Institution: University of Southampton		
Unit of Assessment: 14 Geography and Environmental Studies		
Title of case study: 14-01 Better boundaries for the collection and publication of official statistics		
Period when the underpinning research was undertaken: 2008 – 2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	**Role(s) (e.g. job title):**	**Period(s) employed by submitting HEI:**
David Martin OBE	Professor of Geography	1992 – present
Samantha Cockings	Associate Professor	2000 – present
Andrew Harfoot	Senior Enterprise Fellow, GeoData	2004 – present
Period when the claimed impact occurred: May 2014 – December 2020		
Is this case study continued from a case study submitted in 2014? N		

1. Summary of the impact

Automated zone design methods and **AZTool** software, developed at the University of Southampton, have enabled more efficient and effective collection and publication of official population statistics, which underpin evidence-based policy, planning and decision-making. There are four strands to the impact: (i) implementation of the AZTool team's methods by UK national statistical organisations to create official statistics for widespread use, (ii) exploitation of the concepts and methods by others, such as public sector organisations and local authorities, to create complementary data products, (iii) uptake and utilisation of these data products to inform policy and decision-making across a range of sectors including national and local government and business, and (iv) use of the team's methods to plan and manage the collection of official statistics, notably the 2021 Census.

2. Underpinning research

The design of geographical zones in terms of size, shape, characteristics and placement of boundaries plays a huge role in determining their usefulness for the collection and publication of data and for mapping and analysis. The research underpinning this impact case study involves continuing development and application of Martin, Cockings and Harfoot's innovative automated zone design methods [**3.1, 3.2**] and AZTool software (https://www.geodata.soton.ac.uk/software/AZTool/), applied to the design of collection and output geographies for official statistics. These methods were used by the Office for National Statistics (ONS) to design small residential-based geographical zones for the publication of data from the 2001 Census. These areas are called Output Areas (OAs) and Super Output Areas (SOAs), here termed 'the OA hierarchy'.

From 2008, the team's research [**3.3, Grant A**] focused on methods for updating the boundaries of OAs and SOAs to simultaneously accommodate population change, maintain confidentiality and minimise boundary changes. The resulting 'maintained' zones were used for publication of data about residents and households from the 2011 Census. They provided, for the first time, a stable set of zones across multiple censuses, facilitating analysis through time.

Due to the very different geographical distributions of residents and workers, residential-based zones are inherently less suited to publication and analysis of data about workers and workplaces. As a result, much workplace data collected by UK censuses prior to 2011 was not published by the national statistical organisations due to confidentiality concerns. From 2009, the team enhanced its automated zone design methods and AZTool software to enable design of an entirely new set of zones (termed Workplace Zones (WZs)) for the publication of workplace data [**3.4, Grant B**]. Working collaboratively with ONS, the team researched and established criteria for the design of WZs. They provided leadership on issues such as confidentiality thresholds, target numbers of workers/workplaces per zone, measures for ensuring internal homogeneity and nesting of zones within existing geographical units, to aid integration with other datasets and through time. This research was carried out as Approved Researchers within a secure setting at ONS.

To provide users with further insights into the characteristics of workers and workplaces at the small area level, the team subsequently developed a geodemographic Classification of Workplace Zones (COWZ). This involved synthesising a wide range of census variables about workers and workplaces into a simplified two-tier classification, which captures the key differences and similarities between areas. A prototype version of COWZ for England and Wales was initially developed by the team with ONS (released 2015), and was later followed by a full UK version with ONS, National Records of Scotland (NRS), and Northern Ireland Statistics and Research Agency (NISRA) (released 2018) [**3.5, Grant B**]. The team also carried out novel research using census commuting flow data and COWZ to reveal the relationships between small areas of residence and work [**3.6**].

A new, but complementary, research theme since 2013 has seen the AZTool team enhance their automated zoning methods to facilitate the design of workload areas for collection of data in the field, for example by census enumerators or survey interviewers [**Grants B, C**]. Whereas previous versions of AZTool involved aggregation of zones based on adjacency, these new methods permit evaluation of connectivity and associated travel costs when designing zones e.g. whether it is possible for an interviewer to travel from one zone to another via a road network and how much this costs in terms of time/distance. These new metrics can be combined with other measures of interviewer workloads such as likely household response rates, difficulty of access, target numbers of addresses per interviewer, compactness of zones and nesting within specified geographical areas.

