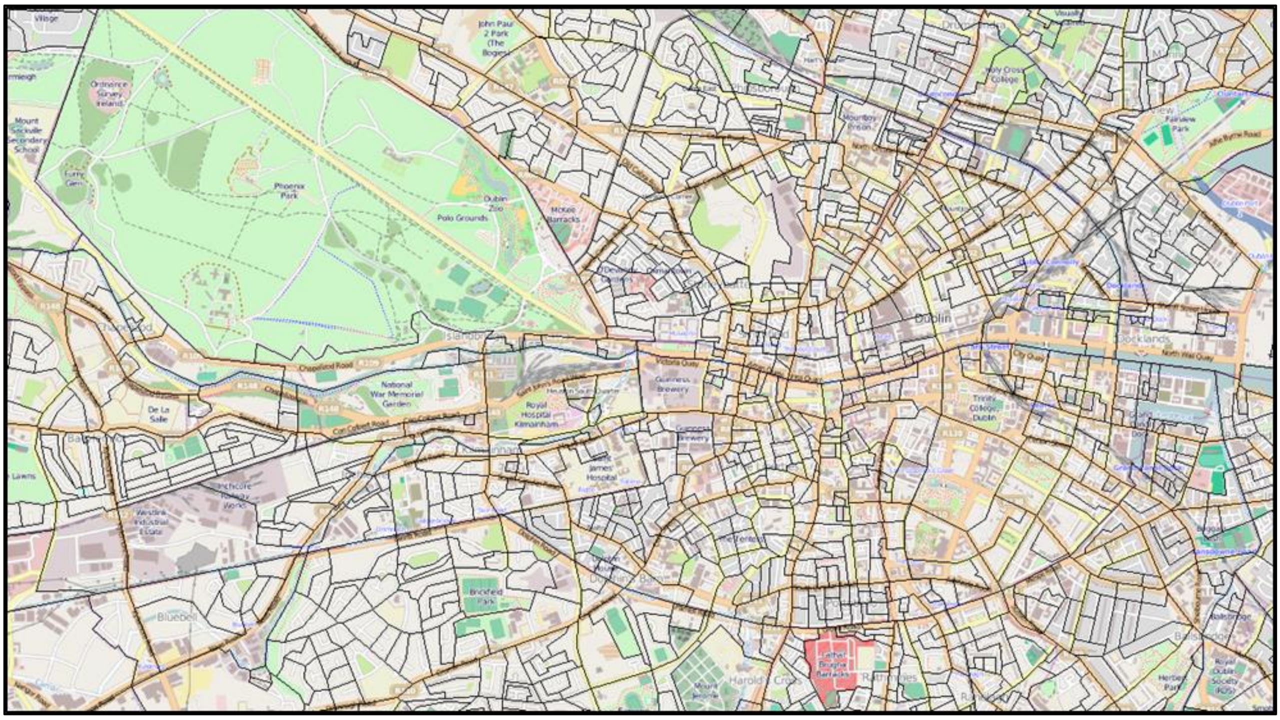


Figure 3.1 Small Areas in Dublin City - 2011

Year of data: 2011

Quality of data: Excellent

Completeness:

Coverage: Republic of Ireland

A lot of socio economic information is available at the Small Area level (demographic data, POWSCAR), provided by CSO. Population data will be used in the zoning delineation.

3.2.3 Census Data

POWSCAR

POWSCAR is travel pattern census data for work and education journeys which has been geocoded to small area level. The data will be used in the demand model to determine total travel levels for these journey purposes to and from zones. It is a good indicator of traffic at a Small Area level, even if it only includes work and education trips, and it will be used to calculate the activity level of the zones.

In addition, the POWSCAR data is also available at 250 metre grid level. This divides the country into 250m x 250m squares, with the destination end (workplace, school or college) of each trip rounded to the centre of the destination POWSCAR square. In areas where SAs cover larger areas (sparsely populated areas), the POWSCAR grid data could provide more detail. Figure 3.2 below illustrates the POWSCAR data grid for Dublin City North, with a colour analysis on the number of trips attracted.

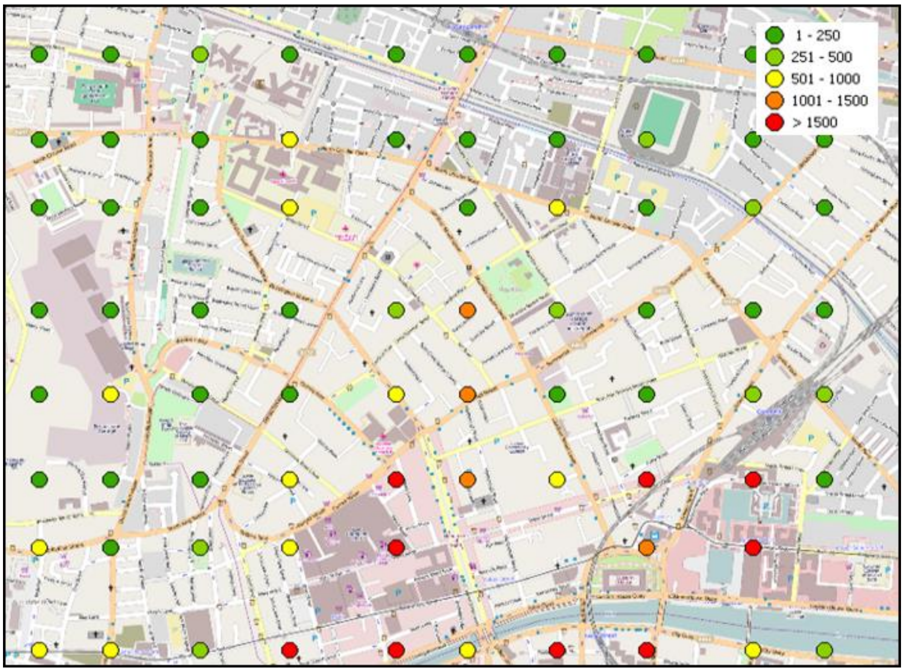


Figure 3.2 POWSCAR Grid – Number of trips attraction – Dublin city north

Quality of data: Good (92% of trips records have an Origin & a Destination coded)

Completeness: Only home to work and school trips

Accuracy: SA level & 250m grid

Coverage: Republic of Ireland

3.2.4 Planning Data

My Plan

My Plan is a public information system containing land use data for each area's Development Plan or Local Area Plan. This data is provided by the Department of the Environment, Community and Local Government in association with the 88 planning authorities across the country (www.myplan.ie).

The database contains data relating to existing land use types in urban areas. This information will be used to make more homogenous zones in terms of land use. The aim will be to limit land use types in each zone to those which exhibit similar trip making patterns. Figure 3.3 below represents the extension of My Plan data around Galway city.

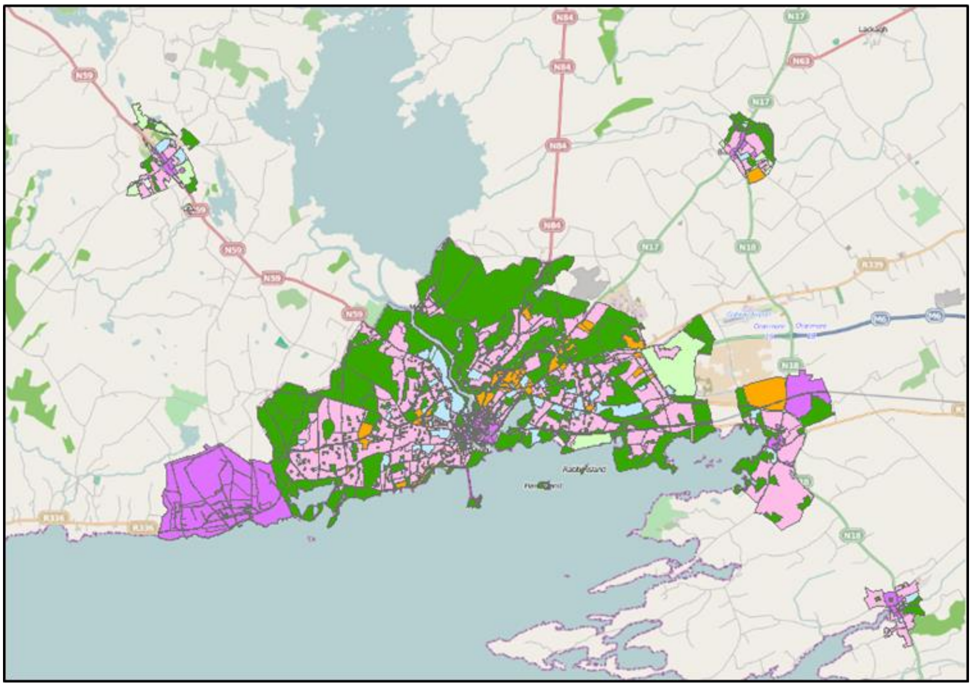


Figure 3.3 My Plan data for Galway

Quality of data: Different interpretation of nomenclature

Completeness: Covers urban areas

Positional Accuracy: OK

Coverage: Cities and major towns

Geo Directory

Geo Directory compiles addresses across Ireland, with postal information and geographic coordinates (www.geodirectory.ie). Each address is categorised as either residential or commercial, with different addresses in the same building included. However, no information on the size of locations is available. This database is developed by An Post and is not on public access.

