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**Economic Commission for Europe**

## Conference of European Statisticians

**Group of Experts on Population and Housing Censuses****Seventeenth Meeting**

Geneva, 30 September to 2 October 2015

Item 5 of the provisional agenda

**Grid statistics: opportunities and challenges****Ireland from Boundary Geography to Geo referenced  
Dwellings in Census 2011****Not a pointless process****Note by the Central Statistics Office, Ireland<sup>1</sup>***Summary*

In Census 2006 and previous five yearly Censuses Ireland's Census Geography was encoded on the Census form using a series of boundary codes based on boundary lines drawn on maps. In the run up to Census 2011 Ireland invested heavily in digital mapping, in building up its GIS expertise and in harnessing the geo referenced postal address file (GeoDirectory) as the basis of enumeration. This paper describes the processes and challenges involved in the transformation which has led to more accurate geography, staff savings, flexible finer geography, grid based data and spin off benefits in other household surveys. The electronic version of the paper includes various hyperlinks.

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<sup>1</sup> Prepared by Gerry Walker.

## **I. Census of Population 2011**

1. Ireland's last Census of Population was taken on the night of Sunday, 10 April 2011.

### **1. Coverage of the 2011 Census**

2. The census counts the *de facto* population, i.e. the population recorded for each area represents the total of all persons present within its boundaries on the night of Sunday, 10 April 2011, together with all persons who arrived in that area on the morning of Monday, 11 April 2011, not having been enumerated elsewhere. The count, therefore, includes visitors present on census night as well as those in residence, while usual residents temporarily absent from the area are excluded from the census count.

3. A limited number of questions, relating mainly to demographic characteristics, were asked in respect of usual residents who were temporarily absent from their households on census night. The responses to these questions enables a usual resident count and a more precise picture to be built up on families and households by excluding visitors present on census night and including residents who were temporarily absent.

### **2. Conduct of the 2011 Census**

4. A temporary field force consisting of 6 Census Liaison Officers (CLO), 44 Regional Supervisors (RS), 438 Field Supervisors(FS) and some 4,854 part-time enumerators carried out the Census. During the four weeks before Census Day the enumerators carried out a visual enumeration of dwellings and delivered blank census forms to 1.65 million dwellings and documented the process in pre-filled enumerator record books. The collection of completed forms took place between Monday 11 April and Friday 13 May, 2011.

### **3. Production of Results**

5. Each enumerator was required to prepare a clerical summary of the population in his/her enumeration area. These clerical summaries were returned to the CSO in advance of the main body of the census field records and it was from these summaries that the Census 2011 [Preliminary Report was prepared and published on June 30, 2011](#). The processing of the Census forms and the digitising of newly identified dwellings took place between May 2011 and December 2011. Dissemination of the definitive population figures, analysing the population by such factors as age, marital status, occupation, etc., commenced in January 2012.

### **4. Publication of Results**

6. The publication schedule for Census 2011 consisted of the "Principal Demographic Results" and "Principal Socio-economic Results", primarily at national level. More detailed data was provided in an additional 9 subject matter profiles. All of the tables published in these reports was be made available on the Central Statistics Office web site ([www.cso.ie/census](http://www.cso.ie/census)) using PC-Axis, PDF Reports and a mapping interface see Appendix 1

## II. Code based Geography in the 2006 and previous Censuses

### 1. Preparatory Phase for 2006 Census

7. Census Geography in the 2006 and previous Censuses was largely paper based. The Ordnance Survey of Ireland (OSi) printed maps showing boundaries of 3,452 Electoral Divisions (LAU-2) and Townlands.

