Pop247NRT:

Near real-time spatiotemporal population estimates for health, emergency response and national security
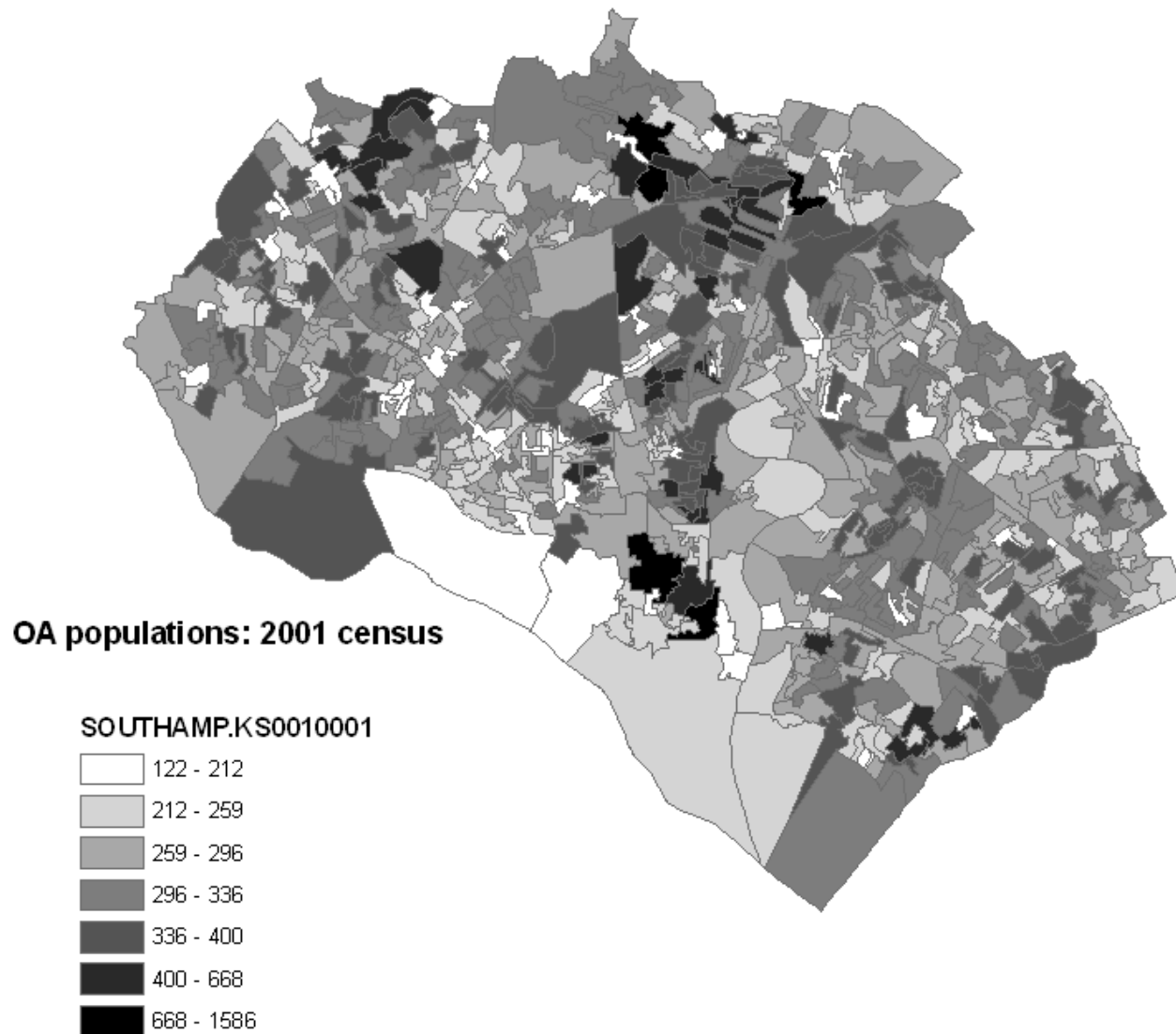
Samantha Cockings

Why do we need space-time specific population estimates?

- For decision-making, planning and policy formulation in many sectors
  - E.g. emergency planning/response, health, national security
- How many people in specific places and specific times e.g. hourly, daily, weekly, seasonal, one-off events/scenarios?
- Idea of 'normal' patterns and 'current/recent' situation
- Census data inadequate (even with recent improvements in workplace, daytime populations etc)
  - Static, residential-based, every 10 years

The problem …
A typical small area population map

OA populations: 2001 census
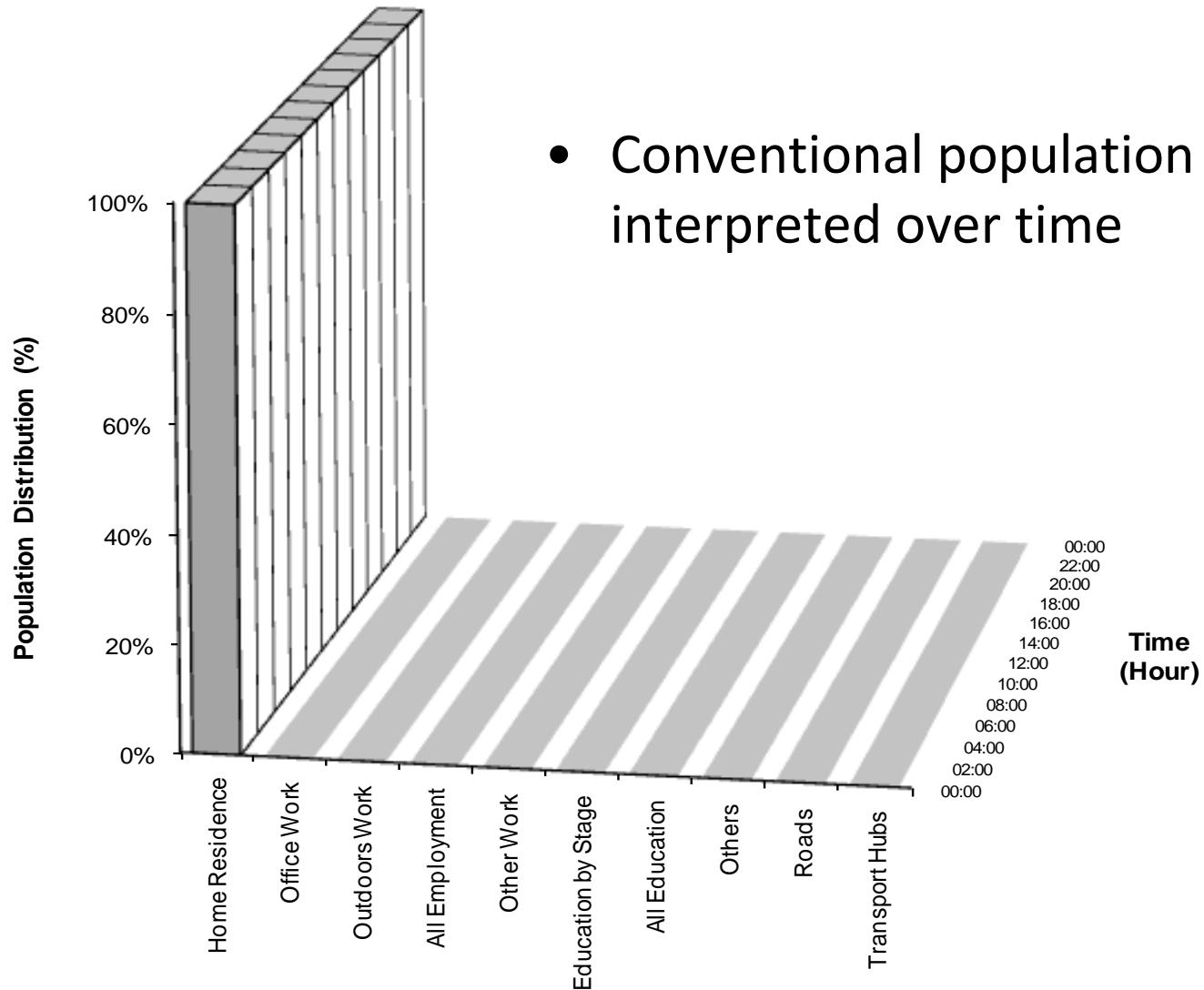
SOUTHAMP.KS0010001