A GIS file can be built from Geo Directory using coordinates, representing each building and the type of address. An example is shown in Figure 3.4, below.

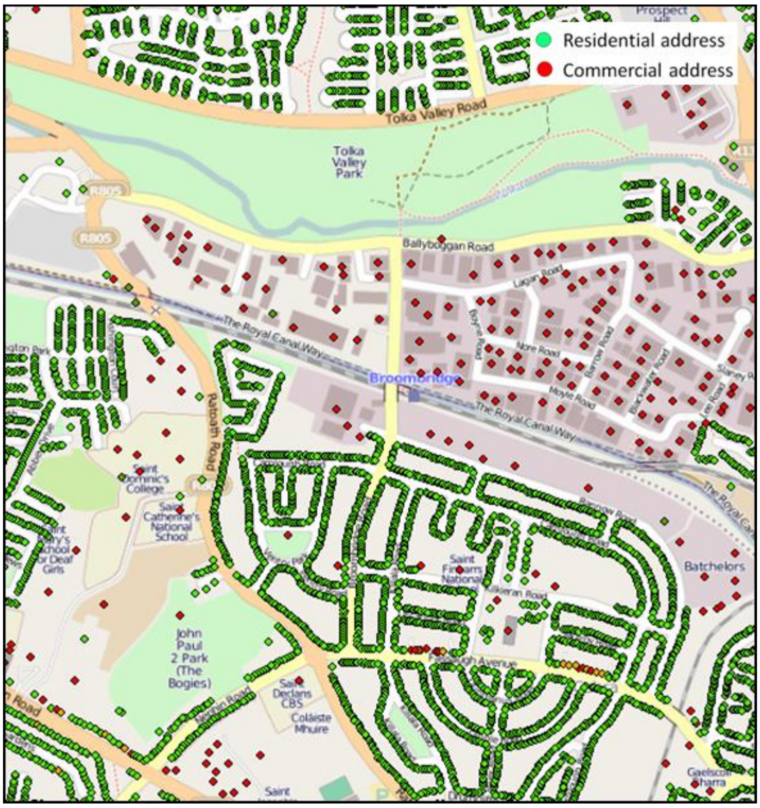


Figure 3.4 Geo Directory shape file – Broombridge area

Quality of data: Good

Completeness: Residential & Commercial addresses

Positional Accuracy:

Coverage: Republic of Ireland

Planning information / Spatial Strategies

Any information contained in planning strategies, or other policy documents, could be useful in determining the final zone system. Documents such as Development Plans, and Local Area Plans, should be reviewed to identify locations of development. For example, areas of predicted population growth are also likely to see a corresponding increase in trips and, in some cases, it might be appropriate to include zones to represent these developments. Such areas (land banks) should be zonally subdivided based on the probable zoned population density.

3.2.5 Mapping

Infrastructure and natural features

Mapping which includes transport and natural features should be used to locate physical boundaries which present a barrier to movement, and might be represented in the model with a zone boundary, e.g. rivers, valleys or motorways.

The density of the transport network should also be considered, zones with a denser network may require delineation in order to more accurately model route choice. Equally, in areas of sparse network model zones can be larger.

3.2.6 Software requirement

Most of the zone delineation work is done on ArcGIS and Excel. ArcGIS is used to spatially join data and cut Small Areas, while Excel is used to analyse data.

3.3 Model Area Definition

3.3.1 Purpose of the step

The definition of the model area is the initial stage of the zone delineation process. It will determine the other steps by giving boundaries to the modelled area. In the majority of cases the model will be broadly defined to meet the project objectives. For example, a model is being built to cover the Greater Dublin Area, or a model is being built to assess a particular transport scheme. This broad definition is then fine-tuned through analysis driven by model purpose and data availability.

In the case of NTA regional models, it is recognised that the models must cover an area in line with the NTA's model specification. However, important decisions relating to the network, zone density and the extent of the fully modelled area, and external area, must still be taken.

3.3.2 Principle

Before attempting to design a representative zone system, it is important to have a good understanding of the model purpose and what it is going to be required to test. These considerations are used in defining the model boundaries which in turn will be used to inform the zoning.

Fully Modelled Area

The fully modelled area is in turn made up of:

- an area of detailed modelling (simulation area); and
- the rest of the fully modelled area (in most cases coded as buffer network)

The area of detailed modelling is characterised by a representation of all trip movements; small zones; very detailed networks; and junction modelling (including flow metering and blocking back).

The rest of the fully modelled area is the area over which the impacts of interventions are considered to be quite likely but relatively weak in magnitude. It would be characterised by: representation of all trip movements; somewhat larger zones and less network detail than for the area of detailed modelling; and speed/flow modelling (primarily link-based but possibly also including a representation of strategically important junctions).

External Area

In this area, impacts of interventions would be so small as to be reasonably assumed to be negligible. It would be characterised by: a network representing a large proportion of the rest of the country, a partial representation of demand (trips to, from and across the fully modelled area); large zones; skeletal networks and simple speed/flow relationships or fixed speed modelling.

Although it is recognised that the boundaries of the fully modelled area for each of the regional models are largely defined by the requirements of the NTA, the following attributes will be used to decide the extent of the simulation network and zone density:

- Population and activity density;
- Previous model area (if applicable);
- Transport network density and extent;
- Model specification (any schemes or plans which will need to be tested with the model); and
- Data availability (data used in calibration / validation, land use information etc.).

This information can be mapped using GIS and detailed model boundaries drawn up.

3.3.3 Process

The process uses a standard GIS package such as ArcGIS or MapInfo. Starting from a Small Area shape file, a field “Model_area” is added to differentiate Small Areas within the simulation area, the buffer network and the external network.

3.4 Criteria definition

3.4.1 Overview

Chapter 3 above outlines a set of criteria that should be utilised when defining zone boundaries. Prior to the delineation process, a set of threshold values should be applied to each set of criteria that reflect local characteristics. It should be noted that it may not possible in all cases for the zone boundary definitions to satisfy all threshold values for each criteria. As such, zone delineation is an iterative process in order to achieve an acceptable balance between the various criteria conditions.

Threshold specification is dependent on data availability, specified model area and specific local area characteristics. Therefore, these threshold values will be different for each NTA Regional Transport Model.

3.4.2 Criteria Threshold Examples

Some typical examples of threshold values and their method of calculation, taken from development of the ERM, are described in the following section to provide information, and guidance, on specifying criteria thresholds:

- **Population:** No minimum value is defined for population because some zones are employment only (e.g. industrial estate) and contain no resident population. The maximum value for population is driven by the maximum number of trips able to load on a single point on the network, as population and trips generation are correlated. A maximum population of 3,000 have been considered for the ERM zoning.

- **POWSCAR activity:** To allow comparison between residential zones that mainly produce trips during the AM peak and employment or education places that mainly attract trips, an activity indicator is used as the sum of both trips production and attraction of a zone. A range of admissible activity values is so defined to make zones consistent from a transport modelling point of view. For the ERM, a [500-2,000] activity range (in trips, all POWSCAR time periods considered) has been used.
- **Intra-Zonal Trips:** Zones with over 5% of total trips that are intra-zonal should be considered for disaggregation.
- **Zone Size:** Zones with an area of over 5km² should be checked in GIS, with consideration given to the network density, location of counts, journey time routes and activity levels.
- **Political Boundaries:** Zone boundaries should not intersect ED boundaries.
- **Physical boundaries:** Major transport facilities such as motorways, railways or canals and physical geography features such as steep slopes and wetlands shouldn't cross any model zone in urban area.

4 RMS Zone Delineation

4.1 Overview

Following the preparation work, outlined in Chapter 3 above, the zone delineation process is carried out in two steps:

- **Small Area Disaggregation** - involves splitting Small Areas that attract large number of trips or crossed by a major physical boundaries or contain inhomogeneous land uses; and
- **Aggregation** - involves aggregating Small Areas and sub Small Areas created by the previous step to make zones that meet specified criteria.

4.2 Small Area disaggregation

4.2.1 Introduction

The process involves disaggregating SAs based on identified special generators/attractors (defined in the criteria definition process), while incorporating criteria on physical boundaries and incompatible land uses. The work is completed in the Small Area shape file. A field "Sub_SA" is added to the file to flag Small Areas that have been disaggregated. This will be useful when it comes to allocate Small Area data (e.g. population, trip destination) amongst the Sub-Small Area TAZs.

4.2.2 Isolate special generators/attractors

A field "Generator" should be added to the Small Area shape file to flag generators/attractors. For each special generator/attractor identified in the criteria definition step, the user should locate it in the Small Area shape file and do the following:

- If the Small Area contains only a generator, then the "Generator" field should be amended in the shape file with a "1" flag and the small area identifier added to the generators/attractors list defined previously.
- If the Small Area contains other land use types, it should be disaggregated to isolate the generator. In the example below, a Small Area has been split to isolate a hospital "Generator".