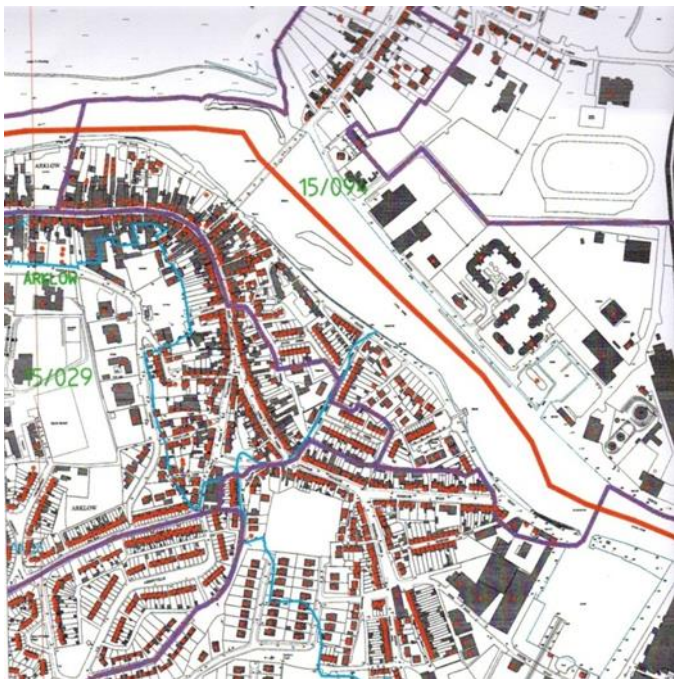
8. For the purposes of the Census, Enumerators were assigned an area of around 320 occupied dwellings (a manageable workload) in which to complete a full visual enumeration, form delivery and collection and summarisation in the 5 weeks before and 5 weeks after Census Night. The Enumerators are managed by Field Supervisors who in turn are managed by Regional Supervisors with supervision ratio averaging one to ten across all levels.

9. The first task was to break the country into Enumeration Areas (EAs) a process called designation. This was achieved by combining townlands and portions of EDs to give areas of around 320 households by reference to the previous Census and taking account of increases in the number or residential address points on a postal database called the GeoDirectory since the last 2001 Census. The GeoDirectory had been around since 1999 but was still under development and in 2005 was not of sufficiently reliable coverage to use as a Census Register. The Enumeration Area boundaries were hand drawn on maps and were digitised by OSi by snapping to boundary features indicated on the maps. Once the EAs were defined Field Supervisor Districts (FD) were defined by combining contiguous EAs in groups of 10-12. Once the Field Supervisor Districts were defined the Regional Supervisor Districts (RD) were defined by combining contiguous FDs.

10. This was a slow labour intensive process involving over 30 staff with the exchange of a lot of paper before the maps for EAs, FDs and RDs were finalised and printed by OSi.

11. Enumerators were provided with a map showing red dots indicating known dwellings on the GeoDirectory and a listing of street and townlands within each Electoral Division in their Enumeration Area detailing the codes assigned to each street/townland and the number of households and population from the 2001 Census.

Figure 1  
 Census 2006 map and Form C



| SUMMARY EA, ED (Electoral District) AND STREET/TOWNLAND CODES |         |         |                      |                      |          |
|---|---------|---------|----------------------|----------------------|----------|
| EA : 026  |         |         |                      |                      |          |
| ED (Electoral District) : 009 CASTLE B                        |         |         |                      |                      |          |
| COUNTY CODE   | EA CODE | ED CODE | STREET/TOWNLAND CODE | STREET/TOWNLAND NAME |          |
| URBAN AREA :  |         |         | LIMERICK CITY        |                      |          |
| 20  | 026     | 009     | 00003                | GLEN ROAD (PT)       | (Street) |
| 20  | 026     | 009     | 00011                | HOSPITAL ROAD        | (Street) |
| 20  | 026     | 009     | 00034                | MANGERTON CLOSE      | (Street) |
| 20  | 026     | 009     | 00036                | SHANNON GREEN        | (Street) |
| 20  | 026     | 009     | 00042                | SHANNON PARK         | (Street) |
| 20  | 026     | 009     | 00056                | SHANNON PLACE        | (Street) |
| 20  | 026     | 009     | 00073                | TOWER ROAD           | (Street) |

12. Enumerators were instructed to traverse every thoroughfare and identify all places of habitation. They assigned each place of habitation a unique sequential dwelling number which they marked on the map beside the appropriate red dot. Where a dwelling was not on the GeoDirectory the Enumerator marked a red dot on the map and assigned it a dwelling number.

13. Using the boundaries marked on the maps and boundary code listing, the Enumerator coded the geography on the front of the Census Form. The process was prone to error, an attempt to Geo-reference the 2006 Census after the event in preparation for 2011, highlighted geocoding errors in 244 of the 3452 Electoral Divisions. The average error rate was 1.1% in the Dwelling count. An investigation of the source of the 1.1 % error, highlighted that 45% was enumerator error, 31% scanning recognition errors, the remaining errors being points on boundaries and boundary errors on maps.