☐	122 - 212
☐	212 - 259
☐	259 - 296
☐	296 - 336
☐	336 - 400
☐	400 - 668
☐	668 - 1586

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Inadequate spatio-temporal resolution

- Conventional population map interpreted over time

Required spatio-temporal resolution

- Integrated multi-source datasets interpreted over time
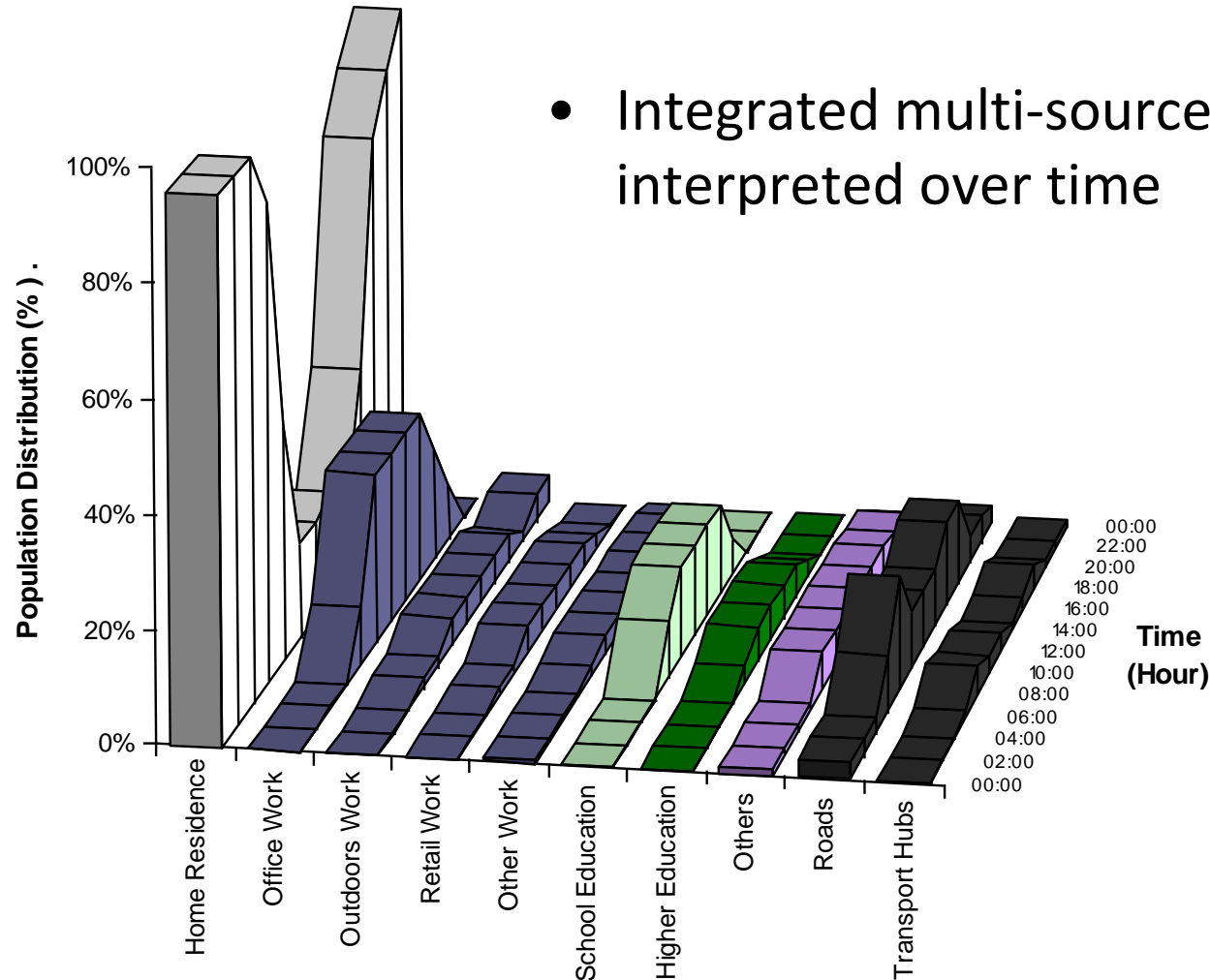
Previous Population247 research

- ESRC Population24/7 project, 2009-2011
  - Spatiotemporal population estimates – by time of day, week, term, season, etc.
  - General approach/framework
  - Software: SurfaceBuilder247 (.NET)
  - Sample outputs

- Various related PhD / University of Southampton projects
  - population exposure to hazards e.g. flooding, radiation

