Introduction to the IMAGE Studio and the example data files

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Aim of the IMAGE Studio

The IMAGE Studio has been developed to assist in the analysis of migration data sets with the following objectives in mind:

1. To address key methodological issues that currently impede international comparisons of internal migration
2. To develop a set of rigorous statistical indicators of internal migration that can be used to make comparisons between countries

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MAUP

- Cross-national comparison of sub-national movements between (and within) geographical areas is problematic because of the different shapes and sizes of the spatial units that are used for counting migration flows
- This problem is a variant of the **Modifiable Area Unit Problem (MAUP)**
- Openshaw (1984) identified two MAUP components:

  - the ***scale effect*** or the variation in results obtained when data for one set of areal units is aggregated into larger spatial units (i.e. where the number of regions changes)

  - the ***zonation or aggregation effect*** or the variation in results obtained from different ways of subdividing geographical space at the same scale (i.e. where the number of regions remains the same)

Four key functions/subsystems

Data Preparation
(Flow matrix, PARs, Shapefiles of Basic Spatial Units (BSUs))

Spatial Aggregation
(Randomly aggregates BSUs into Aggregate Spatial Regions (ASRs))

Migration Indicators
(Intensity, impact, connectivity)

Spatial Interaction Model
(Doubly constrained SIM)

Aggregation of BSUs to ASRs

- We start with an origin-destination matrix of migration flows between **Basic Spatial Units (BSUs)** - typically these refer to an administrative zonation used to collect migration flows data, such as local authority districts or municipalities
- IMAGE studio contains algorithms that enable BSUs to be aggregated into larger regions that we call **Aggregated Spatial Regions (ASRs)**
- The user is asked to choose between *single* and *multiple* aggregation, where the former involves the specification of single level of aggregation, whilst the latter provides progressively greater levels of aggregation with correspondingly fewer ASRs
- At each level of aggregation (scale), the user can choose a number of configurations of BSUs

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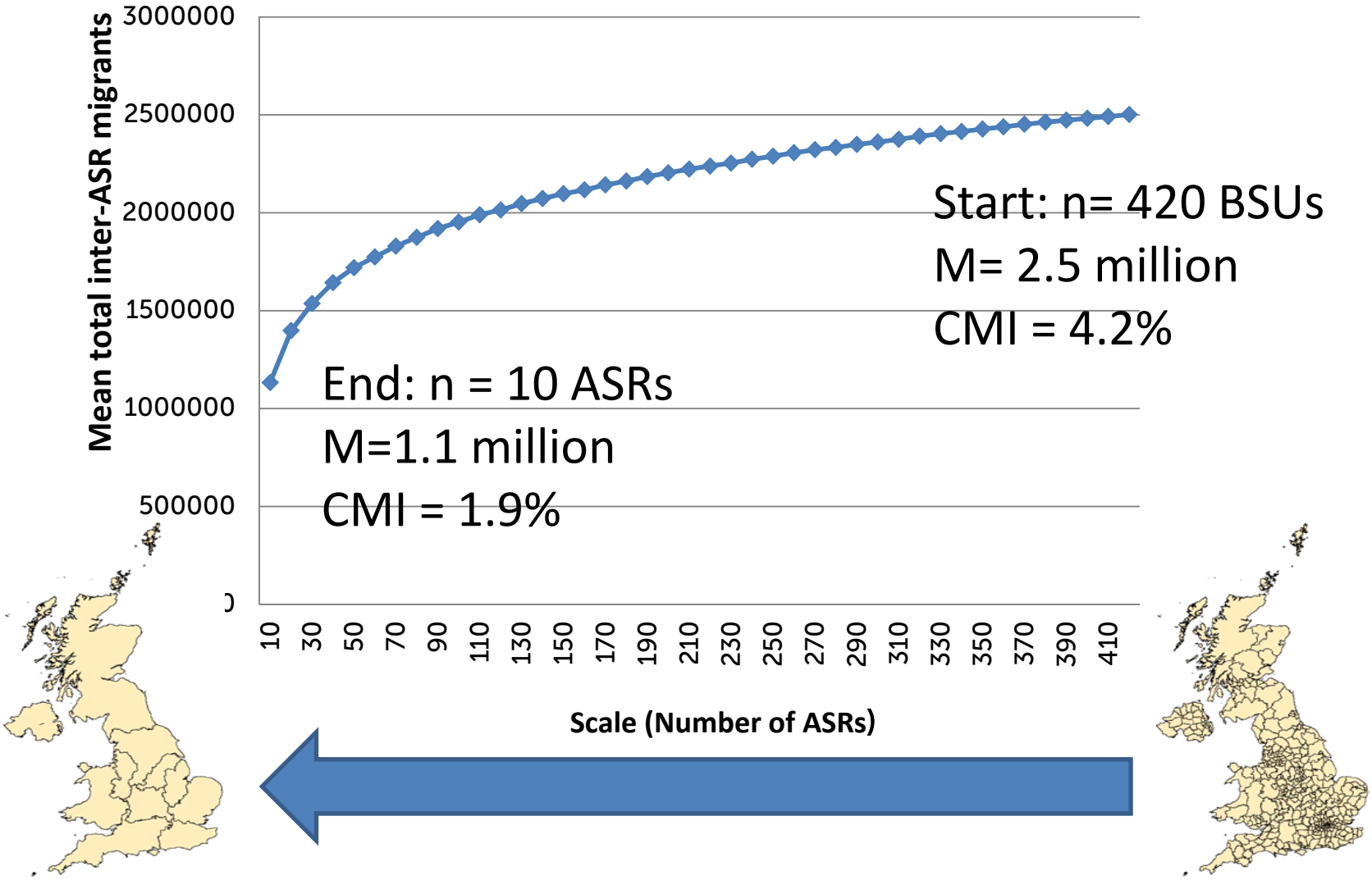
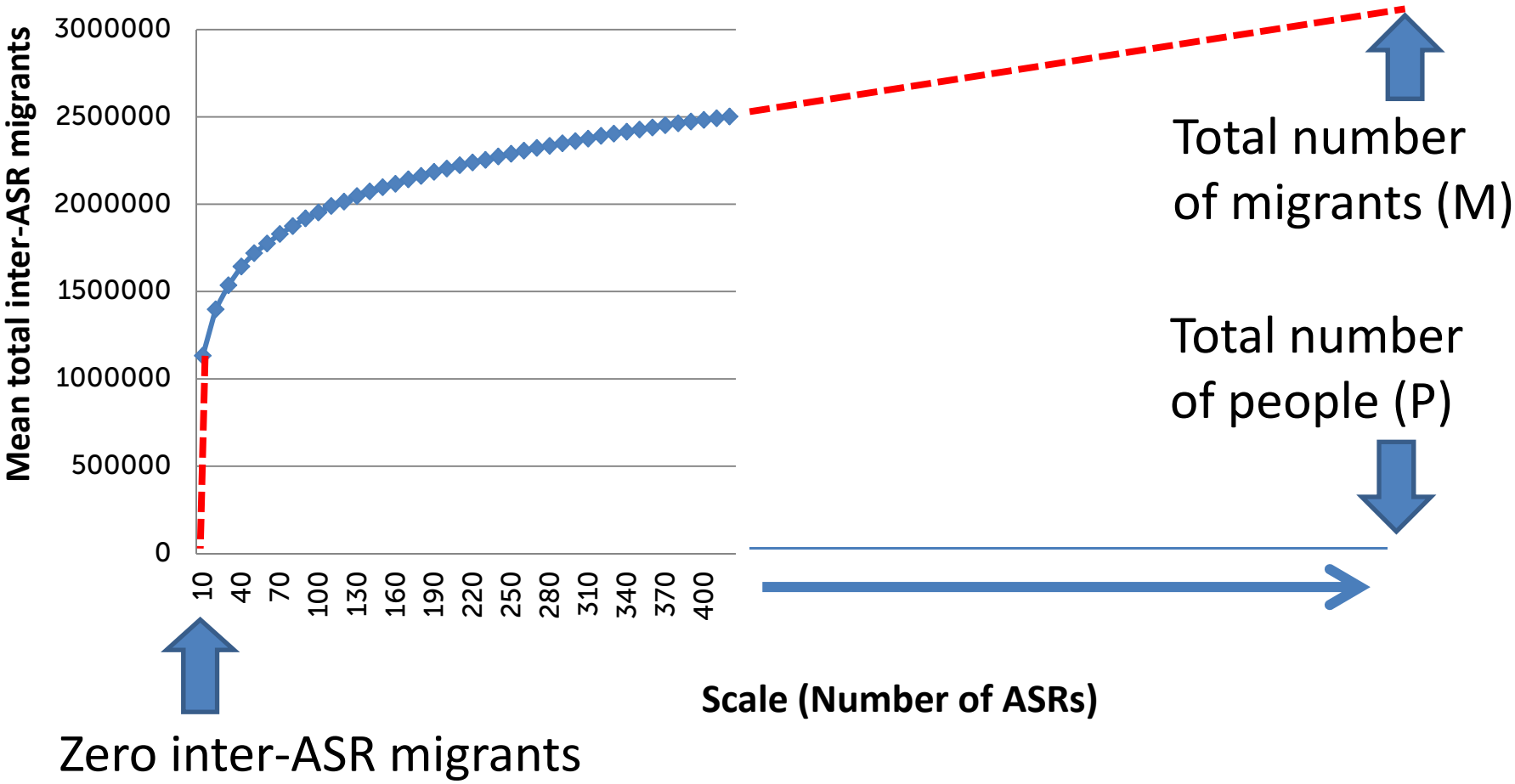
Example aggregation for the UK