Figure 2  
Census form Geography 2006

| For office use only                   |                       |         |                      |       |
|---------------------------------------|-----------------------|---------|----------------------|-------|
| House Number and Street/Townland Name |                       |         |                      |       |
| <b>1 MANGERTON CLOSE</b>              |                       |         |                      |       |
| County Code                           | Enumeration Area Code | ED Code | Street/Townland Code | D No. |
| 2 0                                   | 0 2 6                 | 0 0 9   | 0 0 0 3 4            | 3     |

Page 1

## 2. Publication Phase for 2006 Census

14. The 1996 Census was published by 9 levels of geography including Census towns, some of these geographies split the geography coded on the form making it necessary to recode at the dwelling number level by reference to the maps returned by enumerators. This process was very laborious and prone to clerical error. Coding the expansion in town boundaries was expensive and the production of grid statistics was impossible. The lowest level of Geography that was available from Census 2006 was Enumeration Areas(EA) for the five cities and Electoral Divisions elsewhere. From a user point of view this was far from ideal. Data and digital boundaries for the EAs were only available for 36% of households also the EA boundaries changed from one Census to the next, while the EDs varied in size from around 20 to 7,860 households resulting in no state wide uniform detailed area data.

15. Because of the above and because Enumerators assigned the dwelling numbers to households sequentially meant it was impossible to link households across Censuses, a decision to invest in digital mapping and GIS and to change from code to point based geography for the Census 2011 was made.

## III. The path to point based geography in Census 2011

### 1. The GeoDirectory and the use of geocoding

16. GeoDirectory is a service, jointly established by An Post and OSi that provides a complete database of all of the buildings in the Republic of Ireland and their geolocation details. It holds records for 2.2 million properties and businesses. As all addresses on the GeoDirectory have spatial coordinates, the benefits to the CSO and the Census are extensive. There were doubts about the coverage of the GeoDirectory at the time of the 2006 Census. The key benefits of linking Census data to the addresses and coordinates contained within the GeoDirectory:

- Providing quality assurance checks on the work undertaken by the enumerators
- Reducing the labour input into certain aspects of post- Census processing operations
- Facilitating the production of completely flexible geographical outputs for existing and new boundaries
- Allowing for the possibility of comparative analysis at dwelling level with future Censuses and other CSO-related surveys

17. The successful testing of the GeoDirectory in the 2009 Census Pilot resulted in it being used to underpin the fieldwork operations for the 2011 Census. The result of this exercise means that every dwelling enumerated in the 2011 Census has spatial coordinates

## **2. Small area boundaries**

18. In 2005, the Small Area Working Group, established as part of the Government's Irish Spatial Data Infrastructure project, discussed the benefits of creating a new level of geography (called the Small Area) for the Republic of Ireland, the operational advantages of using Small Areas and how to introduce the Small Area into Irish administrative records.

19. As a key member of this group the CSO committed itself to the collection and dissemination of data at Small Area level for the census in 2011. Arising from the group's recommendations, the National Centre for Geocomputation, at the request of OSi, devised an algorithm to produce a series of Small Area boundaries for the State.

20. It was recognised that the GeoDirectory was considered essential for this algorithm. The number of residential address points within the GeoDirectory was chosen as the basis for setting the minimum and maximum threshold values of dwellings within each Small Area. Polygons were then generated around the coordinates of residential buildings from the GeoDirectory using road centreline segments as the boundary outline. The digital boundaries of legacy geography (EDs, Townlands) and natural divisions (rivers, canals and railway lines) were also taken into consideration during the creation process.

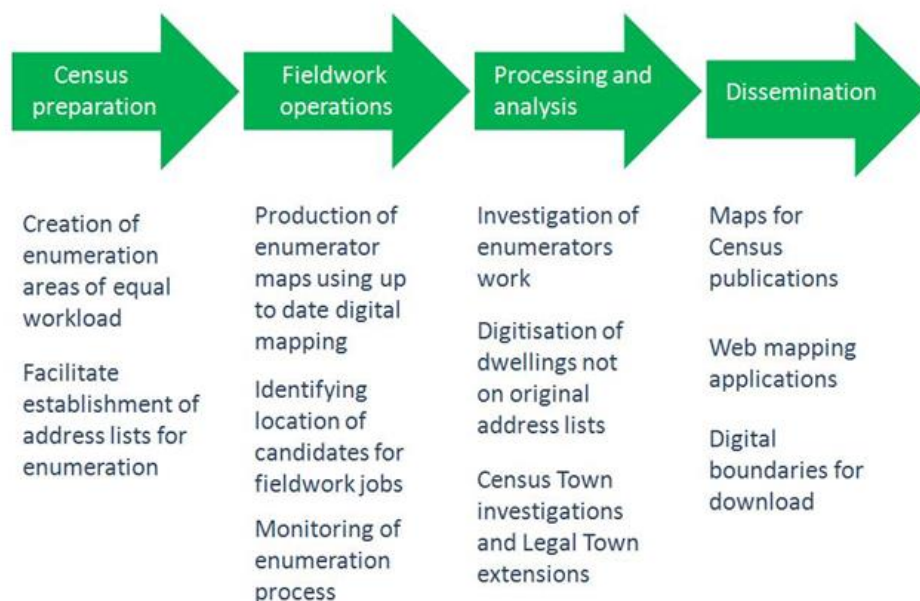
21. Staff from both CSO and OSi liaised on reviewing the output produced by the algorithm, which involved each Small Area polygon being checked in order to ensure that they were practical and navigable. Other issues such as the Small Area codes and ownership rights were agreed by the two agencies prior to their release in 2009. By using the GeoDirectory as the source for their creation, around 92% of the 18,488 Small Areas have a range of between 75 to 150 dwellings.