Spatial domain

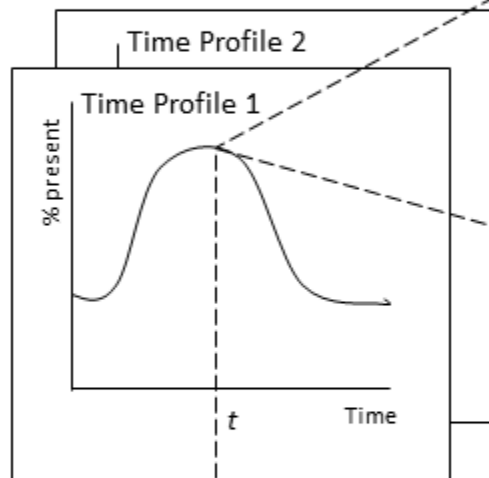Locations
(origins and destinations)
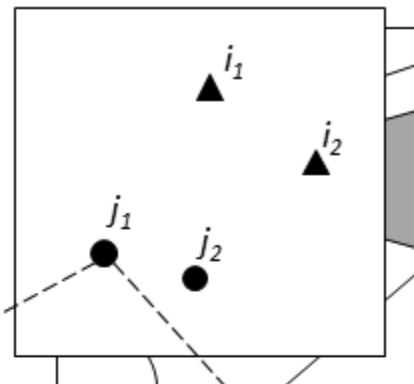
Background features

Background

Time profiles

Magnitudes

Temporal domain

Time Profile 2

Time Profile 1

% present

t

Time

Attribute domain

Origins

	PR_{c1}	PR_{c2}	...
i_1	100	20	...
i_2	80	150	...

Destinations

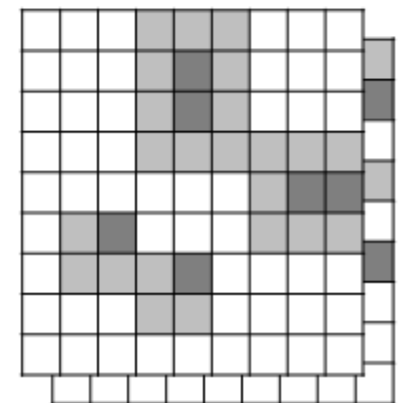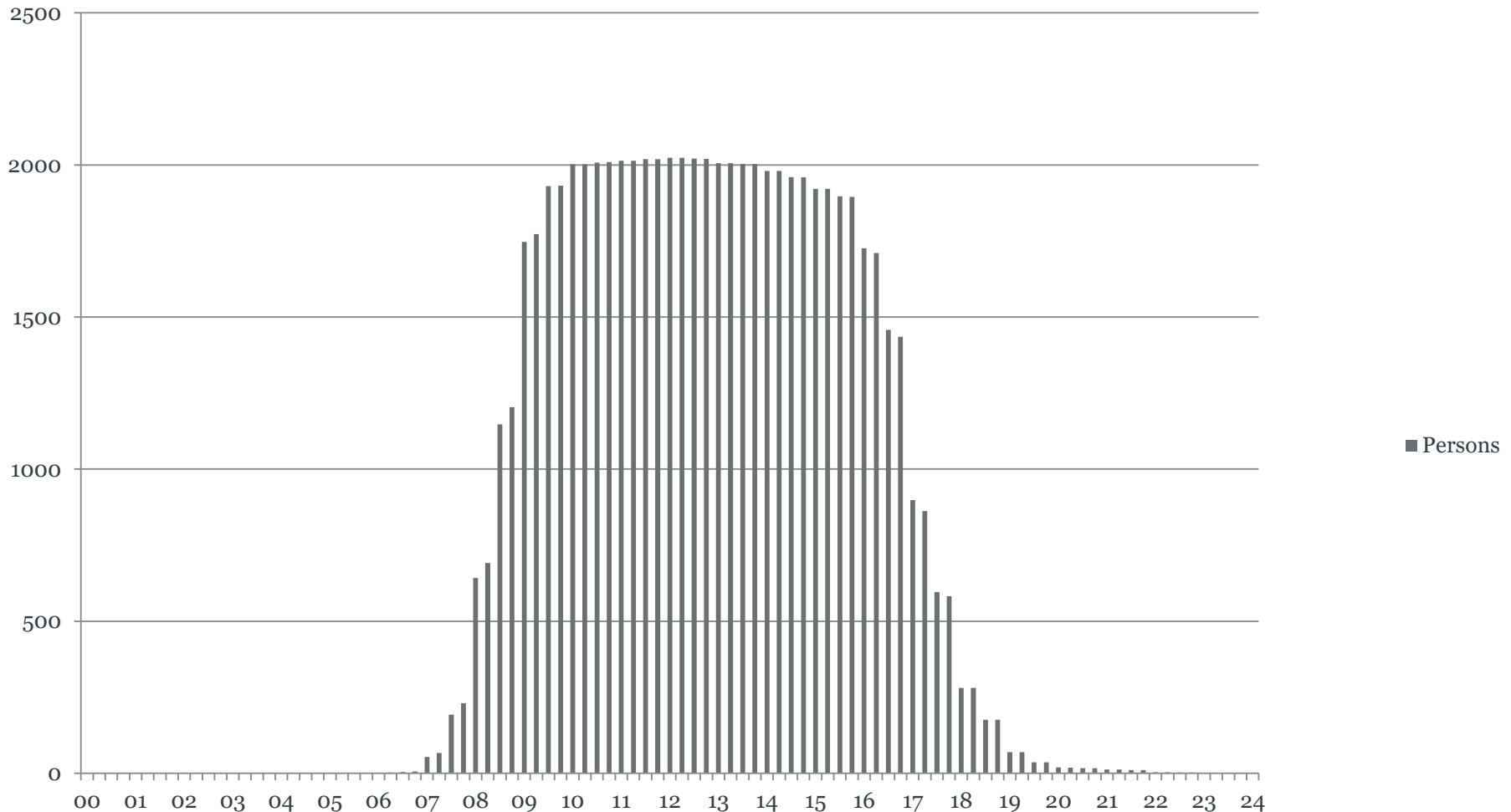|	PNR_{c1}	PNR_{c2}	$TProf$	W	...
j_1	250	50	1	10	...
j_2	100	25	2	5	...