The research was funded by various awards to the AZTool team from ESRC, ONS and partners, and University of Southampton. Harfoot has been seconded to ONS during 2016-2021, initially funded by an ESRC Impact Acceleration Account award (52 days, 2016-17) and then by ONS (35 days, 2017-18; 52 days 2018-19; 50 days 2019-20; 36 days 2020-2021), reflecting ongoing commitment to the strategic partnership between UoS and ONS.

3. References to the research

3.1 Martin D, Nolan A, Tranmer M (2001) The application of zone design methodology to the 2001 UK Census, Environment and Planning A, 33(11), 1949-1962 https://doi.org/10.1068/a3497

3.2 Cockings S, Harfoot A, Martin D, Hornby D (2013) Getting the foundations right: spatial building blocks for official population statistics, Environment and Planning A, 45(6), 1403-1420 https://doi.org/10.1068/a45276

3.3 Cockings S, Harfoot A, Martin D, Hornby D (2011) Maintaining existing zoning systems using automated zone design techniques: methods for creating the 2011 Census output geographies for England and Wales, Environment and Planning A, 43(10), 2399-2418 https://doi.org/10.1068/a43601

3.4 Martin D, Cockings S, Harfoot A (2013) Development of a geographical framework for census workplace data, Journal of the Royal Statistical Society Series A – Statistics in Society, 176, 585-602 https://doi.org/10.1111/j.1467-985X.2012.01054.x

3.5 Cockings S, Martin D, Harfoot A (2020) Developing a national geodemographic classification of Workplace Zones, Applied Spatial Analysis and Policy, 13, 959–983, https://doi.org/10.1007/s12061-020-09337-4

3.6 Martin D, Gale C, Cockings S, Harfoot A (2018) Origin-destination geodemographics for analysis of travel to work flows, Computers, Environment and Urban Systems, 67, 68-79 https://doi.org/10.1016/j.compenvurbsys.2017.09.002

Grants and other evidence of quality of research

Grant A: Cockings S (2008-10) Towards 2011 output geographies: adapting and evaluating automated zone design methods for maintaining the 2001 output geographies, ESRC Award ES/F035373/1 £77,859

Grant B: Cockings S, Martin D, Harfoot A (2009-20) ONS/QIF/DfT funding for OA/SOA/WZ//COWZ/Collection Geographies research and development £335,061 Award numbers PU-10-0141 (until May 2017) and PU-16-0031-6.009 (June 2017-March 2021)

Grant C: Cockings S, Martin D, Harfoot A (2016-17) Automated zone design for collection geographies (Secondment of A Harfoot to ONS), ESRC Impact Acceleration Account £12,835

4. Details of the impact

The impact relates to the publication and collection of official population statistics and has four strands: (i) implementation of the AZTool team's methods and tools by UK national statistical organisations to create official statistics for widespread use, (ii) exploitation of the team's concepts and methods by other organisations to create complementary data products, (iii) utilisation of these data products including by central and local government and business, and (iv) use of the team's methods and tools to plan and manage the workloads of field staff in the collection of official statistics, notably for the 2021 Census.

(i) The team's methods and tools have been implemented by UK national statistical organisations. ONS previously employed the AZTool software and automated zone design methods to generate a completely new set of 53,578 small areas, called Workplace Zones (WZs), covering England and Wales (released Jan 2013). As a direct result of these more suitable geographical zones, in May 2014 ONS were able to publish 21 detailed tables of demographic and employment data for workers and workplaces in each of the WZs, compared to just four such tables released for Output Areas (OAs) in 2001 due to confidentiality concerns [**5.1**]. Reviewing these outputs in 2019, ONS noted that *"One of the successes… was the advent of workplace zones to help provide a more appropriate geography for workplace statistics, where ONS SDC [Statistical Disclosure Control] worked closely with ONS Geography and University of Southampton to address disclosure risk"* which "*allowed more to be provided publicly in all areas across the country, and this particularly benefited some of the origin-destination outputs*" [**5.2**].

Following positive user feedback for WZs and strong demand for UK-wide statistics, National Records of Scotland (NRS) and Northern Ireland Statistics and Research Agency (NISRA) requested the creation of WZ boundaries for Scotland and Northern Ireland. Produced by ONS in collaboration with the AZTool team, these were published in 2016, together with associated data for WZs in Scotland. Building on the team's prototype geodemographic classification of workplace zones for England and Wales (COWZ-EW), a full UK version (COWZ-UK) was produced and published by ONS in 2018 [**5.3**].