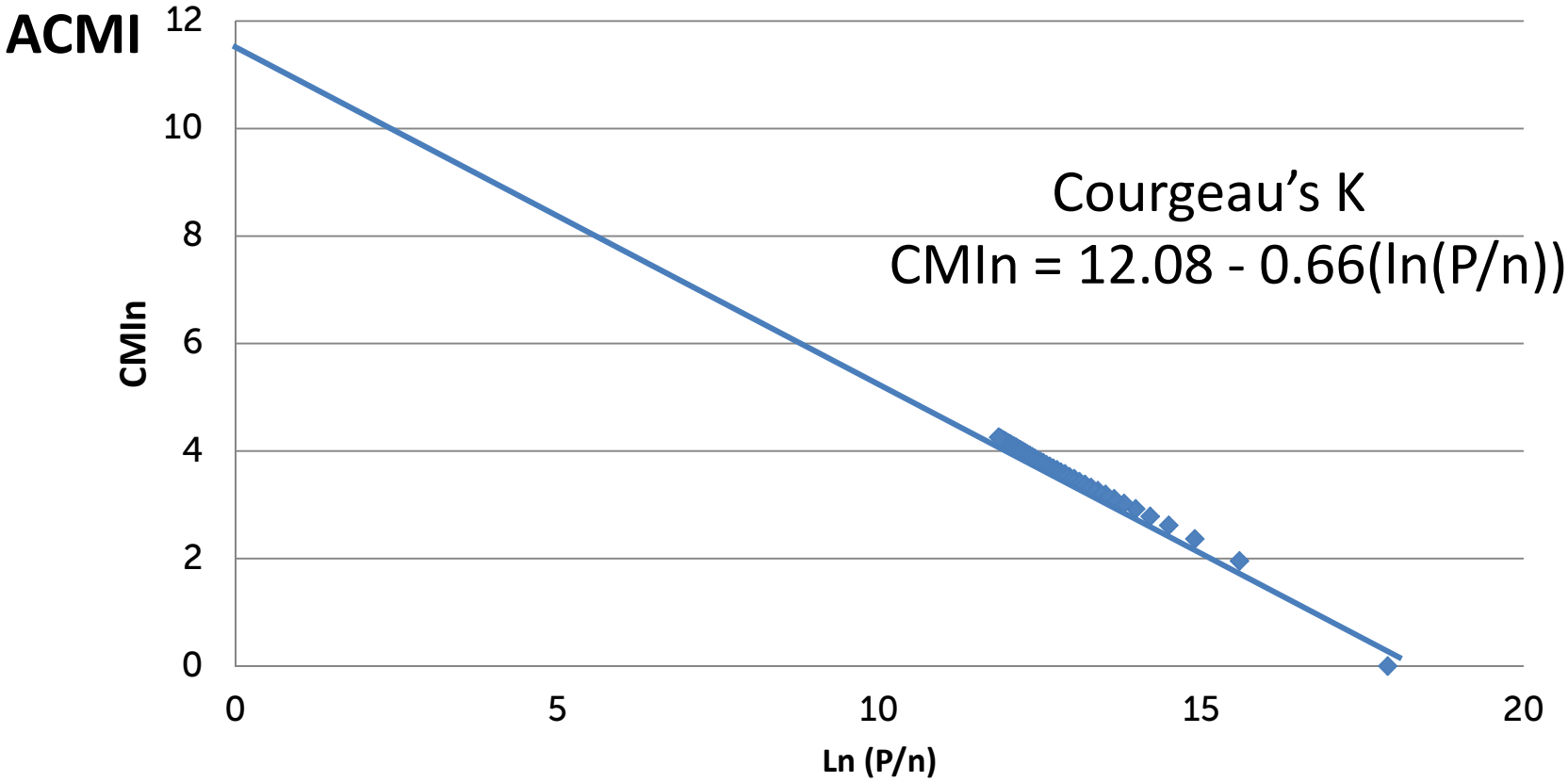
Aggregation is part of series



Link with Courgeau's k

Y axis: Inter-ASR migration volume transformed into the
Crude Migration rate at scale n (CMIn)

X axis: Number of ASRs transformed into the
Log of the mean ASR population at scale n (ln(P/n)



Migration indicators and SIM

- Algorithms are available in the Studio for the:

  (i) calculation of a range of global (systemwide) and local (zone-specific) **indicators of migration intensity, connectivity, distance and impact**