Data
system

Analysis
system

Query
(space-time-attribute)

Modelled
output

Mapped
representation

University of Southampton travel survey: respondents on campus, 15 minute intervals
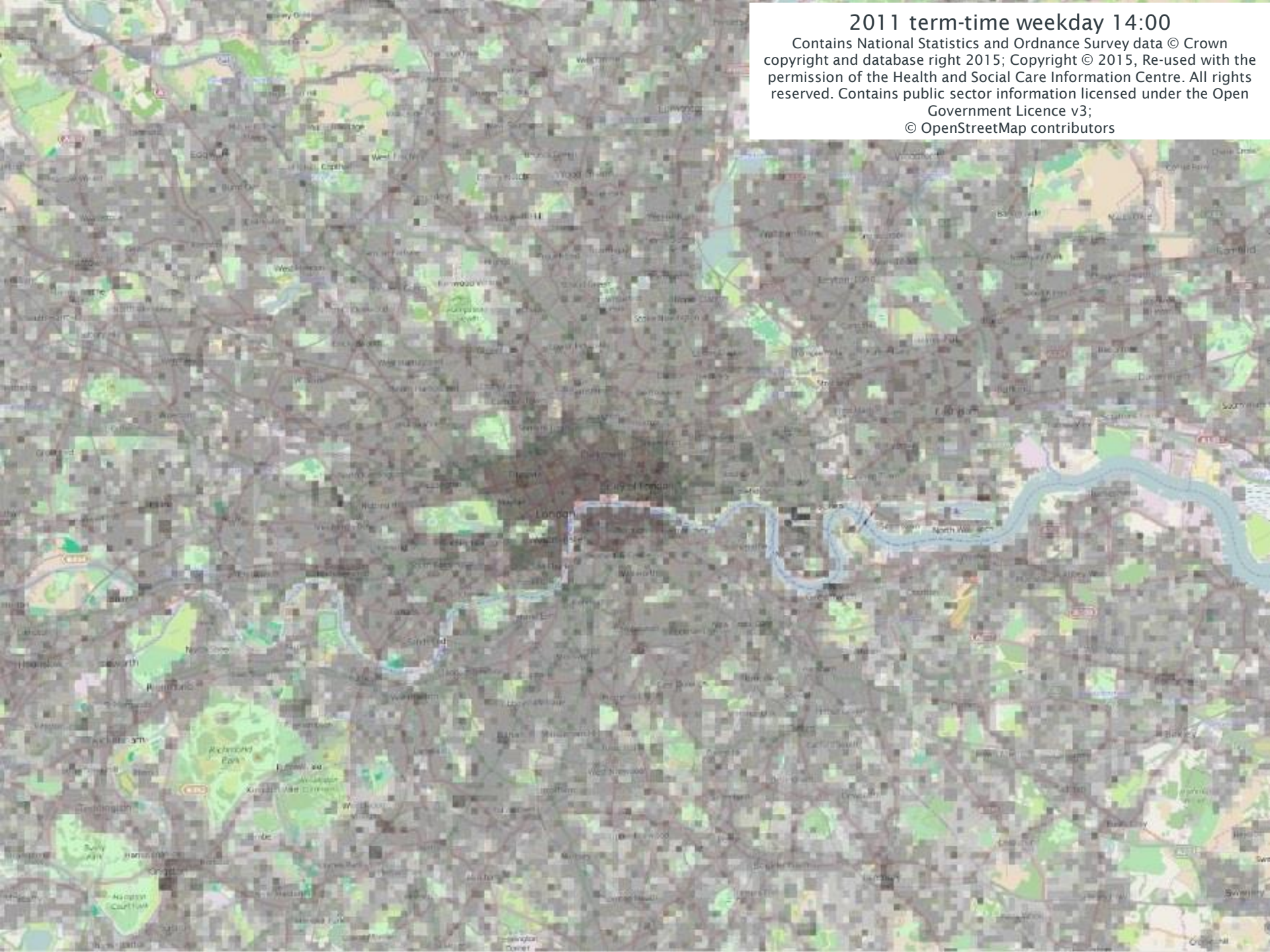
Total population +/- external visitors
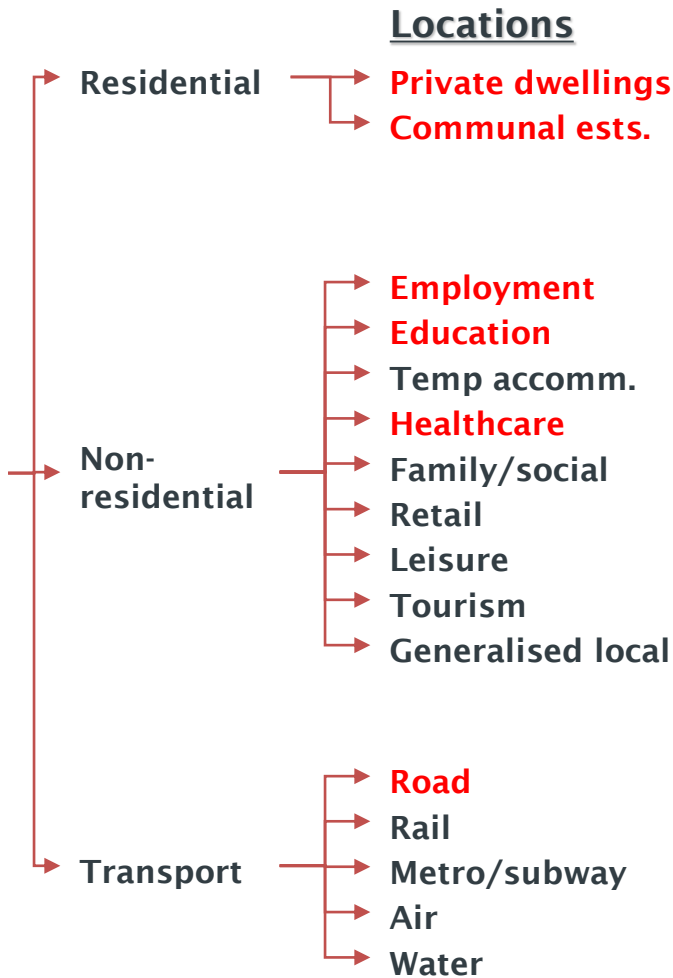
	Locations	Data Sources
Residential	**Private dwellings**	- **Census, Mid-Year Population Estimates (MYEs)**
	Communal ests.	- **Census, Mid-Year Population Estimates (MYEs)**
Non-residential	**Employment**	- **Census, Annual Business Inquiry, QLFS**
	Education	- **EduBase, DCSF school performance tables, HESA**
	Temp accomm.	- VisitBritain, Annual Business Inquiry
	Healthcare	- **Hospital Episode Statistics**
	Family/social	- VisitBritain
	Retail	- Annual Business Inquiry, commercial sources
	Leisure	- **ALVA Visitor Statistics,** DCMS
	Tourism	- **ALVA Visitor Statistics,** DCMS
	Generalised local	-
Transport	**Road**	- **DfT Road Statistics, Annual Average Daily Flow**
	Rail	- National Rail station usage data
	Metro/subway	- DfT Light Rail Statistics, TfL Tube customer metrics
	Air	- **CAA UK Airport Statistics**
	Water	- DfT Sea Passenger Statistics , London River Services

Acronyms: **QLFS** Quarterly Labour Force; **DCSF** Department for Children, Schools and Families; **HESA** Higher Education Statistics Agency; Survey; **DCMS** Department for Culture, Media and Sport; **ALVA** Association for Leading Visitor Attractions; **DfT** Department for Transport; **TfL** Transport for London; **CAA** Civil Aviation Authority

New sources/signals/proxies for more dynamic/less routine activities … e.g.