(ii) The reach of this impact has continued to grow, as **other organisations have adopted the concepts of OAs/SOAs and WZs/COWZ and produced related data products**. UK Travel to Work Areas were built from SOAs by Newcastle University/ONS in 2015 and are used in policy and planning by business, central and local government. For their 2016 Census, the Central Statistical Office (CSO) created WZs and released associated data for the Republic of Ireland [**5.4**]. In 2017, the Greater London Authority (GLA) commissioned a bespoke London Workplace Zones Classification [**5.5**]. GLA summarised the power of these new data, which can be used by organisations across London *"to help with economic, transport and other planning and to identify appropriate areas for siting projects"* [**5.5**]. The Health and Safety Executive (HSE) aggregated potentially disclosive business-level data from ONS' Inter-Departmental Business Register to WZs, thus enhancing their National Population Database (NPD). "*The use of WZs has allowed HSE to undertake analysis based on comprehensive and annually updated business data which have been statistically controlled to protect data sensitivity".* This has meant that "*de-sensitised data can be shared with external partners for wider research and analysis. Outside of HSE the data have been used for natural hazard risk assessment, emergency planning, and transport planning"* [**5.6**]. WZs and COWZ are embedded within Public Health England's online Strategic Health Asset Planning and Evaluation (SHAPE) Atlas, used by NHS and Local Authority professionals to plan service delivery in health and social care.

(iii) While the most direct impact relates to the production of official statistics, by far **the largest group of beneficiaries are the users of small area statistical data,** who now have access to detailed information and mapping on populations both at locations of residence and workplace. Since 2014 ONS has provided an Open Geography Portal service from which users can

download OA, SOA and WZ digital boundaries and lookup tables, of which there have been more than 80,000 downloads to date [**5.1**].

The new series of workplace-related data products has provided users with greatly enhanced insights into the distribution and characteristics of workers and workplaces at the small area level and is now underpinning planning and decision-making in a range of sectors. Representative examples from local government and business are included here. The City of London Corporation describes WZs as *"a valuable tool for analysing workplace data at a local level and being able to clearly identify the spatial patterns and characteristics of the workforce"* [**5.7**]**.** Hampshire County Council has grouped together WZs to permit new insights into the demographic, socio-economic, occupational and travel-to-work characteristics of workers in local 'employment centres' in Hampshire [**5.8**]. Greater London Authority has employed WZs and COWZ-EW to explore changes in the number of employees in WZs in London between 2009 and 2015 and to provide in-depth insights into different types of employment clusters across London at the local level [**5.9**]. Hackney Council based its 2015-2025 Transport Strategy on evidence gained from analysis of its resident and workplace populations [**5.10**]. CACI, a key commercial data provider, has generated a unique segmentation of the UK workforce based on WZs (termed Workforce Acorn) for exploitation by clients in a range of sectors [**5.11**].

New and ongoing impact of the OA hierarchy is evidenced by its adoption as a common non-disclosive geography for data aggregation and sharing between different agencies. A key example is the 2015 and 2019 Indices of Deprivation, constructed by the Ministry for Housing, Communities and Local Government as the official measure of relative deprivation in England, based on the 2011 SOAs. These "*are used by national and local organisations to identify places for prioritising resources and more effective targeting of funding"* [**5.12**]

Most recently, ONS and the Joint Biosecurity Centre (JBC) combined the unique workplace and residential perspectives provided by the WZ and SOA geographies to inform national response to the COVID-19 pandemic [**5.13**]: (a) The WZ geography has provided the ideal basis for aggregation of potentially disclosive data on businesses and employees from the Inter-Departmental Business Register, permitting the estimation of industry-related COVID-19 risk. This workplace data has been combined with SOA-level residential characteristics to inform decisions about local lockdowns. (b) The SOA geography has been employed for integration of data from a wide variety of sources (including the Indices of Deprivation and industrial risk) to construct a COVID-19 risk index. These data have been linked to wastewater catchment areas to identify areas at greatest risk. This information has been used to inform targeted sampling to detect virus RNA in wastewater to provide early warnings of outbreaks.

(iv) The team's most recent enhancements to AZTool enable the **design of efficient and effective workload areas for the collection of data in the field**. This functionality is now firmly embedded in ONS' 2021 Census fieldforce management processes and is being explored for use in survey design [**5.1**]. AZTool was used to design Coordinator Areas for managing workloads of field staff for the 2019 Census Rehearsal and Interviewer Areas for the 2019 Census Coverage Survey Rehearsal. These were the precursors to the full 2021 Census and 2021 Census Coverage Survey. The ability of AZTool to rapidly and repeatedly design zones using different criteria was exploited by ONS to evaluate different sample designs and associated cost implications for the 2021 Census Coverage Survey, informing the decision to retain a two-stage sampling method based on OAs and postcodes.