22. The Small Areas were used as the building blocks for the designation of Enumeration Areas for 2011 and are now the sample blocks for all CSO household surveys including the Labour Force Survey.

## **3. Investment in GIS**

23. In 2007 the use of GIS was limited to the production of static thematic maps for publication purposes. CSO invested in hardware, GIS software, digital raster and vector mapping data at scales varying from 1:50,000 to 1:1000 and hired an additional Statistician to research and implement a solution for Census 2011 covering the four stages of the Census.

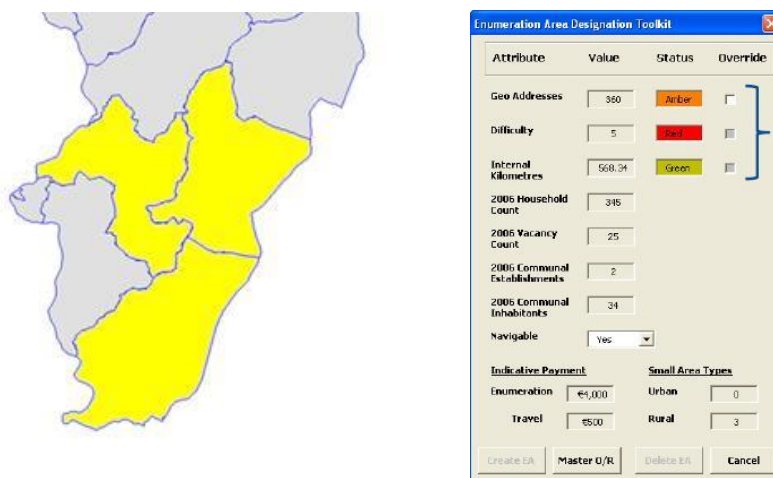
Figure 3  
The use of GIS by the CSO in Census 2011



#### 4. Census Preparation

24. The creation of the Census 2011 Enumeration Areas was an entirely digital operation involving GIS. This was in comparison to previous Censuses, which involved manually intensive logistics associated with drawing boundary changes on paper maps for amendment and reprinting by OSi. The areas were created by digitally amalgamating Small Area boundaries using the GIS. To facilitate the designation, a customised tool was developed which displayed information about the proposed Enumeration Area, such as the potential number of GeoDirectory residential address points, the internal number of kilometres, as well as Census 2006 data regarding the number of occupied dwellings and the vacancy rate. Geography staff could then commit the area if looked viable.

Figure 4  
The creation of the Census 2011 Enumeration areas using a customised tool in GIS

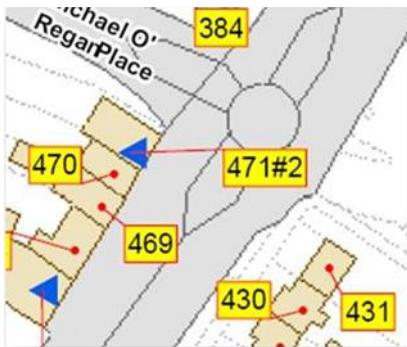




25. The efficiencies of using GIS to create the Census 2011 Enumeration Areas can be measured through the observation that the process lasted three months compared to eight months for the designation of the Census 2006 Enumeration Areas and involved half the number of staff.