- **Retail** – supermarkets, retail centres, high streets

- **Leisure** – tourist sites, leisure activities, sports events

- **Transport** – transport hubs e.g. airports, train stations

- **One-off/unusual events** – festivals, Bank Holidays

Population247 Near Real Time (Pop247NRT) Project

- ESRC NEFD Policy Demonstrator Project (Feb 17-May 18*)
  - Enhance existing methods and tools for harvesting, processing, integrating and calibrating new, emerging and existing data sources
  - Deliver two case studies with project partners to show how methods can be used to inform policy and practice
  - Promote knowledge transfer between and beyond partners
- Partners
  - Public Health England (PHE)
  - Defence, Science and Technology Laboratory (Dstl)
  - Health and Safety Executive (HSE)

*3-month no-cost extension

Pop247NRT: project team

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Southampton

PHE
Tom Charnock

Dstl
Glen Hart

HSE
Will Holmes

University of Southampton (UoS)

Geography
Samantha Cockings
David Martin

GeoData

GIS

Web

Electronics and Computer Science (ECS)
Nick Gibbins

E·S·R·C
ECONOMIC
& SOCIAL
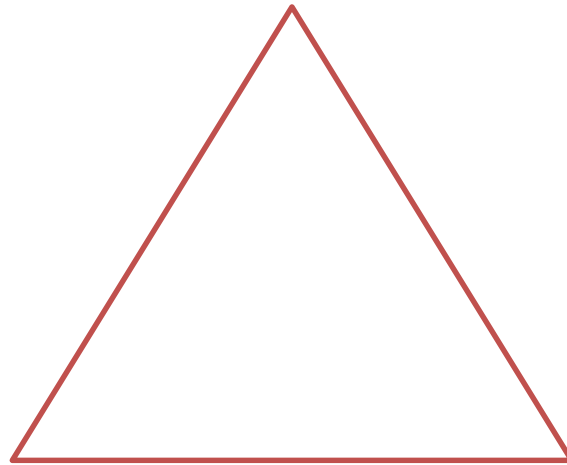RESEARCH
COUNCIL

New, emerging and existing forms of data
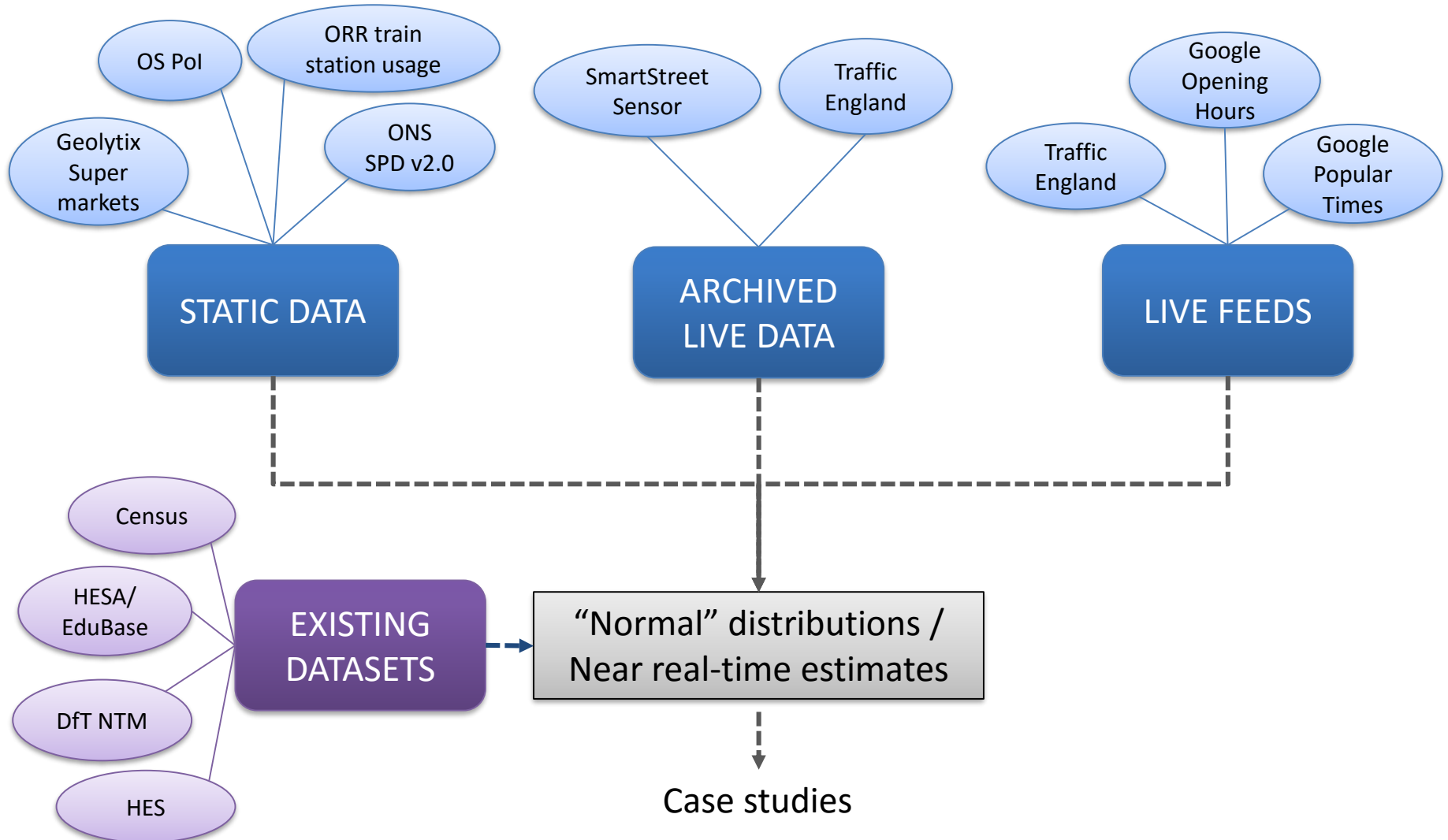
Retail example 1: stand-alone large stores e.g. supermarkets