  (ii) calibration a doubly constrained **spatial interaction model (SIM)** that generates a distance decay parameter that quantifies the frictional effect of distance on migration
- The Studio is an environment for investigating what changes are apparent in the migration indicators/parameters at different spatial scales and what variation they show between different ASR configurations at any one scale

Global and local Indicators

	Global information or Indicator
1	Total population
2	Area
3	Population density
4	Total migrants
5	Mean migration flow
6	Median migration flow
7	Max migration flow
8	Min migration flow
9	Crude migration intensity
10	Aggregate net migration
11	Aggregate net migration rate
12	Migration effectiveness index
13	Mean migration distance (between)
14	Mean migration distance (within)
15	Mean migration distance (All)
16	Median migration distance (between)
17	Median migration distance (within)
18	Median migration distance (All)
19	Coefficient of variation
20	Index of connectivity
21	Index of inequality
22	Theil index

	Local Information or Indicator
1	Population
2	Population density
3	Area
4	Intraregional flow
5	Intraregional rate
6	Mean migration inflow
7	Median migration inflow
8	Max migration inflow
9	Mean migration outflow
10	Median migration outflow
11	Max migration outflow
12	Net migration balance
13	Net migration rate
14	Turnover
15	Turnover rate
16	Churn
17	Churn rate
18	Migration effectiveness index
19	Coefficient of variation
20	Index of migration inequality
21	Index of connectivity
22	Inflows
23	Inflow rates
24	Inflow mean migration distance
25	Inflow median migration distance
26	Outflows
27	Outflow rates
28	Outflow mean migration distance
29	Outflow median migration distance

Spatial Interaction Model

- Conventional modelling would typically involve calibrating a model for a selected set of Basic Spatial Units, e.g. fitting a doubly constrained SIM:

$$M_{ij} = A_i O_i B_j D_j d_{ij}^{-\beta}$$

where O_i = the out-migration from zone i to all other zones

D_j = the in-migration to zone j from all other zones

A_i and B_j = balancing factors that ensure the constraints are satisfied

$d_{ij}^{-\beta}$ = negative power distance decay function with parameter β

- Model uses an iterative search routine (Newton Raphson) to find the optimum β parameter when the mean distance migrated calculated from the modelled matrix is equal (or very close) to the mean migration distance from the observed matrix of flows

What initial data are required?

For any country of interest:

I. an origin-destination matrix of flows between a set of BSUs
II. digital boundaries of the corresponding BSUs
III. populations at risk (PAR) of the respective BSUs

United Kingdom data files

- **Migration matrix** is from 2001 Census Special Migration Statistics Table MM01CUK - one-year transition data for all persons aged 1 and over between 404 local authority districts (LADs)

  - extracted via UK Data Service **WICID** interface

- BSU **boundaries** are for corresponding LAD polygons

  - Extracted via UK Data Service **Easy Download** interface

- **PAR** are 2011 Census (end-of-period) populations for 404 LADs

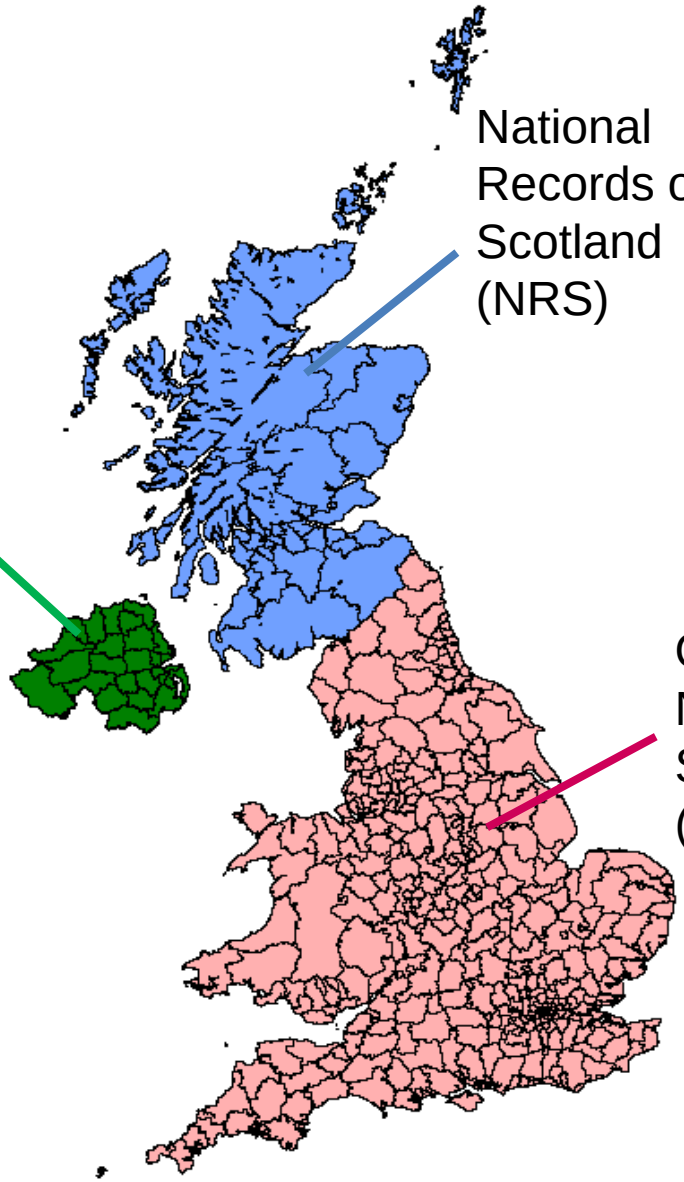
  - extracted via the UK Data Service **InFuse** Interface

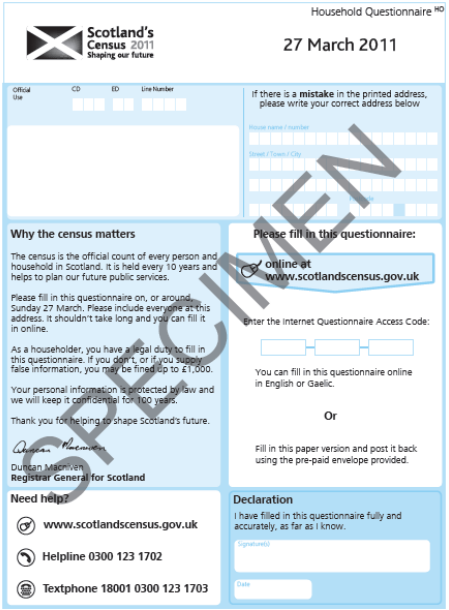
Data collected by National Statistical Agencies

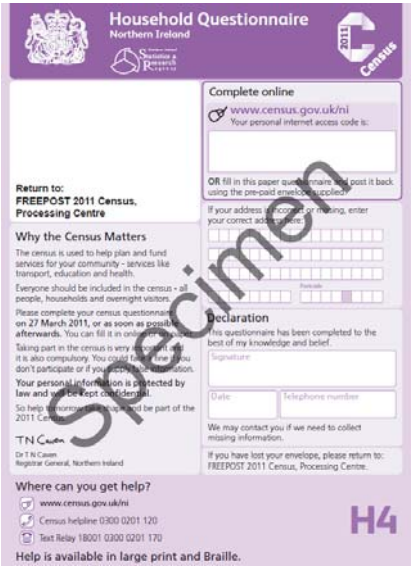
National Records of Scotland (NRS)