26. GIS also facilitated the production of address lists for the enumeration process. The July 2010 GeoDirectory was used for the selection of all valid residential address points for Census 2011 enumeration. Each address point was allocated a pre-assigned three digit dwelling number, which in turn was displayed and labelled on the enumerator maps. A key component of linking Census 2011 data to the GeoDirectory was to ensure that all dwelling numbers are clearly and legibly displayed on the map. In order to do this specialised labelling software was applied in GIS to disperse any overlapping labels.

Figure 5  
**Labelling of dwelling numbers on the Census 2011 enumerator maps**



## 5. GIS in Field Operation

27. The CSO took over responsibility for creating and printing the maps required for Census 2011 enumeration replacing the, OSi who printed the maps in 2006. GIS produced the maps of the Enumeration Areas, along with Regional maps and ‘Cluster Maps’ (for areas where the enumerator needed a lower scale map in order to read the labels). The maps were then output as PDFs for printing and checking. A prefilled Enumerator Record book was supplied to each Enumerator which referenced the location on the map using a unique dwelling number. This dwelling number was encoded on the front of the Census form so that it could be linked back to the exact geo location on the map.

Figure 6  
**Panel from ERB 2011**

|                    |    |                     |                    |  |
|--------------------|----|---------------------|--------------------|--|
| D No.              | SA | Name of householder | Address            |  |
| 2                  | 5  |                     | 23 Meadowvale Park | Called 13/3. Calling card 15/3. Spoke to neighbour 31/3, house is vacant. Verified 14/4. |
| Occupied           | 1  |                     |                    |  |
| Temporarily absent | 2  |                     |                    |  |
| Vacant house/CE    | 3  |                     |                    |  |
| Vacant flat        | 4  |                     |                    |  |
| Holiday home       | 5  |                     |                    |  |
| Under construction | 6  |                     |                    |  |
| Detrital           | 7  |                     |                    |  |
| Commercial only    | 8  |                     |                    |  |
| Does not exist     | 9  |                     |                    |  |

| M T W T F S S |    |    |    |    | M T W T F S S |    |    |    |    |    |    |    |    |
|---------------|----|----|----|----|---------------|----|----|----|----|----|----|----|----|
| 7             | 8  | 9  | 10 | 11 | 12            | 11 | 12 | 13 | 14 | 15 | 16 | 17 |    |
| 14            | 15 | 16 | 17 | 18 | 19            | 20 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| 21            | 22 | 23 | 24 | 25 | 26            | 27 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| 28            | 29 | 30 | 31 | 1  | 2             | 3  | 2  | 3  | 4  | 5  | 6  | 7  | 8  |
| 4             | 5  | 6  | 7  | 8  | 9             |    | 9  | 10 | 11 | 12 | 13 | 14 | 15 |

|                  |        |           |
|------------------|--------|-----------|
| Form             | Issued | Collected |
| What             |        |           |
| Indv             |        |           |
| List             |        |           |
| Persons expected |        |           |
| Male             |        | Female    |

|       |   |   |       |       |       |
|-------|---|---|-------|-------|-------|
| Cen 1 | H | E | Rem 1 | Rem 2 | Ref 1 |
|-------|---|---|-------|-------|-------|

Downlap check  RF



Figure 7  
Census form front Panel 2011

| Address                   |                       |                 |        |  |         |       |
|---------------------------|-----------------------|-----------------|--------|--|---------|-------|
| <i>23 Meadowvale Park</i> |                       |                 |        |  |         |       |
| County Code               | Enumeration Area Code | Small Area Code | D. No. | Number of persons present in the dwelling, if occupied |         |       |
|                           |                       |                 |        | Males  | Females | Total |
| 05                        | 006                   | B               | 258    |  |         |       |

28. GIS also contributed towards identifying the location of candidates for the fieldwork jobs associated with Census 2011, as well as providing information in relation to certain queries and requests from enumerators during the fieldwork operations.

## 6. GIS in Processing and Analysis

29. GIS was used to digitise the location of the 49,000 (2.5%) additional dwellings which enumerators found that were not listed on the GeoDirectory and marked on their maps. In order to spatially reference these dwellings, they are allocated the centroid coordinates of their Small Area location. Staff digitally 'pulled' the points of the additional dwellings to their correct location as indicated by the enumerator maps by visual observation. There were also 1,800 dwellings which had location errors. Enumerators indicated the correct position on their map and noted that the location had been corrected in a table on the map. Incorrectly positioned dwellings were then pulled using the GIS to their correct location.