Geolytix locations + size bands

Locations + extents

Time profiles

Google Popular Times

Magnitudes

Geolytix size bands
Indicative footfall – by size band

Geolytix - supermarkets

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	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	gluid	retailer	fascia	store_name	address_c	address_t	town	locality	postcode	long_wgs	lat_wgs	bng_e	bng_n	pqi	open_date	size_band
1739	1.01E+09	Aldi	Aldi	Aldi Henbury, Bristol	Crow Lane		Bristol	Henbury	BS107EN	-2.62537	51.5078	356696.3	178949.6	1		B
1740	1.01E+09	Aldi	Aldi	Aldi Bristol	670-680 Fishponds R	Bristol	Fishponds	BS163HJ	-2.53373	51.4783	363032.5	175622.9	1		B
1741	1.01E+09	Aldi	Aldi	Aldi Bristol	North Stre	Bedminst	Bristol	Southville	BS31JA	-2.61421	51.4428	357410	171715.2	1		B
1742	1.01E+09	Aldi	Aldi	Aldi Bradley Stoke	Brook Wa	Patchway	Bristol	Bradley St	BS329DA	-2.55803	51.5413	361398.1	182646.7	1		B
1743	1.01E+09	Aldi	Aldi	Aldi Bristol	273-279 Church Road	Bristol	Easton	BS59HT	-2.55244	51.4598	361717.7	173575.8	1		B
1744	1.01E+09	Aldi	Aldi	Aldi Bristol	Bath Road		Bristol	Longwell	BS309DE	-2.49472	51.4383	365711.6	171156.1	1		B
1745	1.01E+09	Asda	Asda	Asda Bristol Whitchurch Superstore	Oatlands Avenue	Bristol	Hengrove	BS140ST	-2.57085	51.4139	360398.4	168482.2	1		D
1746	1.01E+09	Asda	Asda	Asda Filton Superstore	Abbeywood Retail P	Bristol	Filton	BS347JL	-2.56047	51.5055	361198.7	178662.1	1		C
1747	1.01E+09	Asda	Asda	Asda Bedminster Superstore	East Street		Bristol	Bedminst	BS34JY	-2.59523	51.4438	358730.3	171823.6	1		D
1748	1.01E+09	Asda	Asda Livin	Asda Living Bristol	Eastgate Retail Park	Bristol	Eastville	BS56XX	-2.56623	51.4737	360771.2	175123.9	1		C
1749	1.01E+09	Asda	Asda Supe	Asda Longwell Green Supercentre	Craven Way		Bristol	Longwell	BS307DY	-2.49701	51.448	365559.8	172238	1		D
1750	1.01E+09	Asda	Asda Supe	Asda Patchway Supercentre	Highwood Lane	Bristol	Patchway	BS345TL	-2.59716	51.5305	358674.9	181467.2	1		D
1751	1.01E+09	Asda	Asda PFS	Asda Bristol Whiteladies Road Petrol Filling Station	Whiteladies Road	Bristol	Redland	BS82XS	-2.61473	51.4702	357400.1	174771.4	1		A
1752	1.01E+09	Budgens	Budgens	Blackhorse	Black Hors	Westerlei	Bristol	Mangotsfi	BS167AN	-2.48238	51.4967	366611.6	177648.8	1		B
1753	1.01E+09	Farmfood	Farmfood	Bedminster	13-14 St Catherines	Bristol	Bedminst	BS34HG	-2.59617	51.4414	358662.8	171549	1		B
1754	1.01E+09	Farmfood	Farmfood	Filton	Unit 6 Shield Retail C	Bristol	Filton	BS347BR	-2.57381	51.5088	360275.7	179039.1	1		B
1755	1.01E+09	Iceland	Iceland	Hartcliffe-Symes Ave	Unit 1-3 Peterson Av	Bristol	Hartcliffe	BS130BE	-2.59809	51.405	358496.4	167510.8	1		B
1756	1.01E+09	Iceland	Iceland	Fishponds	Unit 3A Ch	Channons	Bristol	Fishponds	BS162EA	-2.53493	51.4797	362950.3	175783.2	1		B
1757	1.01E+09	Iceland	Iceland	Bedminster	2-8 St Catherines Pla	Bristol	Bedminst	BS34HG	-2.59585	51.4417	358685.3	171591	1		B
1758	1.01E+09	Iceland	Iceland	Staple Hill	Units 3-5 Fountain C	Bristol	Mangotsfi	BS165LR	-2.50477	51.4815	365045.7	175964.9	1		B
1759	1.01E+09	Iceland	Iceland	Knowle	Units 20-21 The Broa	Bristol	Knowle	BS42QU	-2.56802	51.4344	360613.2	170759.1	1		B
1760	1.01E+09	Iceland	Iceland	Easton	190 Lawnwood Road	Bristol	Easton	BS50EU	-2.56566	51.4616	360800.3	173779.8	1		B
1761	1.01E+09	Iceland	Iceland	Kingswood	41-43 Regent Street	Bristol	Kingswoo	BS158LA	-2.50952	51.463	364702.1	173906.7	1		B
1762	1.01E+09	Iceland	Iceland	Henbury	139-141 Crow Lane	Bristol	Brentry	BS107DS	-2.62203	51.5091	356929.6	179097.4	1		A
1763	1.01E+09	Iceland	Iceland	Southmead 1	Arnside Road	Bristol	Southmea	BS106AT	-2.60291	51.5036	358251.1	178471.4	1		B
1764	1.01E+09	Lidl	Lidl	Lidl Southmead	Southmead Road	Bristol	Southmea	BS105NE	-2.59206	51.5006	359001.7	178129.6	1		B
1765	1.01E+09	Lidl	Lidl	Lidl Bishopsworth	59 Whitchurch Lane	Bristol	Hartcliffe	BS137TE	-2.61119	51.4145	357593.9	168574.1	1		B
1766	1.01E+09	Lidl	Lidl	Lidl Hanham	135 High Street	Bristol	Hanham	BS153QY	-2.51205	51.448	364514.4	172247.3	1		B
1767	1.01E+09	Lidl	Lidl	Lidl Fishponds	Fishponds Road	Bristol	Fishponds	BS163UF	-2.53127	51.4791	363203.6	175715	1		B
1768	1.01E+09	Lidl	Lidl	Lidl Emersons Green	Unit A3 Th	Emerson	Bristol	Mangotsfi	BS167AE	-2.47474	51.4937	367140	177309.8	1		B
1769	1.01E+09	Lidl	Lidl	Lidl Bedminster	Sheene Road	Bristol	Bedminst	BS34EG	-2.60077	51.4381	358340.2	171187.8	1		B
1770	1.01E+09	Lidl	Lidl	Lidl Brislington	Brislingtor	Bath Road	Bristol	Brislingto	BS45NG	-2.54568	51.4309	362163	170360	1		B
1771	1.01E+09	Lidl	Lidl	Lidl Lawrence Hill	Church Ro	Lawrence	Bristol	Easton	BS50BT	-2.56468	51.4586	360865.7	173443.5	1		B
1772	1.01E+09	Makro	Makro	Makro Bristol	Lysander Road	Bristol	Patchway	BS107TZ	-2.60866	51.5249	357871.9	180844.9	1		D
1773	1.01E+09	Marks and	Marks and	Bristol	78 Broadmead	Bristol	Central Br	BS13DS	-2.59072	51.4578	359056	173378.3	1		B
1774	1.01E+09	Marks and	Marks and	Longwell Green Bristol	Unit H Longwell Gre	Bristol	Longwell	BS307DA	-2.49706	51.4458	365554.3	171988	1		B
1775	1.01E+09	Marks and	Marks and	Cribbs Causeway	The Mall,	Patchway	Bristol	Patchway	BS345QT	-2.59432	51.5237	358865.5	180702.9	1		C