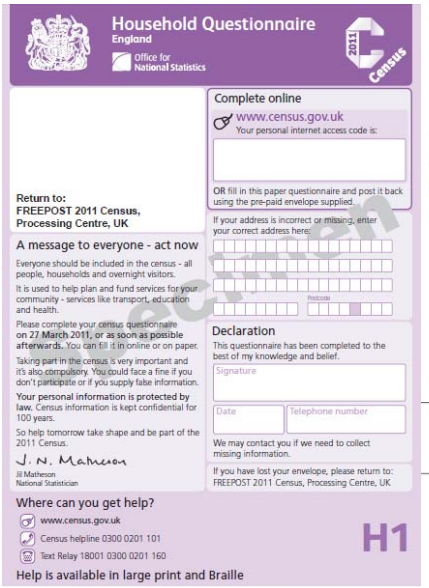
Northern Ireland Statistics and Research Agency (NISRA)

Office for National Statistics (ONS)









UK Data Service Census Support

Access tools: WICID, EasyDownload and InFuse

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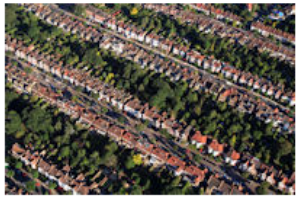
Census > Get data > Aggregate data

- Aggregate data
  - 2011 plans
- Flow data
- Microdata
- Boundary data
- Related data
- Explore online

Census aggregate data

SHARE



Aggregate data provide area counts, usually of individuals or households with particular characteristics. An example might be the number of males, aged 20-24, who are divorced and live in Devon.

We hold aggregate data from censuses in England, Wales and Scotland held in 1971, 1981, 1991, 2001 and 2011, as well as data for Northern Ireland from censuses in 1991, 2001 and 2011. These data are aggregated to a range of geographical levels (e.g. counties and districts) from output areas which are the smallest spatial units.

2011 Census data

InFuse now contains 2011 Census data. 2011 data are being released in phases. Find out more about the availability and plans for 2011 Census aggregate data.

- Guide to census aggregate data

ACCESS AGGREGATE CENSUS DATA

InFuse – access 2011 and 2001 Census aggregate data by selecting topics, categories within topics, and geographic areas.

Anyone can access InFuse.

LOGIN / REGISTER

DISCOVER UK DATA SERVICE

GO

Census Data | Website

QUICK ACCESS TO

- InFuse
- Casweb
- 2011 Census data plans

RELATED LINKS

A beginner's guide to UK geography

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Subsystems of the IMAGE Studio

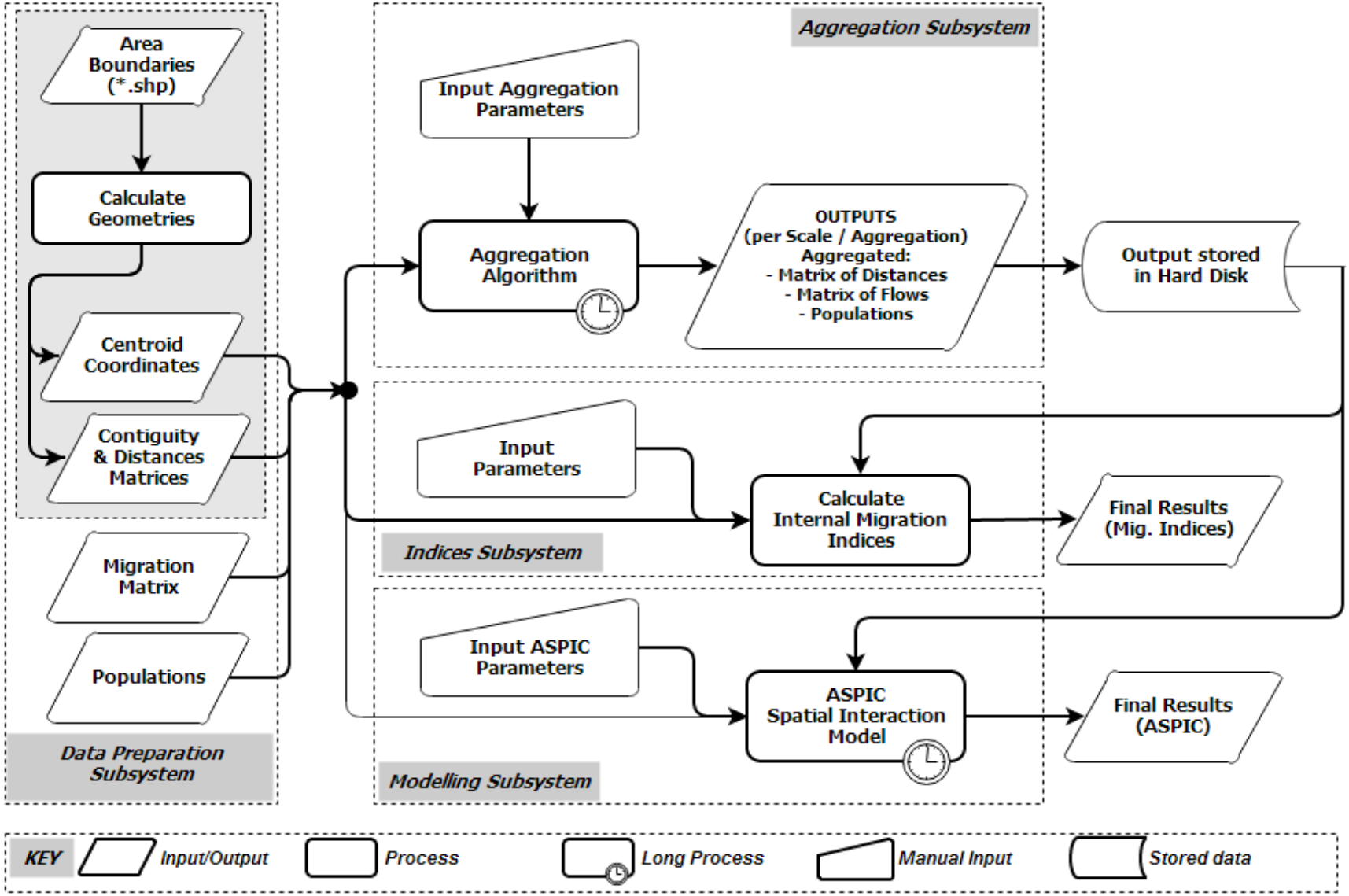
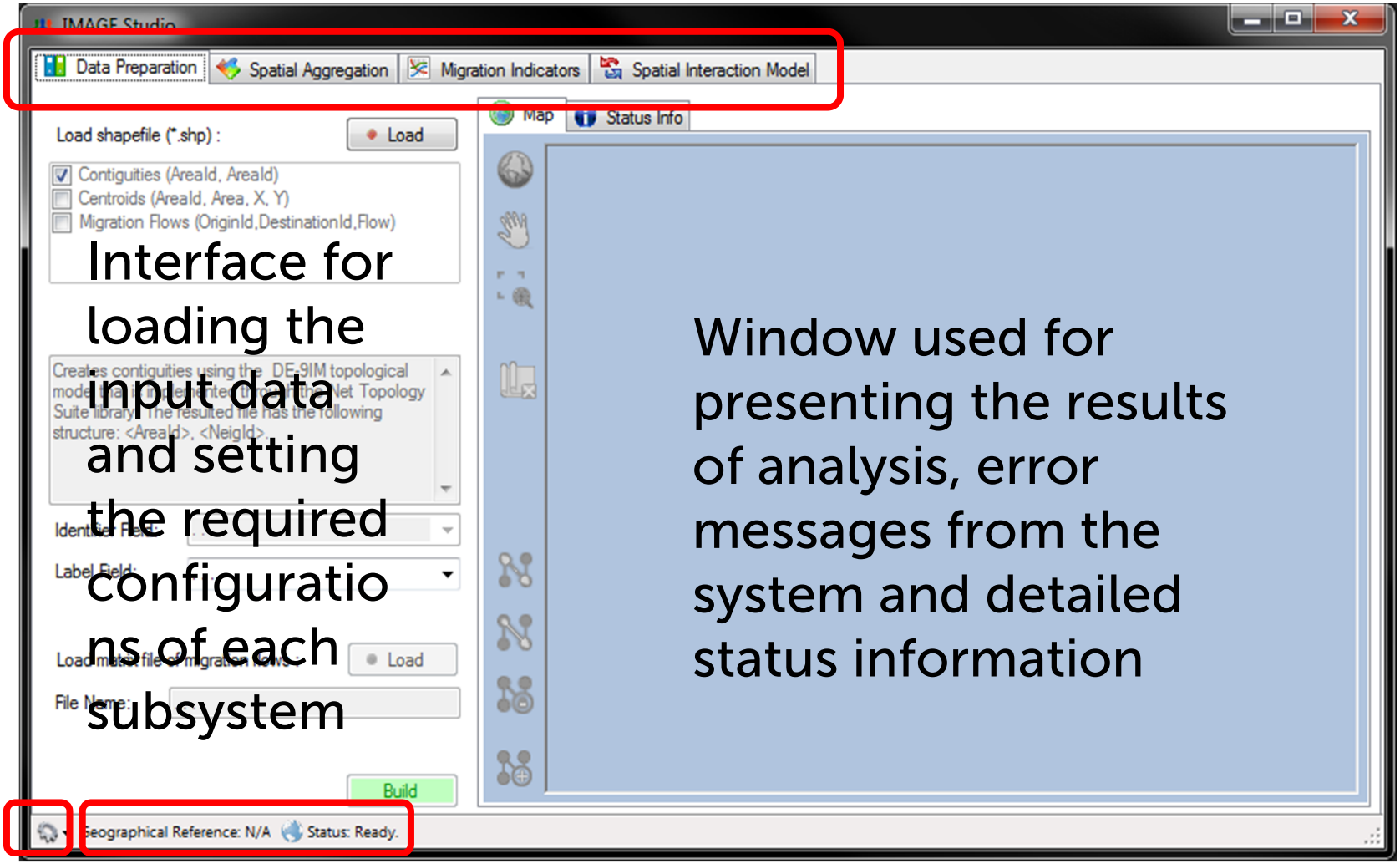