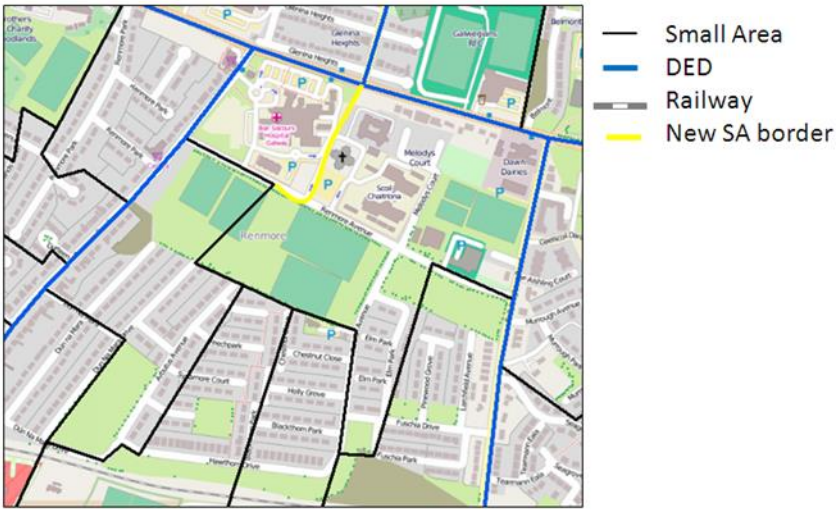


Figure 4.1 Example of small area disaggregation to isolate a generator/attractor

4.2.3 Disaggregation along boundaries

Physical boundaries constrain people's movement and shouldn't cross any zones as they represent a barrier to movement in the real world.

The user should consider the list of boundaries defined in the criteria definition step when processing the Small Area shape file. Each time a Small Area is crossed by a boundary, it has to be disaggregated along this boundary. This is illustrated in the example in Figure 4.2 below: the railway line acts as a barrier to movement through several Small Areas, therefore these Small Areas should be disaggregated along this line (dashed yellow line on the map).

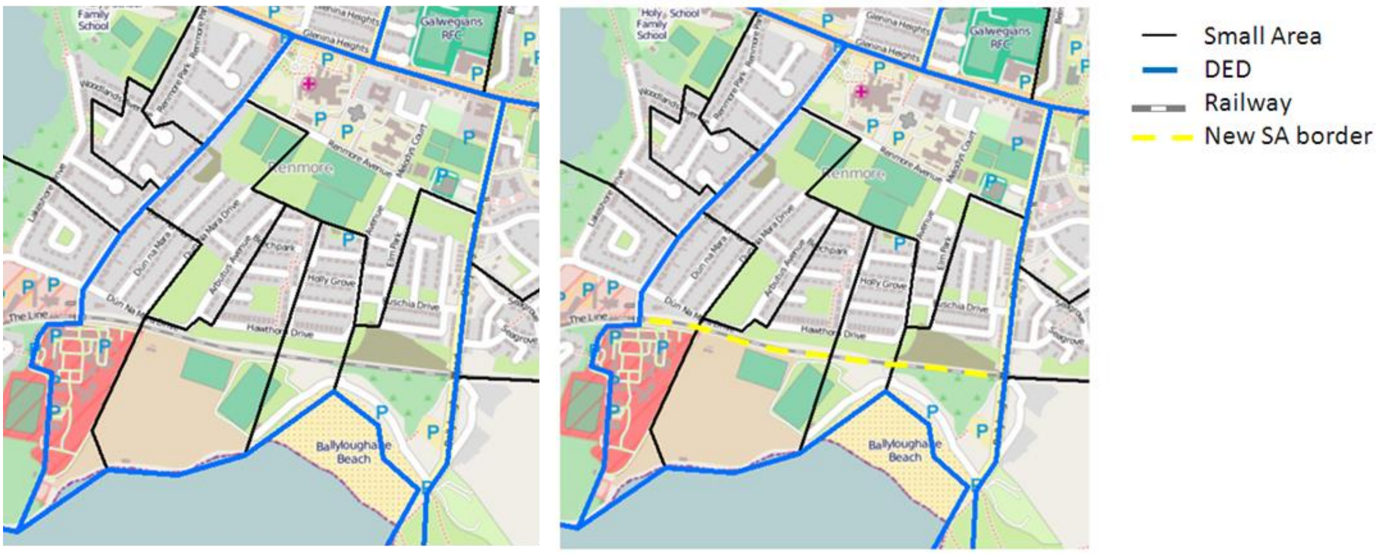


Figure 4.2 Example of Small Areas disaggregation along a physical boundary (railway)

When applying these divisions, thought should be given to the size and accessibility of the new zones created. Figure 4.3 below, illustrates an example where using a railway as a zone boundary would not be sensible as it would leave small pockets of land between the railway and DED boundary. These pockets contain no generators of trips, and so, can remain as part of the Small Area.

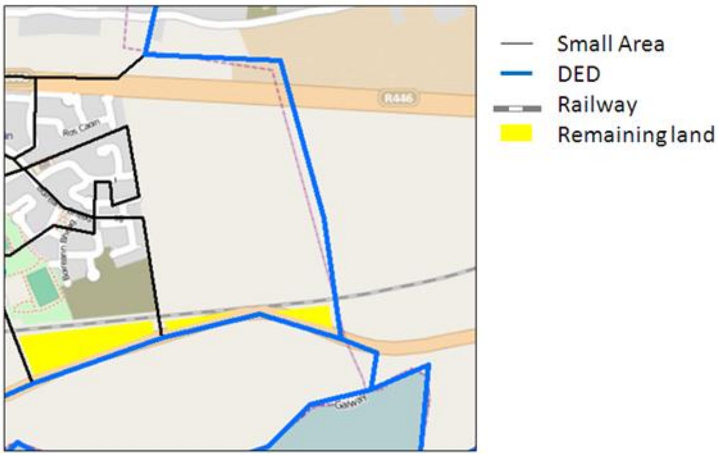


Figure 4.3 Example of a SA where disaggregation along physical boundary is not possible

4.2.4 Land use disaggregation

Using the eight land use categories that have been defined in 2.5:

- Airport / Port;
- Development area;
- Education / Health;
- Green spaces – Agriculture;
- Industry;
- Office / Commercial;
- Residential; and
- Tourism / Infrastructure

An intersection between the Small Area shape file and My Plan shape file can be made in ArcGIS. The resulting shape file contains both small area and My Plan data. Land use data for each small area is then calculated within the GIS.

By exporting it to Excel, the area ratio of land use categories within each Small Area is then calculated. Small Areas containing at least two disparate categories (area ratio over 15% for each category) are to be identified. (See Section 2.5 above for more details on incompatible land use categories)

Where inhomogeneous land uses have been identified the Small Area needs to be disaggregated. When disaggregating a Small Area, the user should also ensure that the Sub-Small Area can form a proper TAZ during the aggregation phase.

The first example, illustrated in Figure 4.4, is a Small Area containing development land, offices, industrial and green space. As both development and industrial area ratios are above 15%, this Small Area is disaggregated along these lines. Green space and office which fall under the 15% threshold are not split into separate Small Areas but instead are grouped with industry.

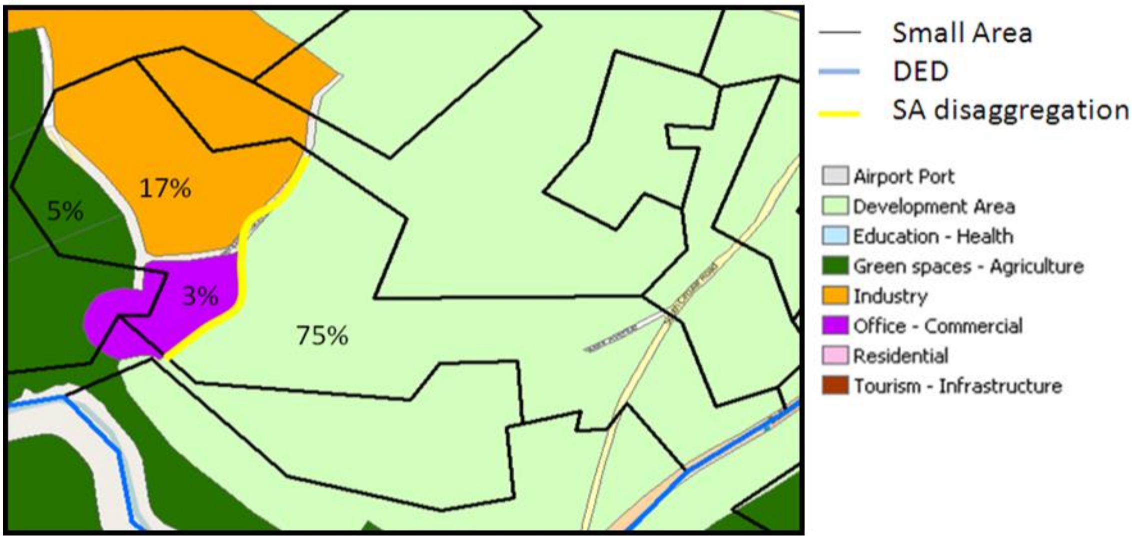


Figure 4.4 1st example: SA with mixed land use suitable for disaggregation

The second example, displayed in Figure 4.5 below, illustrates a Small Area containing residential, green spaces and industry. However because only the residential land use exceeds 15%, the Small Area is not disaggregated further.