Google Places – Popular Times
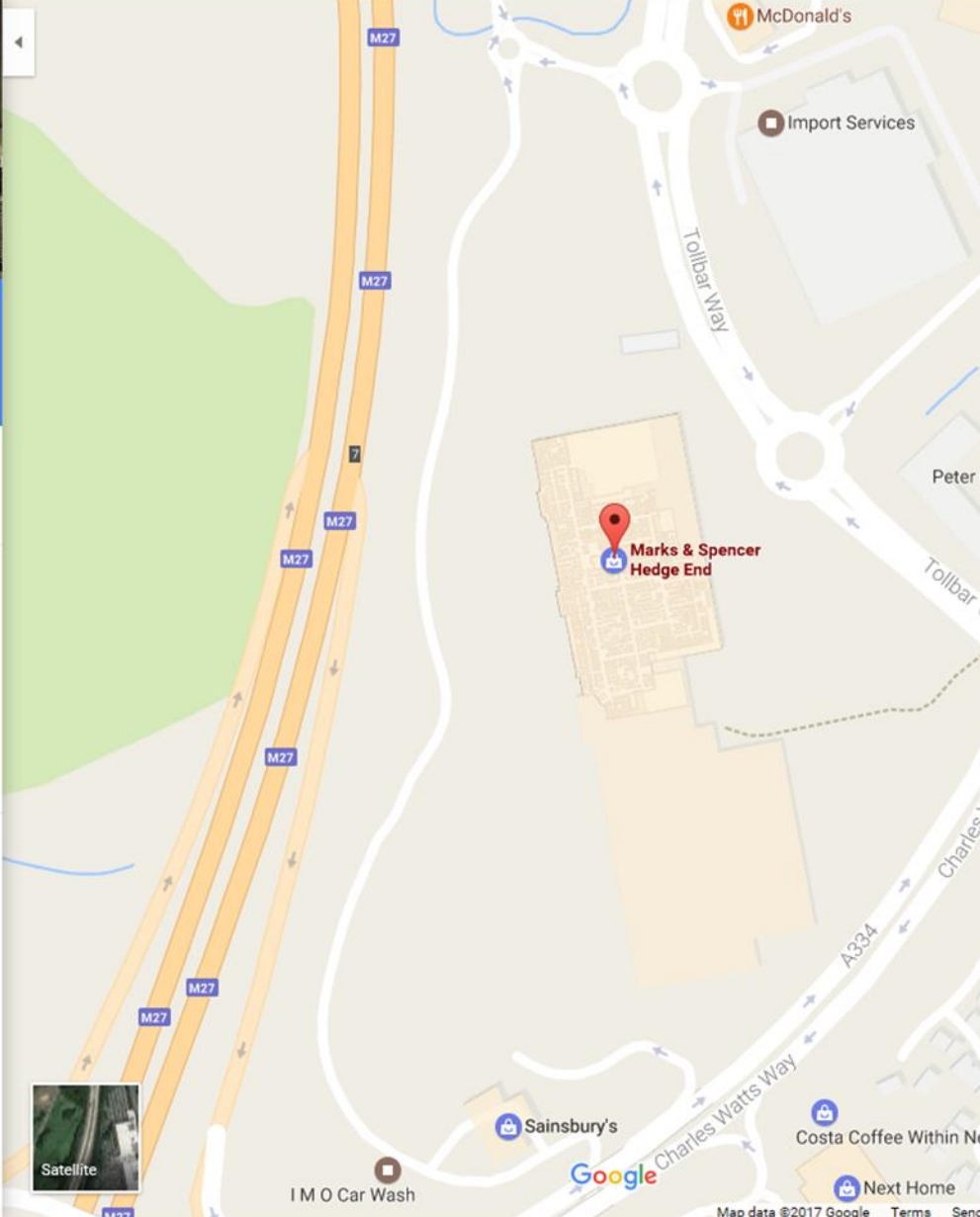
Retail example 2: area of mixed retail use e.g. high street, shopping centre

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cc-by-sa 2.0 - by Richard Bird

Census – Classification of Workplace Zones (COWZ)
OS Points of Interest – retail locations