IMAGE Interface

Tabs that represent the four different subsystems



Interface for loading the input data and setting the required configuratio ns of each subsystem

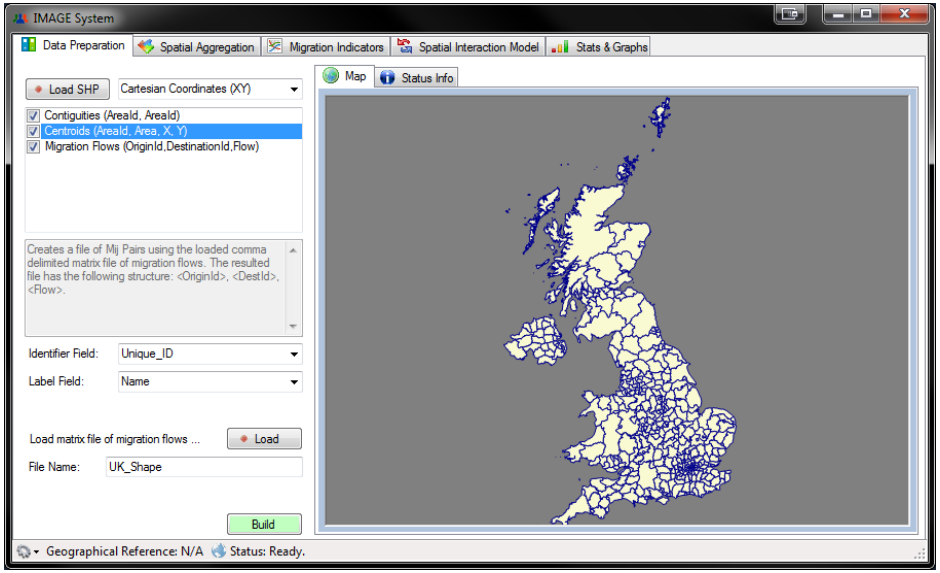
Window used for presenting the results of analysis, error messages from the system and detailed status information