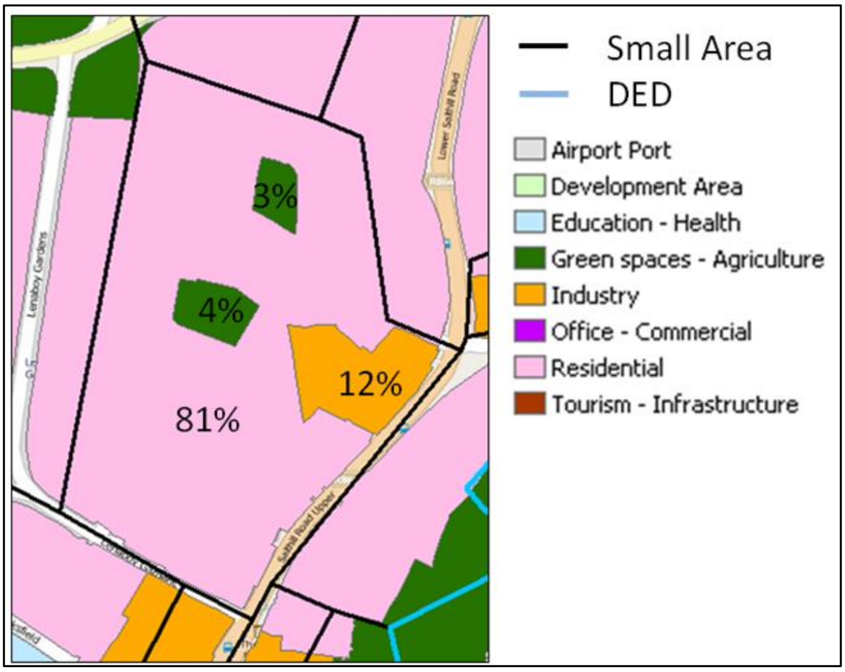


Figure 4.5 2nd example: SA with mixed land use not suitable for disaggregation

4.2.5 Small Area disaggregation conclusion

The Small Area shape file is amended to identify special generators and attractors. Barriers to free movement and areas with inhomogeneous land uses are also identified. The Small Areas are disaggregated based on the criterion described above and are flagged in the field “Sub_SA” in the shape file.

Population and activity should then be calculated for every Small Area and Sub-Small Area using the disaggregation process detailed in Chapter 5.

4.3 Aggregation

4.3.1 Overview

Once land use is split into Sub-Small Areas as detailed above, the process of aggregation to model zones can start. The following section details how to aggregate Small Areas and Sub-Small Areas to meet the defined criteria (see Section 3.4), and create model zones with common attributes. The process involves determining the number of possible zones present in each District Electoral Division (DED) based on defined activity level ranges and maximum population criteria. Once this is known, the aggregation of the Small Areas, and Sub-Small Areas, into these zones are determined based on defined population, land use, physical boundaries and activity level criteria.

4.3.2 Determine number of zones per Electoral Division

This step is undertaken for each ED and its purpose is to define approximately how many new zones will be created in each ED.

A basic requirement for zoning is that a new zone cannot cross an ED; therefore the aggregation process will be based at that level (i.e. no zones from separate EDs will be aggregated).

The first task is to estimate activity levels at the ED level. If there are any generators/attractors in the ED, they have to be considered separately as they are already defined as a proper zone.

By comparing the activity range and maximum population defined in the criteria step, a range for the number of zones that the DED should contain is determined (see Example 1 below).

Example 1

For DED number X with:

Population: 10,000

Origin trips: 4,500

Destination trips: 1,500

Given the criteria for a new zone:

Population maximum: 3,000

Activity range: 500 – 2,000

Gives a range for the number of zones within the DED as follows:

Population criterion: At least 4 zones

Activity criterion: between 3 and 12 zones

ED X should so contain between 4 and 12 zones. This range is calculated to guide the user when it comes to put together Small Areas and sub Small Areas to make actual zones.

4.3.3 Display data

The aggregation process can be completed in ArcGIS. To facilitate the work, population and activity are to be displayed for every small area and sub-small area (see example in Figure 4.6 below).

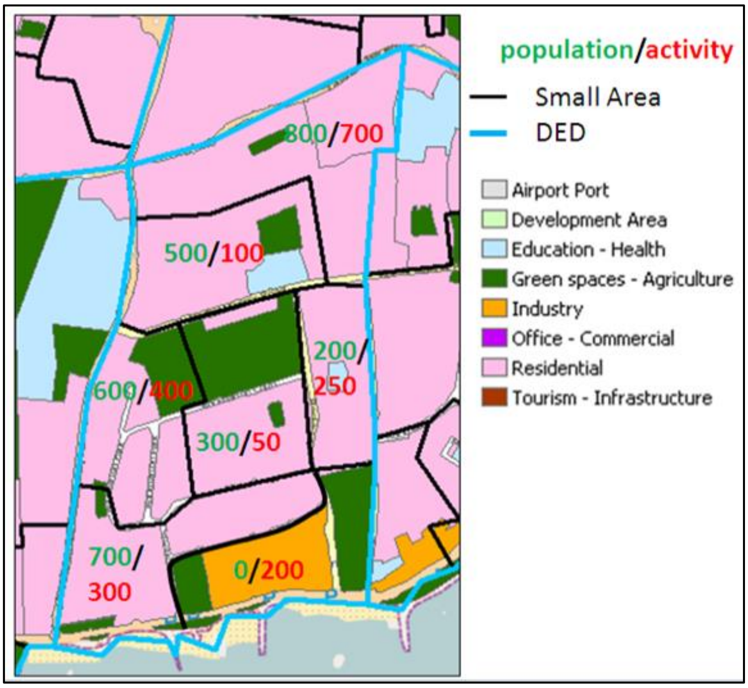


Figure 4.6 Display of Small Area's population and activity within a DED

4.3.4 Aggregation process

Principle

Once the possible number of zones within each DED is defined (using the process described in Section 4.3.2 above), the Small Areas and Sub-Small Areas are aggregated to make zones within each DED that satisfy the following three criteria, in hierarchical order:

1- **Activity Levels** - New Zone activity should be in the defined range.
2- **Land Use** - New Zone should not contain more than 2 inhomogeneous land-use categories (area ratio over 15%)

3- **Population -** New Zone population should be below the defined maximum.

Every zone within an ED should satisfy all three of the selection criteria outlined above. There may be several options that fit the criteria, and in this instance the most balanced and sensible one is to be chosen. If this is not possible, the first criterion (i.e. activity level) is to be put forward and the zone is to be flagged for a client review (using field "Review").

In the small area shape file, a field is created to identify the zone to be associated with each Small Area or Sub-Small Area. As the zone delineation process is built through several iterations, a field "Zone_v*(iteration number)*" is thus created to keep tracks of the changes.

A field "Review" is also created to identify locations where choices have to be made, and so, facilitate agreement on those choices. This simply provides an easy way to find cases for review later on.

Example 2

An example illustrating the process of determining the appropriate layout of aggregated zones within DEDs is detailed below, using the same activity level and population criteria as Example 1 above, i.e.:

Population maximum: 3,000

Activity range: 500 – 2,000

The ED population is 3,100 and activity is 2,000. The possible number of zones will therefore be between 2 and 4 (using the process described in Section 5.3.2 above)

Option 1 is made of 2 zones:

Zone 1: Population: 1,300 / Activity: 800

Zone 2: Population: 1,800 / Activity: 1,200

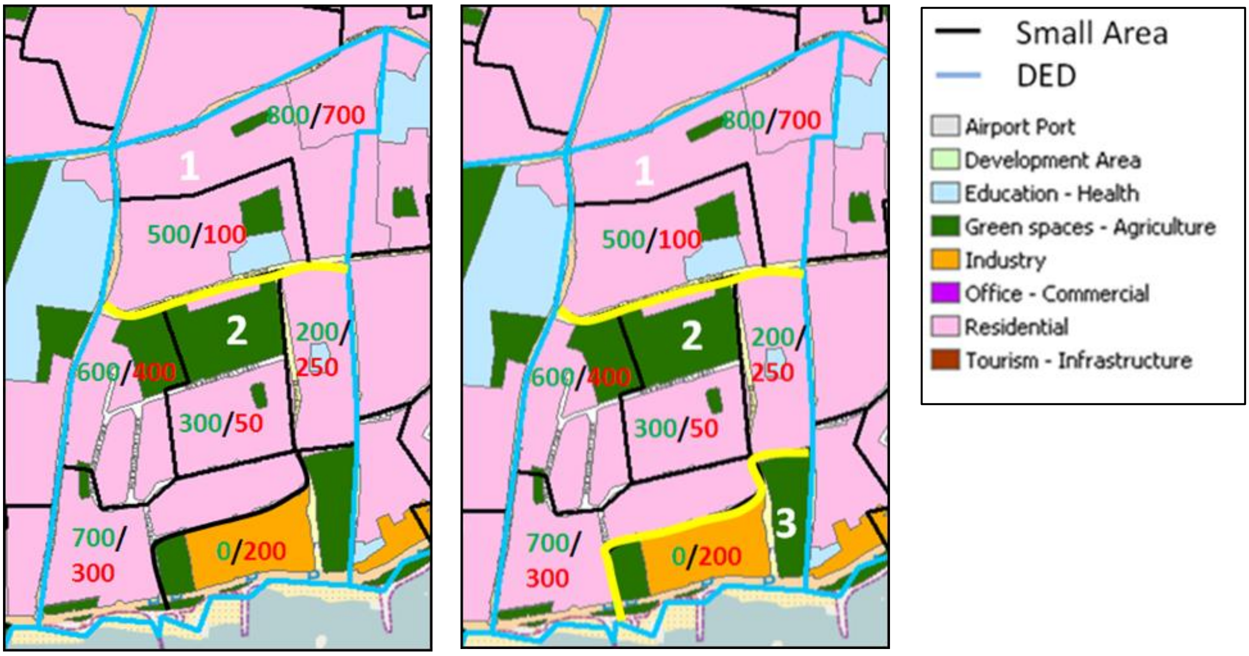
It meets criteria 1 & 3 but not criterion 2, as industry is mixed with residential in the same zone;

Option 2 is made of 3 zones:

Zone 1: Population: 1,300 / Activity: 800

Zone 2: Population: 1,800 / Activity: 1,000

Zone 3: Population: 0 / Activity: 200



Option 1 Option 2

Figure 4.7 Option 1 and Option 2

It meets criteria 2 & 3 but not criterion 1, as zone 3 has an activity below 500.

Option 1 is to be chosen, rather than option 2, as it meets criterion 1 in the hierarchical order (i.e. Activity Level) but this zone has to be flagged for a review and agreement by the client.

If zone 3, in Option 2, contained an activity level above 500, then it would be the preferred option as it meets all the criteria, and would be carried forward as the defined model zones.

5 Definition of Population & Employment at Sub-SA level

5.1 Introduction

As mentioned previously, the zoning development process is initially based on Census Small Areas (CSA). However, those shapes' boundaries don't necessarily follow major transport arteries such as motorways, railways or canals which are a barrier for person trips. In addition, different types of land use (residential, commercial, agriculture, industry) could be in the same SA, which may deteriorate forecasting accuracy.

Section 4.2 above outlines the approach to the disaggregation of those SA, to build more homogeneous zones that respect physical geography and land uses. Therefore, statistical data available at the SA level (e.g. population, POWSCAR information) need to be shared between the Sub-Small Areas created.

The purpose of this chapter is to detail a methodology for the SA disaggregation, using available data outlined in Section 3.2 to allow sharing of SA statistical data. Two distinct data apportion processes are considered, one for population (linked to trip origins in the AM) and one for trips attraction (linked to employment or education activities).

5.2 Population Disaggregation

5.2.1 Methodology

The following two population disaggregation methodologies have been developed using Geo Directory and My Plan data presented in Section 3.2.4 previously:

- **Method P1:** Disaggregation based on Geo Directory, residential addresses only. For each sub-SA, residential addresses are counted. Population is to be shared based on the proportion of overall SA residential houses located in each sub-SA. A homogenous occupancy of housing is assumed; and
- **Method P2:** Disaggregation based on My Plan land use, residential areas. For each sub-SA, Residential areas are to be calculated. Population is to be shared based on the proportion of overall SA residential area located in each sub-SA.

Population in sub SAs using both methodologies P1 and P2 above are calculated. The results for each method should be similar, and where there are large discrepancies, these SAs should be manually investigated.

The Geo Directory provides a database of actual locations of residential and commercial properties across Ireland. Therefore, Method P1 above is the preferred option in disaggregating population, as it is most representative of actual settlement patterns. If Geo Directory data is missing (no addresses registered), Method P2 should be used instead, as it provides plausible results.

5.2.2 Population Disaggregation Example

SA 267001009, taken from the ERM, is used to illustrate the two methodologies outlined above for disaggregating population between sub-SAs. This SA has been split in three, to isolate the airport (3), and to follow the M50 physical boundary (1) & (2) (see Figure 5.1 below).

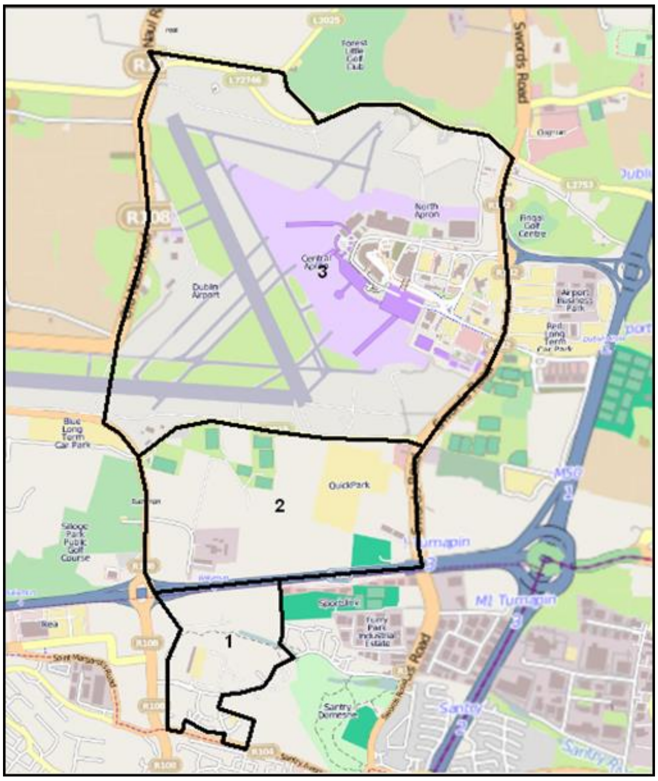
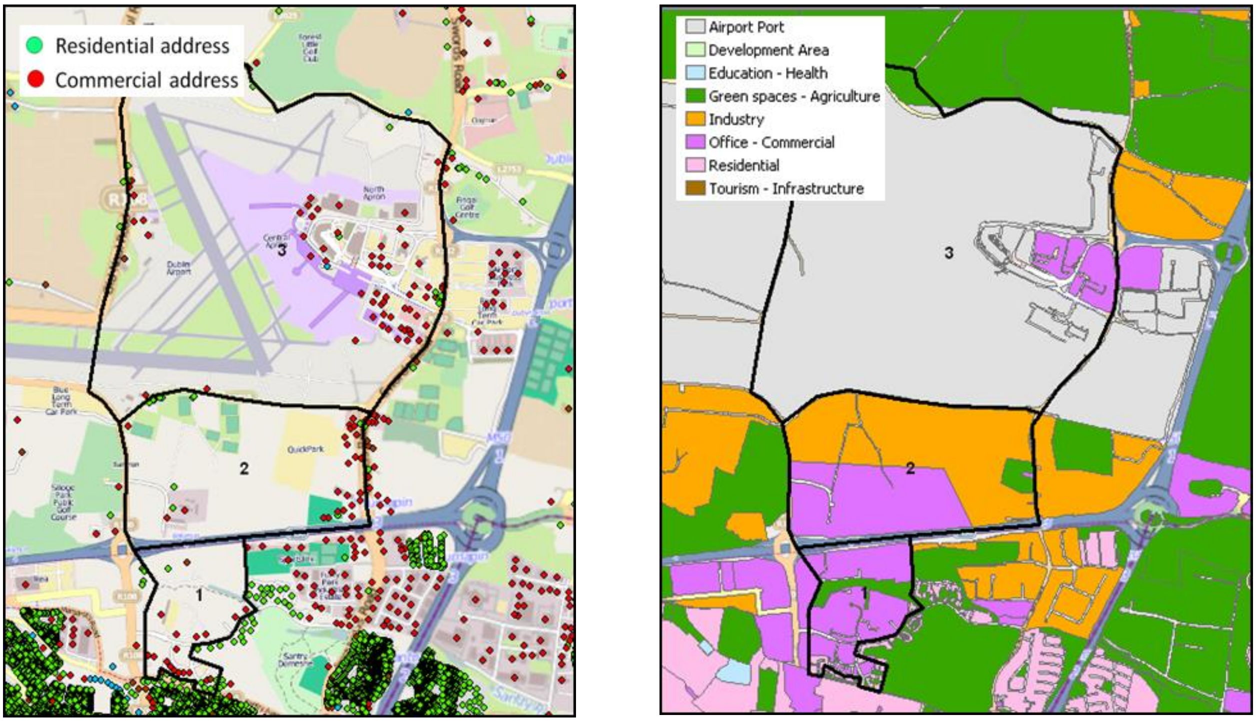
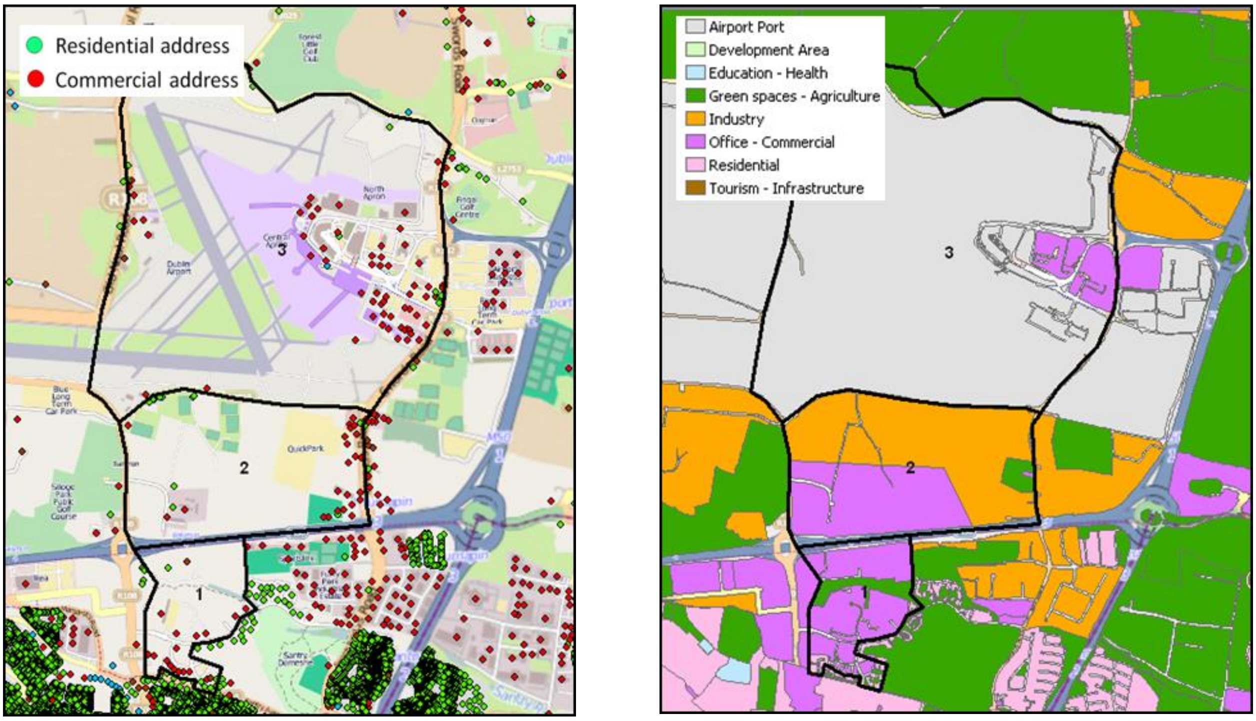