Significance and long-term sustainability of impact. This is evidenced through ONS' confirmed plans for 2021 Census design. ONS' user consultations revealed strong demand for OAs, SOAs and WZs, and their associated data products, to be continued as 2021 census outputs. *"Engagement with users on the value of the OA and WZ geographies continues to demonstrate a great deal of support for the principles of stability, comparability over time and continuity with outputs from previous censuses"* and *"the OA hierarchy (OAs,* [SOAs]*, WZs) for which census outputs will be presented will remain largely unchanged to enable comparability with both 2001 and 2011 Census results"* [**5.14**]. These outputs will be produced using the AZTool team's automated design and maintenance methods, which are now well-established in-house within ONS [**5.1**].

Beyond UK official statistics, the AZTool team has provided expert advice on automated zone design to analysts in a range of sectors, many of whom have employed AZTool for analysis. These include UK local boundary reform, utilities and sports management, cancer surveillance in the US, and design of new census output geographies for South Africa and Costa Rica.

The impact of this research was recognised in 2015 through the Royal Geographical Society's Back Award to Martin *"for influencing policy with respect to the Census and its applications"*. One award is made annually for applied or scientific geographical studies which make an outstanding contribution to the development of national or international public policy [**5.15**].

5. Sources to corroborate the impact

5.1 Testimonial from Director of Population and Public Policy Operations, Office for National Statistics

5.2 Spicer K (2019) Statistical Disclosure Control (SDC) for 2021 UK Census. Paper EAP125, UK Statistics Authority, Methodological Assurance Review panel – Census https://uksa.statisticsauthority.gov.uk/about-the-authority/committees/methodological-assurance-review-panel-census/papers/ (see final para, p30-31)

5.3 Office for National Statistics (2018) Classification of Workplace Zones (COWZ-UK) https://www.ons.gov.uk/methodology/geography/geographicalproducts/areaclassifications/2011workplacebasedareaclassification (see page 17, section 6)

5.4 Testimonial from Census Geography Department, Central Statistics Office, Ireland

5.5 Greater London Authority (2017) ADD2111 Production of a Classification of Workplace Zones https://www.london.gov.uk/decisions/add2111-production-classification-workplace-zones (see section 1.9)

5.6 Testimonial from Head of Science Impact and Quality, Health and Safety Executive

5.7 City of London Corporation (2014) City of London Workforce CENSUS 2011 – Introduction, No longer online - copy in REF document repository (see p. 12, para 1)

5.8 Hampshire County Council (2014) Census 2011 Workplace Zones: Examples of Workplace Population Data https://documents.hants.gov.uk/Economy/ExamplesofWorkplaceZones.pdf (see entire document, but particularly section 3, page 12 onwards, on Employment Centres)

5.9 Greater London Authority (2016) Economic Evidence Base for London 2016 https://www.london.gov.uk/sites/default/files/economic_evidence_base_2016.compressed.pdf (see section 2.61, including Maps 2.21 & 2.2, pages 76-77; and Maps B6 & B7, pages 646-647)

5.10 Hackney London Borough Council (2015) Hackney Transport Strategy 2015-2025: Evidence Base Paper 1: Census 2011 Travel to Work Data-Transport Analysis https://drive.google.com/file/d/1tu4p_CGFB29e-nBExceDR72Br-RsTLqE/view (see Section 5: Travel patterns and characteristics of Hackney's Workplace Population, page 28 onwards)

5.11 Workforce CACI (2015) Acorn product sheet https://www.caci.co.uk/sites/default/files/resources/Workforce_Acorn_product_sheet.pdf

5.12 Ministry of Housing, Communities and Local Government (2019) The English Indices of Deprivation 2019, Research Report https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/833947/IoD2019_Research_Report.pdf [see pages 7-8]

5.13 Testimonial from Deputy Director, Innovation and Partnerships Hub, Joint Biosecurity Centre

5.14 HM Government (2018) Help Shape Our Future: The 2021 Census of Population and Housing in England and Wales (2021 Census White Paper) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/765089/Census2021WhitePaper.pdf (see sections 5.36 and 5.37, pages 101-102)

5.15 Royal Geographical Society (with IBG) (2015) Back Award. Citation: David Martin "for influencing policy with respect to the census and its applications" https://www.publishersweekly.com/binary-data/NEWS_BRIEFS/attachment/000/000/192-1.pdf (see page 3)