Popup button showing system

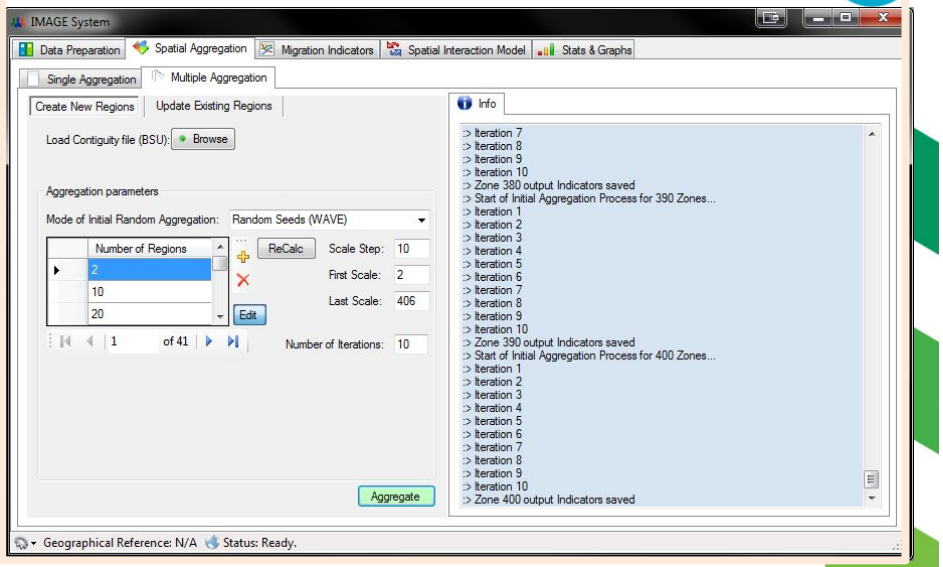
General status information about the

IMAGE Studio – Subsystem Interfaces

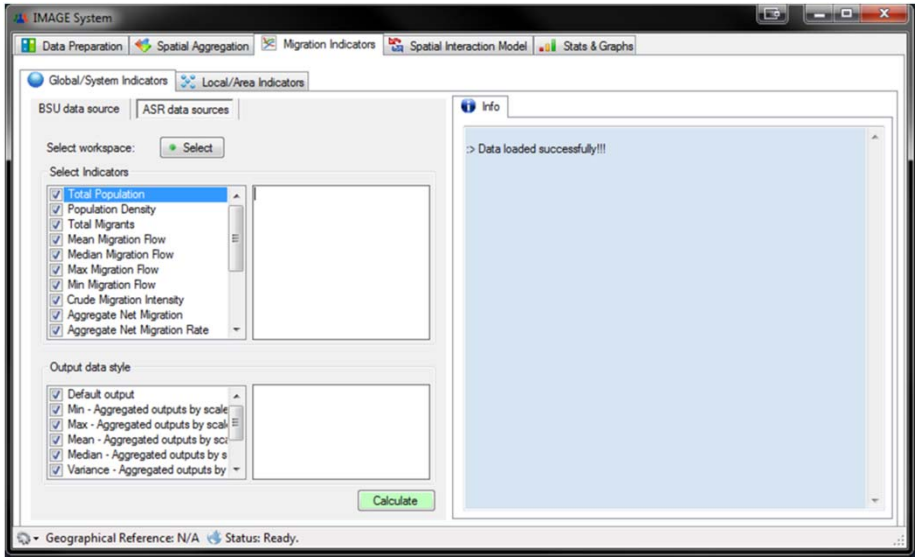
Data Preparation



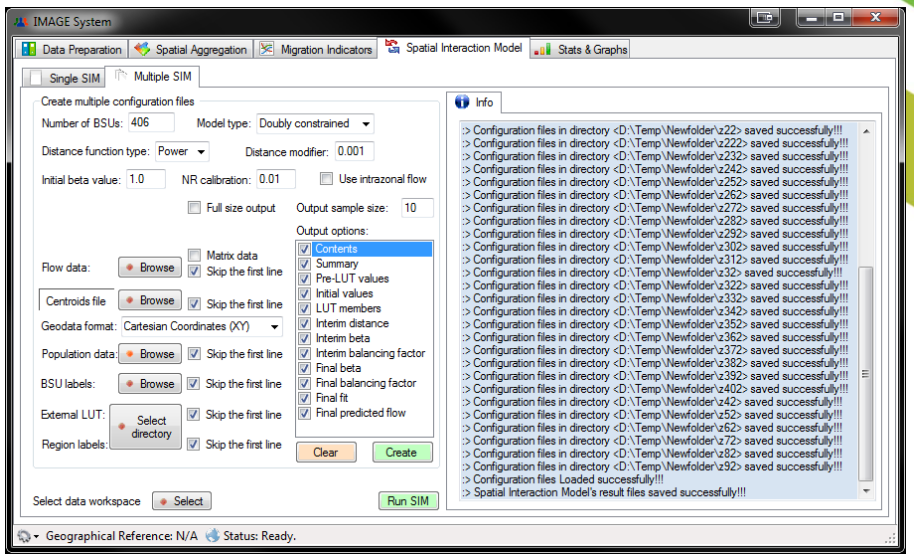
Spatial Aggregation



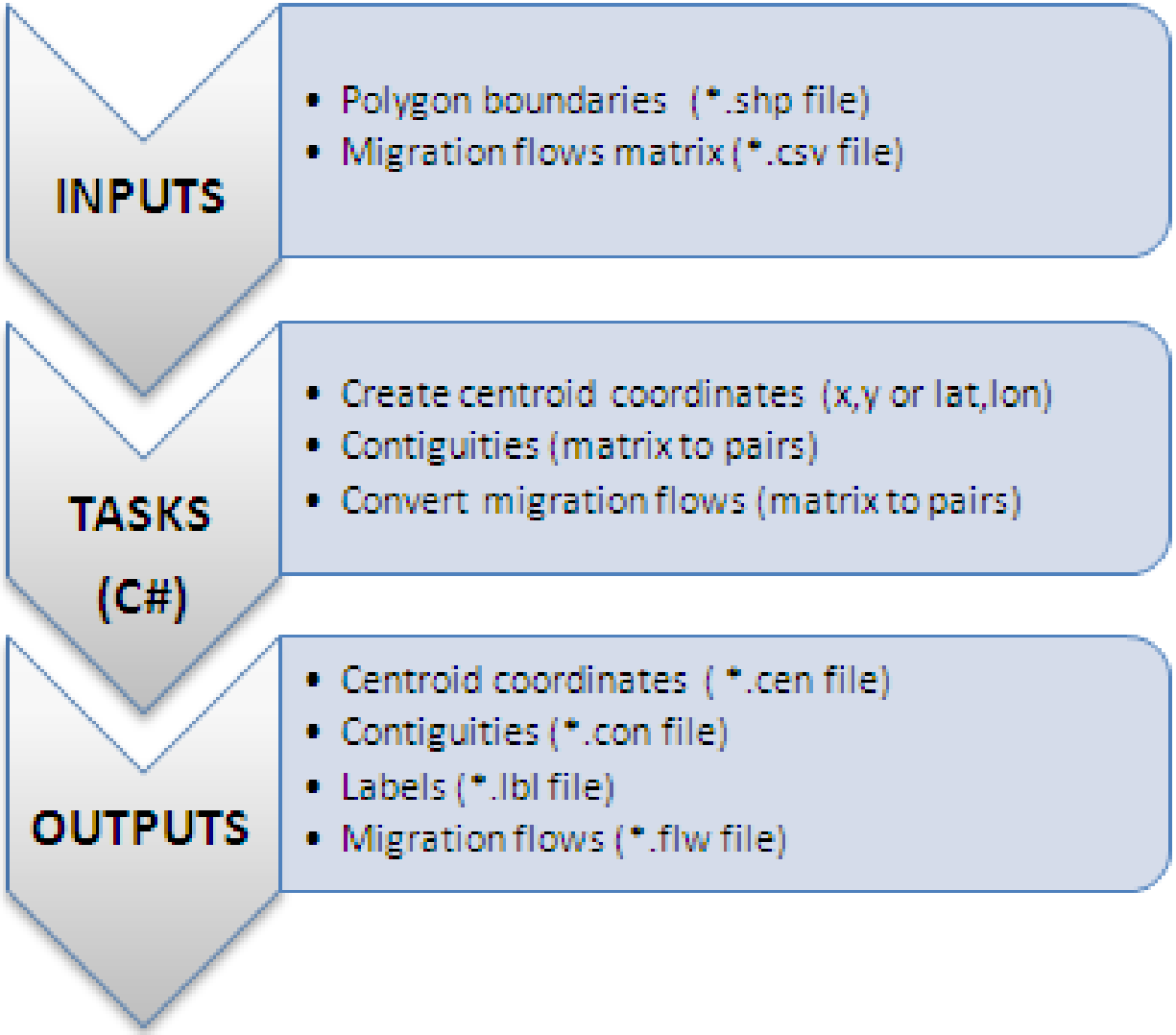
Internal Migration Indicators



Spatial Interaction Modelling

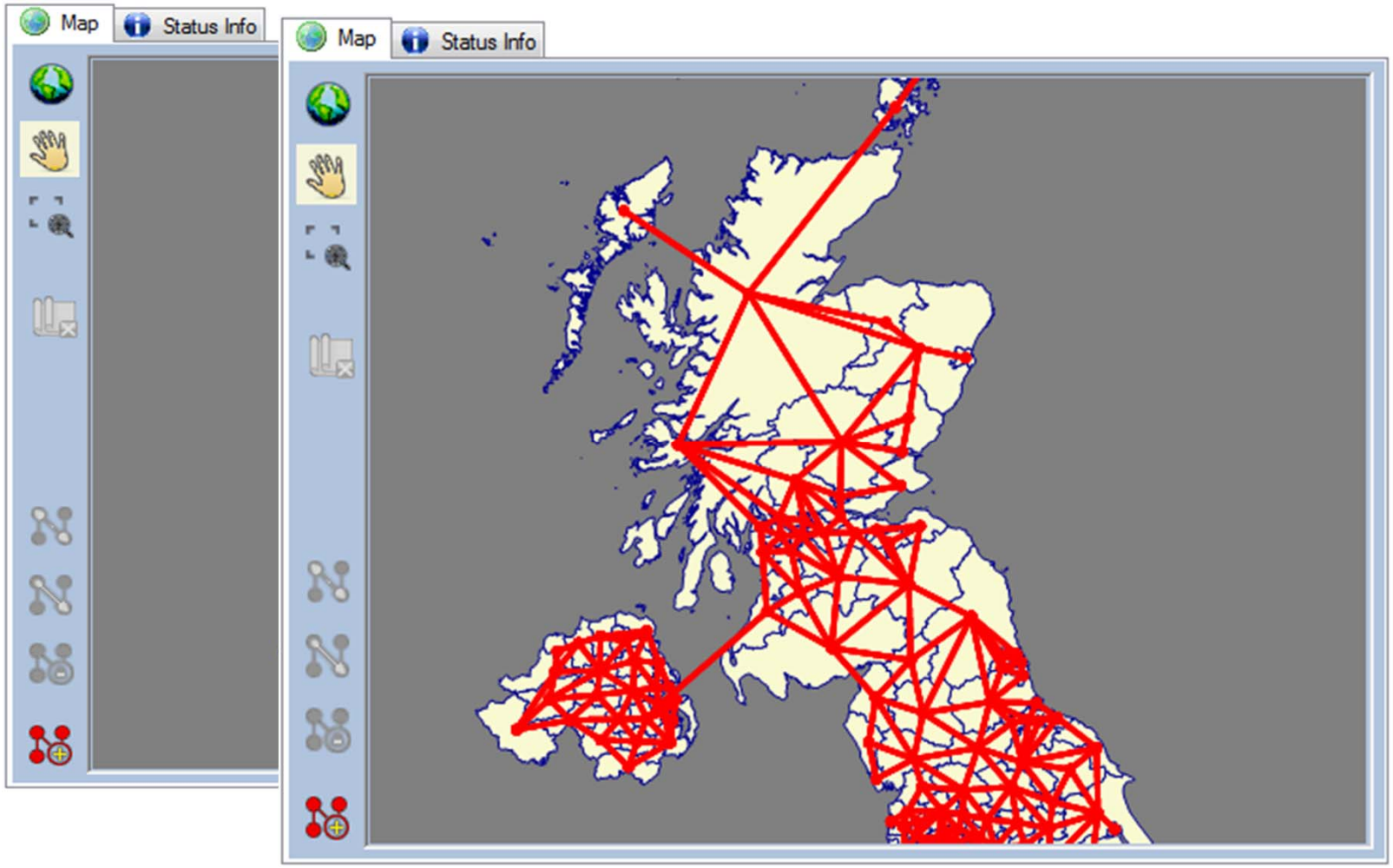


Data Preparation Subsystem



Contiguities between all BSUs are required

User can check display and check contiguities



Aggregation Subsystem

INPUTS

- Output files from Data Preparation Subsystem

TASKS (C#)

- *LOOP* for given *Scale Step*
  - *LOOP* for given *Iterations*
    - Aggregate areas to larger regions (IRA)
    - Calculate the data for the new regions

OUTPUTS