30. GIS was also used to identify expansions to the suburbs of the five administrative cities, legal towns and create or expand the boundaries of towns with a population centre of greater than 200 persons. This was done using clustering algorithms to produce draft boundaries which were adjusted digitally by Census Geography staff in accordance with the requirements of the United Nations classifications of urban and rural areas.

## 7. GIS in Dissemination

31. At the end of 2011 processing all dwellings had accurately digitised locations. In theory the production of any Geography just involved placing these boundaries over the dwellings to code the geography. We found the following issues with boundaries which had been digitised from paper maps:

- (a) Slivers where boundaries were not topologically sound
- (b) Issues with islands which might belong to boundary area but were digitised as separate polygons
- (c) Issue with the labelling and attribution of polygons
- (d) Issues with dwellings close to the coast and on recovered land due where dwellings would fall outside the boundaries.

32. We worked closely with OSi on dealing with issues a,b,c and sorted out issue d by manually coding the dwellings.
33. We produced [Census results](#) according to 15 different geographies including police administrative boundaries, local and state election areas and small areas.
34. We put up a facility to download boundary files and aggregate population data for use by GIS users.
35. We released national [grid population data](#) and contributed to EFGS Eurogrid Statistics.
36. We had not developed the expertise in house to develop specialised mapping tools so formed an alliance with the [All-Island Research Observatory \(AIRO\)](#) which is funded under Interreg. AIRO have created a number of [Census mapping tools](#) allowing users to visualise data.

#### **IV. Concluding remarks**

37. By changing to point based geography and investing in GIS we were able to increase the accuracy of and flexibility of our geography, provide more detailed geographic data to users, provide and enable data visualisations for users and reduce staff input.
38. There were 53 person years geography input on Census 2006 in Census 2011 this was reduced to 33 and would expect to make further savings in our 2016 Census because we have broken the ground. Changing to point based geography was certainly not a pointless process.

## Appendix

| Reports  | Published                    |
|--|------------------------------|
| › <a href="#">Preliminary Report</a>   | <a href="#">30 June 2011</a> |
| › <a href="#">This is Ireland ,Highlights from Census 2011 Part 1 (Formerly Principal Demographic Results)</a>                     | <a href="#">29 Mar 2012</a>  |
| › <a href="#">Population by Area (Formerly Volume One )</a>  | <a href="#">26 Apr 2012</a>  |
| › <a href="#">Profile 1 Town and Country - Population Distribution &amp; Movements</a>   | <a href="#">26 Apr 2012</a>  |
| › <a href="#">Profile 2 Older and Younger - An Age Profile of Ireland</a>  | <a href="#">24 May 2012</a>  |
| › <a href="#">This is Ireland,Highlights from Census 2011 Part 2 (Formerly Principal Socio Economic Results)</a>                   | <a href="#">28 June 2012</a> |
| › <a href="#">Profile 3 At Work - Employment, Occupations &amp; Industry in Ireland</a>  | <a href="#">26 July 2012</a> |
| › <a href="#">Small Area Population Statistics (SAPS) – including SAPMAP</a>   | <a href="#">31 July 2012</a> |
| › <a href="#">Profile 4 The Roof over our Heads - Housing in Ireland</a>   | <a href="#">30 Aug 2012</a>  |
| › <a href="#">Homeless persons in Ireland, a special Census 2011 report</a>  | <a href="#">06 Sept 2012</a> |
| › <a href="#">Profile 5 Households and Families - Living Arrangements in Ireland</a>   | <a href="#">20 Sept 2012</a> |
| › <a href="#">Profile 6 Migration &amp; Diversity in Ireland - A profile of diversity in Ireland</a>                               | <a href="#">04 Oct 2012</a>  |
| › <a href="#">Profile 7 Religion, Ethnicity and Irish Travellers – Ethnic and Cultural background in Ireland</a>                   | <a href="#">18 Oct 2012</a>  |
| › <a href="#">Profile 8 Our Bill of Health - Health, Disability &amp; Carers in Ireland</a>  | <a href="#">01 Nov 2012</a>  |
| › <a href="#">Profile 9 What We Know - A Study of Education, Skills and the Irish Language</a>                                     | <a href="#">22 Nov 2012</a>  |
| › <a href="#">Profile 10 Door to Door – Commuting in Ireland</a>   | <a href="#">13 Dec 2012</a>  |
| <a href="#">Census Area Profiles</a>   | <a href="#">2 May 2013</a>   |
| <a href="#">Census 2011 - Ireland and Northern Ireland (Joint Publication with Northern Ireland Statistics and Research agency</a> | <a href="#">12 June 2014</a> |