Figure 5.1 SA 267001009 – Airport area



A B

Figure 5.2 below illustrates the Geo Directory & My Plan shape file for the area. From analysing the datasets, 144 residential addresses have been counted in Geo Directory, and Residential areas in My Plan are only located in sub-SA (1).



A B

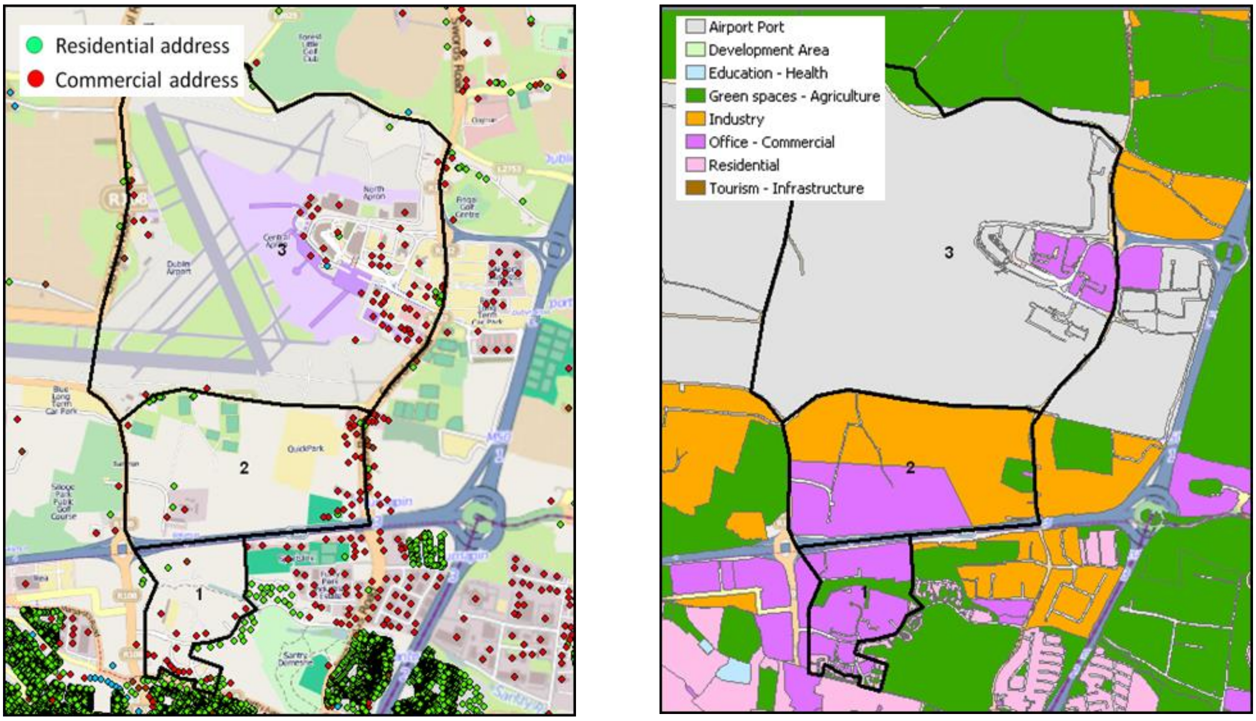
Figure 5.2 SA 267001009 – Geo Directory (A) & My Plan (B)

The results of the population disaggregation using Method P1 and Method P2 are outlined in Table 5.1 below.

Table 5.1 SA 267001009 – Sub-SA ratio and population by methodology

Sub-SA (Ratio)	Method P1	Method P2
1	83%	100%
2	7%	0%
3	10%	0%

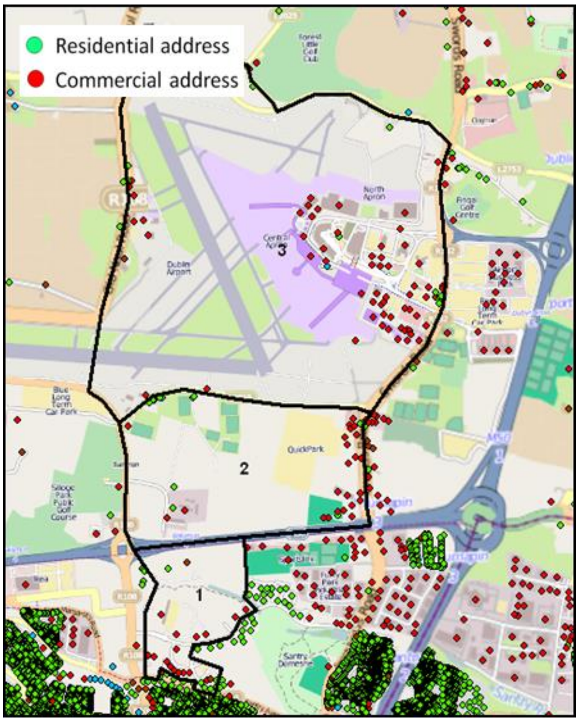
Sub-SA (Population)	Method P1	Method P2
1	867	1,049
2	73	0
3	109	0



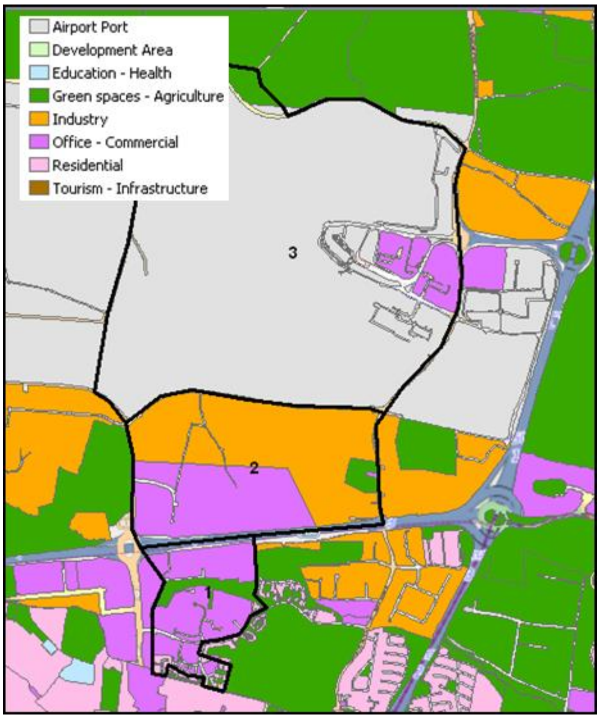
A B

Figure 5.2b above, that Geo Directory residential addresses are located in each of the three sub-SAs, with the majority located in Sub-SA (1). Therefore, Method P1 apportions the majority of the population for SA 267001009 to Sub-SA (1).