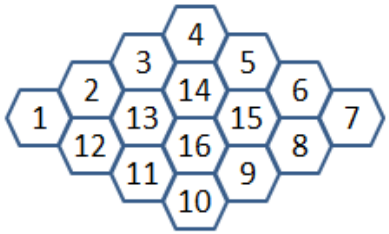
- Contiguities for each *Aggregation*
- Centroids/Area for each *Aggregation*
- Distances for each *Aggregation*
- Migration Flows (intra/in/out flows) for each *Aggregation*
- Populations for each *Aggregation*

Aggregation routines

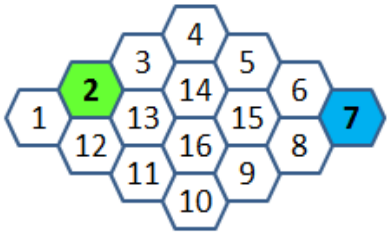
- User can choose between two **Initial Random Aggregation (IRA)** algorithms:
- Original IRA algorithm developed by Openshaw provides a high degree of randomisation to ensure that the resulting aggregations are different during the iterations
- Second aggregation algorithm (*IRA-wave*) is a hybrid version of the original *IRA* algorithm with strong influences from the mechanics of the breadth-first search (BFS) algorithm

IRA wave algorithm

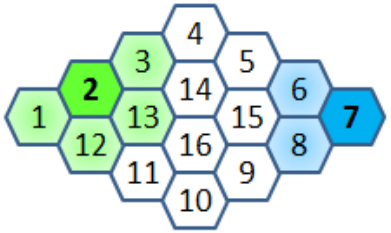
Basic Spatial Units (16 BSUs)