As mentioned previously, Method P2 uses the My Plan land use dataset illustrated in



A



B

Figure 5.2b to apportion population data. In this example, residential land use is only located in Sub-SA (1). Therefore, using Method P2, all the population for SA 267001009 is assigned to Sub-SA (1).

5.3 Work Destination Trips Disaggregation

5.3.1 Methodology

The following three methodologies should be used when disaggregating work destination trips to a Sub-SA level:

- **Method W1:** Disaggregation is based on Geo Directory, Commercial addresses only. For each Sub-SA, commercial addresses are to be counted. Destination trips are to be shared on a pro rata basis. This option doesn't take account of density of activity;
- **Method W2:** Disaggregation is based on My Plan land use, considering weighted macro categories, to take account of different employment densities. Coefficients used are given below:
    - Office / commercial (4)
    - Education / Health (4)
    - Industry (2)
    - Port / Airport (1)

  For the purpose of this assessment, these coefficients were extracted from a study on employment densities made by English partnerships in 2001. A similar study led by the "Laboratoire d'Economie des Transports" on the Lyon area (Simbad 2008) provide the following coefficients:

- Office / commercial (6.1)
- Education / Health (3.2)
- Industry (1.3)
- Port / Airport (1)

For each Sub-SA, macro category areas are to be calculated and weighted summed. Destination trips are to be shared between Sub-SAs on a pro rata basis.

- **Method W3:** Disaggregation is based on POWSCAR grid data. POWSCAR grid point work trips located within each Sub-SA are summed. Destination trips are apportioned based on the proportion of work trips within each Sub-SA.

The process of disaggregating work destination trips involves applying the three methodologies described above (W1, W2 & W3) separately. The results calculated using each methodology are compared, and an indicator is derived to identify Small Areas where data is unable to provide a clear way of disaggregating destination trips i.e. where there are significant differences between the results calculated using each method. The indicator is calculated as follows:

$$Indicator_{A,B} = \frac{1}{N_{sub\ SA} \times T} \sum_{i \in sub\ SA} abs(T_{A,i} - T_{B,i}) \quad \textbf{(Equation 1)}$$

Where

$N_{sub\ SA}$ Number of sub-SAs of the SA

T Total SA destination trips

$T_{A,i}$ Destination trips with process **A** (e.g. Method W1) to sub SA **i**

$T_{B,i}$ Destination trips with process **B** (e.g. Method W2) to sub SA **i**

This indicator (0 < Indicator < 1) measures the difference in trips apportioning between two methods. The lower it is, the closer the apportioning results are for the two methods. This indicator is calculated for each potential combination of work trip disaggregation methods i.e. $Indicator_{W1,W2}$, $Indicator_{W1,W3}$ & $Indicator_{W2,W3}$.

Every SA for which at least one of these three indicators is below 10% is validated for automatic apportioning, because two different processes provide close results. All other SAs should be investigated manually using additional data (e.g. Google Maps, Local knowledge) to establish the most accurate method of work trip destination apportionment between Sub-SAs.

5.3.2 Work Destination Trips Disaggregation Example

SA 268036007, taken from the ERM, is used to illustrate the methodology involved in determining the disaggregation of Work Destination Trips to Sub-SA level. This SA has been split for land use purposes, to isolate McKee barracks from the residential estate (See Figure 5.3 below).

The My Plan (a), Geo Directory (b) and POWSCAR (c) data for this SA are illustrated in Figure 5.4A, B and C.

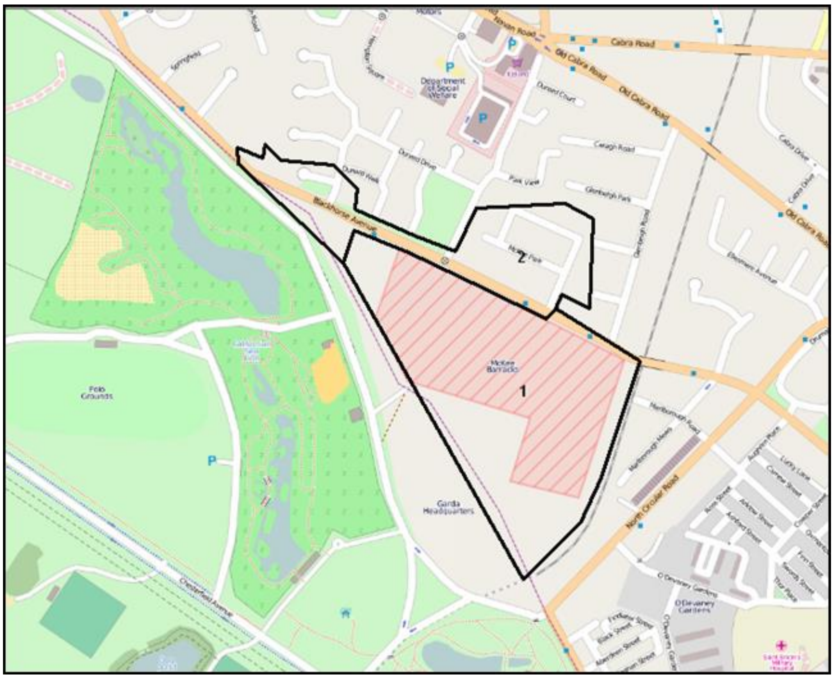
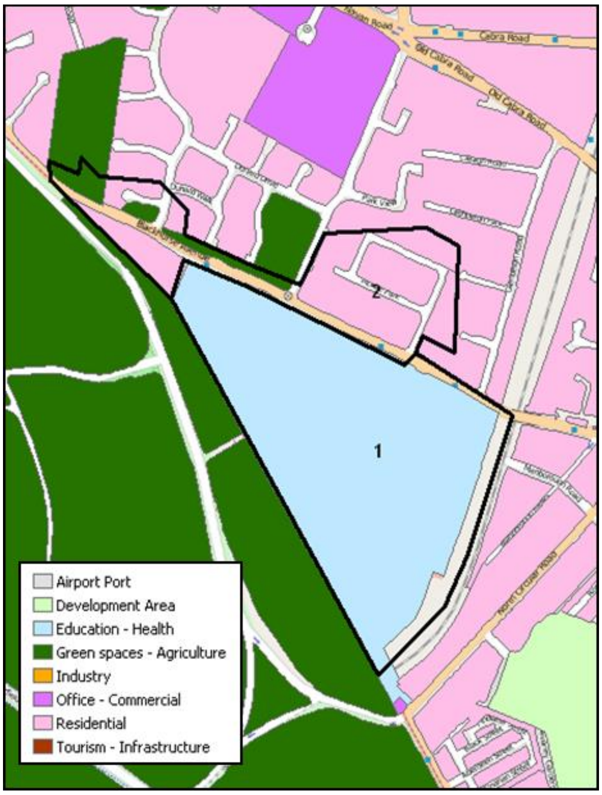
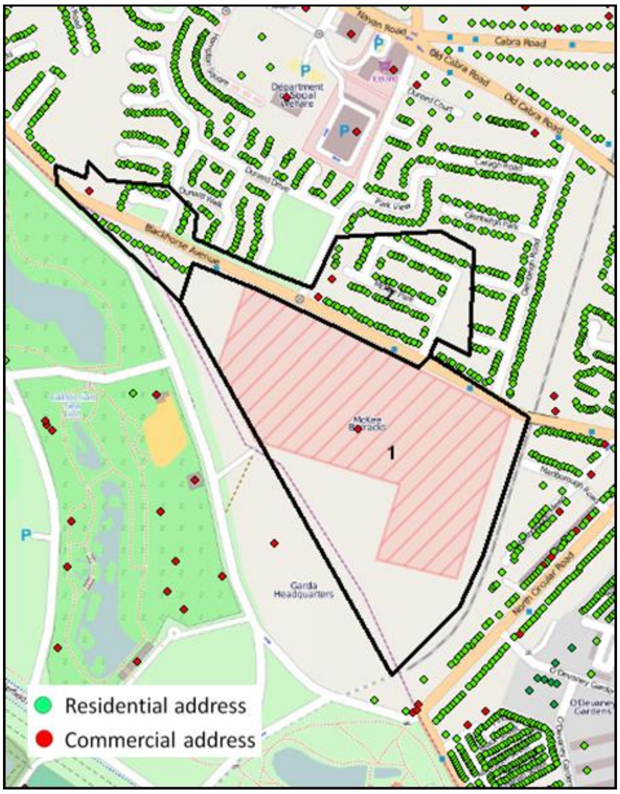