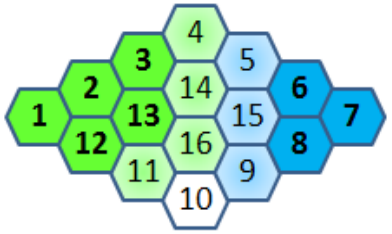
1) Select 2 random seeds



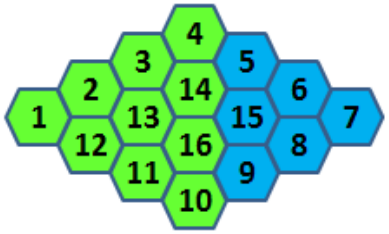
2) Select all neighbouring areas



3) Assign the selected areas to region



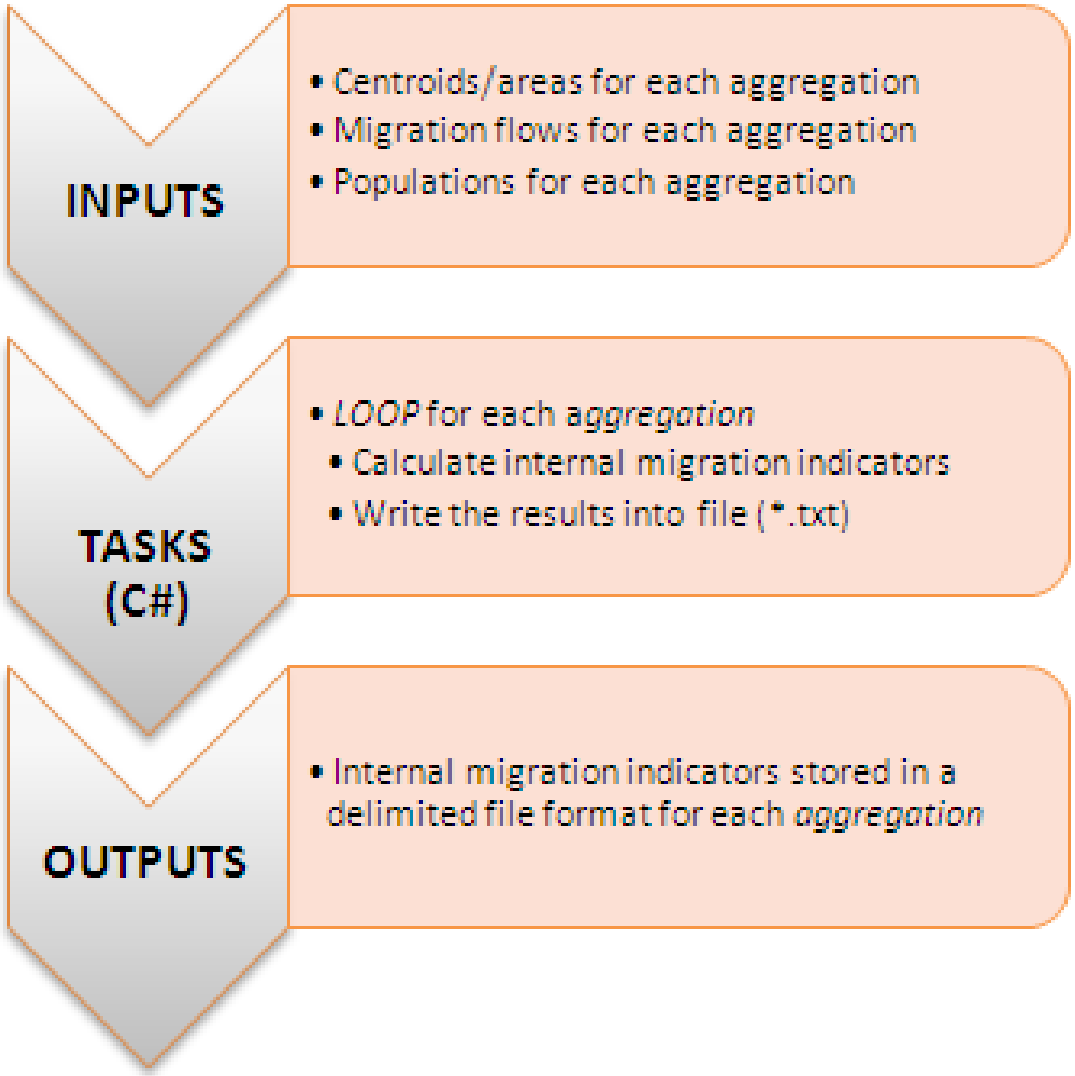
Final Aggregation to Aggregate Spatial Regions (2 ASRs)



Optimising routines

- Aggregation subsystem of the Studio also has facility to optimise the ASR configuration at each spatial scale using:
  - equal or similar ASR populations
  - equal or similar ASR area sizes
  - equal or similar ASR population densities
  - equal or similar ASR intra-area flows
- Difference between equality and similarity objective functions is that the former tries to minimise the variance between ASRs whilst the letter minimises the variance within the ASRs

Migration Indicators Subsystem



Modelling Subsytem

INPUTS

- Contiguities for each *aggregation*
- Centroids for each *aggregation*
- Migration flows for each *aggregation*
- Populations for each *aggregation*
- ASPIC configuration file for each *aggregation*

TASKS (Fortran)

- *LOOP* for each *aggregation*
  - Doubly constrained SIM
  - Write the SIM results into file (*.txt)

OUTPUTS

- SIM results stored in a simple text file format for each *aggregation (summary comma delimited file also provided)*.

See results on screen in text editor

Info | cfg Viewer | Results

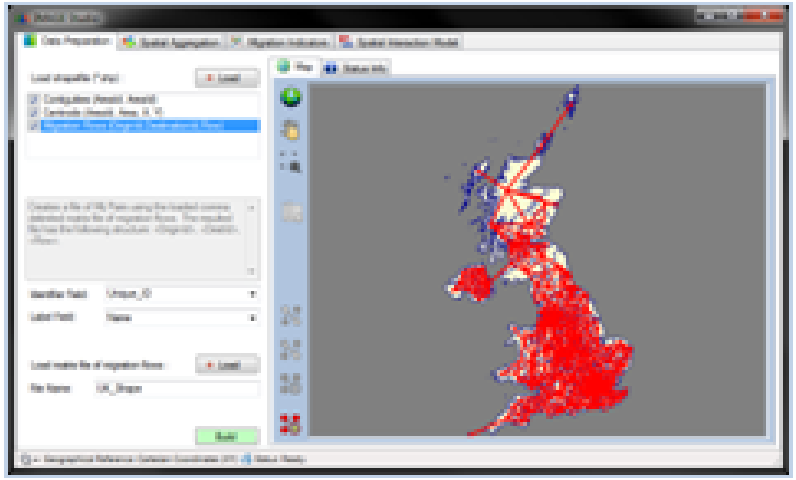
```
## Summary

The doubly constrained interaction model: m(i,j) = a(i) * b(j) * o(i) * d(j) * f(d(i,j))


* Negative power distance decay model
* Initial beta value:  1.000
* Convergence criteria:  0.010
* Newton-Raphson increment value: 0.0100
* Constant:   1.00000000
* Sum of migration in system:     2484029.
* Max Mij value:       4225.
* Max Dij value:       1197.9
* Distance modifier:     0.001000

## Interim results

++ Round 1

* Balancing factor convergence iteration   4 the largest value difference is  0.005224
* Observed mean migration distance:     98.58
* Predicted mean migration distance:    147.05
* Difference:    -48.47(     0.00      0.00)
* Beta value:     1.00(     0.00      0.00)
* Newton Raphson - beta changed to:   1.010000
```

Open file with default viewer

Use the IMAGE Manual

IMAGE STUDIO 1.4.2

User Manual



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July 2014

Questions

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