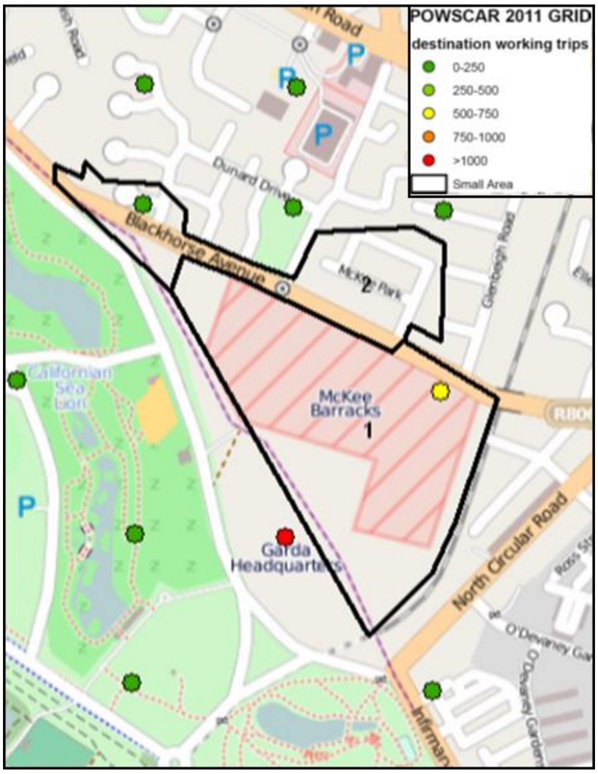
Figure 5.3 SA 268036007 – McKee barracks



A



B



C

Figure 5.4 SA 268036007 My Plan (A) / Geo Directory (B) / POWSCAR (C) – McKee barracks

Method W1

The Geo Directory database, displayed in Figure 15b, indicates that there are more commercial addresses located in Sub-SA (2) than in Sub-SA (1) (5 addresses vs 1 address). Therefore, using Method W1, the majority of work trips are assigned to Sub-SA (2).

Method W2

Within the My Plan data, McKee Barracks is identified in the Education – Health macro category which is almost entirely located within Sub-SA (1) (see Figure 5.4A above). Sub-SA (2) contains mainly residential and Green-spaces – Agriculture land uses and therefore, the majority of work trips are assigned to Sub-SA (1) using Method W2.

Method W3

Two POWSCAR grid points are considered, one in each Sub-SA as per Figure 5.4C above. The one in Sub-SA (1) contains 620 work trips while the one in Sub-SA (2) contains only 2 work trips. Therefore, using Method W3, 99.7% of the SA trips would be attributed to Sub-SA (1).

Conclusion

The overall results of the three methodologies are outlined in Table 5.2 below. In this example, Method W2 and W3 provide very similar results and therefore, either method is automatically chosen as the correct level of apportionment.

However, if the calculated indicator value (see Equation 1 above) between the results for Method W2 and W3 is above the 10% threshold, the correct methodology of apportionment should be manually selected through investigation of the SA. In this case, trips' destinations are more likely to be attracted to McKee barracks than the other part of the SA. Therefore, either Methods W2 or W3 should be adapted for the disaggregation.

Table 5.2 SA 268036007 – Destination trips ratio between Sub-SA by options

Sub-SA (Ratio)	Method W1	Method W2	Method W3
1	17%	99%	100%
2	83%	1%	0%

5.4 Education Destination Trips Disaggregation

5.4.1 Methodology

The methodology used for disaggregating education trips to Sub-SAs is very similar to that outlined above for work trips in Section 5.3. The following four methodologies should be used:

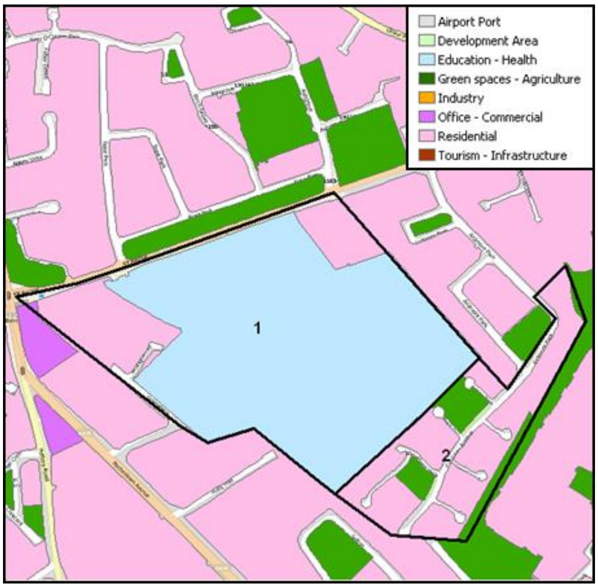
- **Method S1:** Disaggregation is based on Geo Directory, education addresses only. For each Sub-SA, education addresses are to be counted. Destination trips are to be shared on a pro rata basis;
- **Method S2:** Disaggregation based on My Plan land use, Education areas. For each sub-SA, Education areas are to be calculated. Education Trips are to be shared based on the proportion of overall SA education areas located in each sub-SA;
- **Method S3:** Disaggregation is based on POWSCAR grid data. POWSCAR grid point education trips located within each sub SA are summed. Destination trips are apportioned based on the proportion of education trips within each Sub-SA; and
- **Method S4:** In the unlikely event that there is no Geo Directory, My Plan or POWSCAR grid education data for a particular SA, the education destination trips should be apportioned based on the population within each Sub-SA calculated using Method P1 (or P2 – see section 5.2 above).

Similar to work destination trips, all three methodologies (S1 – S3) should be carried out for each SA and their associated results compared. As outlined in Section 5.3 above, indicators are calculated, using equation 1, to identify the difference in results using each alternative methodology. If all the indicator values are above the 10% threshold, then the SA should be manually investigated using additional data sources to correctly identify the apportionment of education trips. It should be noted that Method S4 should only be used if there is no Geo Directory, My Plan or POWSCAR grid education data available.

5.4.2 Education Trips Disaggregation Example

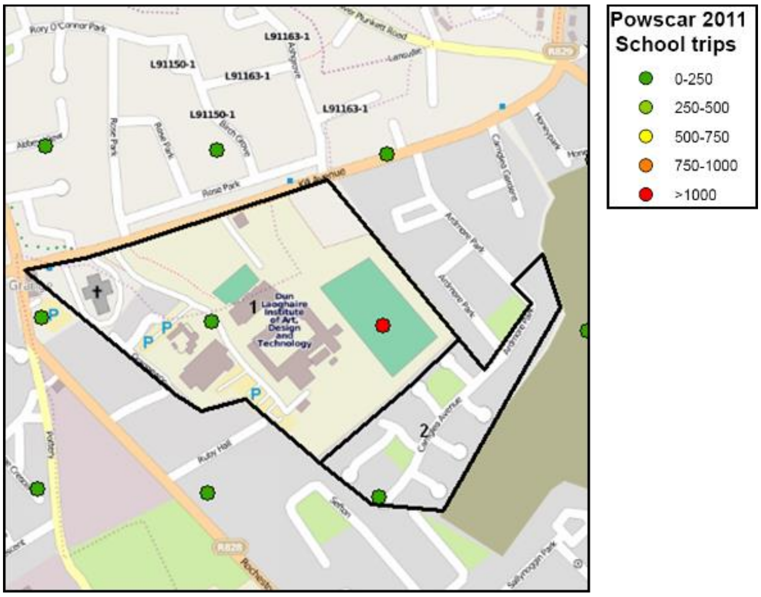
Small Area 267074001, containing the Dun Laoghaire college of Art & Design, is used as an indicative example to illustrate the process involved in disaggregating education trips to a Sub-SA level.

Figure 5.5A, B and C, display the My Plan (a), Geo Directory (b) and POWSCAR (c) data for SA 267074001.



A

B



C

Figure 5.5 SA 267074001 My Plan (a) / Geo Directory school (b) / POWSCAR (c)

Method S1

In the Geo Directory database, there are three educational addresses registered in Sub-SA (1), with none in Sub-SA (2). Therefore, using Method S1, 100% of school trips within the SA are allocated to Sub-SA (1).

Method S2

Within My Plan, the Dun Laoghaire Institute of Art, Design and Technology is represented as an educational feature in Sub-SA (1) (See Figure 5.5A above). There is no Education – Health land use located in Sub-SA (2) and therefore, 100% of school trips within the SA are allocated to Sub-SA (1).

Method S3

Three POWSCAR grid points are located within the SA, two in Sub-SA (1), with 1,976 school trips, and one in Sub-SA (2), with zero school trips. Therefore, using Method S3, 100% of school trips within the SA are allocated to Sub-SA (1).

Conclusion

In this example, all three methods provide the same results and, as such, all can be used in disaggregating school trips. As explained previously for work trips in Section 5.3, if the results of the three methodologies differed significantly, then the SA should be manually investigated to determine the correct apportionment of educational trips.

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