Locations + extents
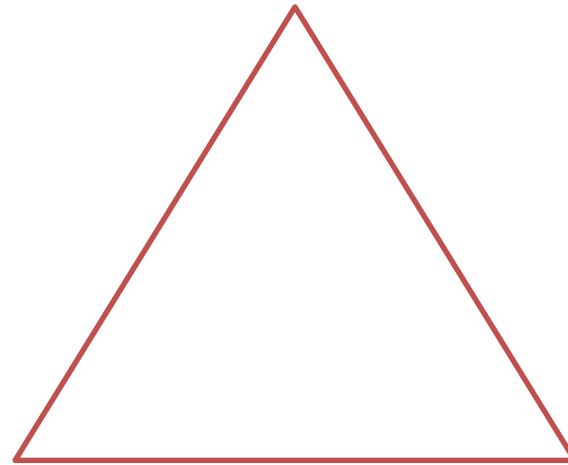
Time profiles
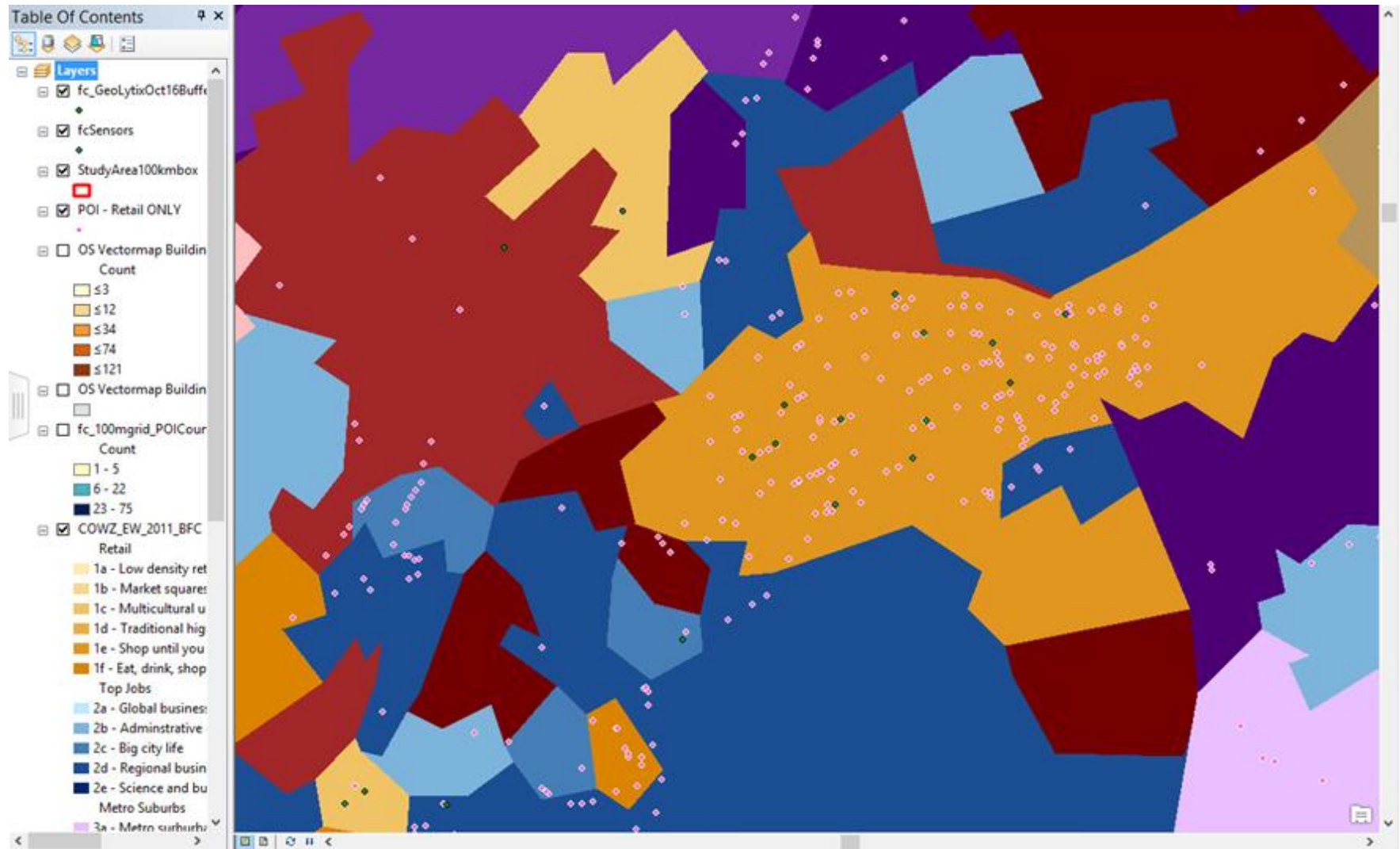
Magnitudes

SmartStreetSensor footfall profiles

SmartStreetSensor footfall counts

SmartStreetSensor / POI locations
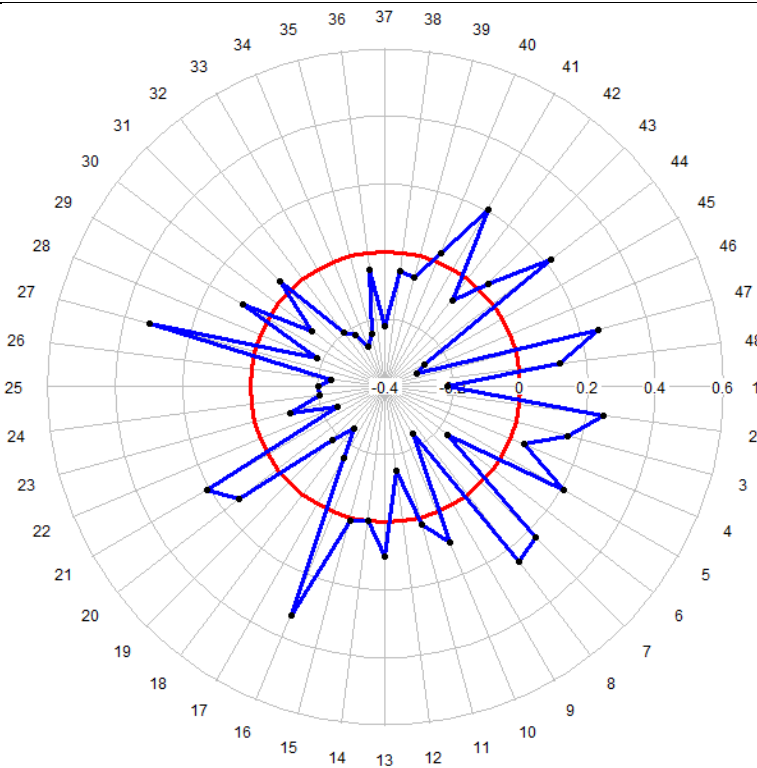
COWZ – Classification of Workplace Zones

Classification of Workplace Zones

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Retail Supergroup

Group 1.5: Shop until you drop (782 Workplace Zones)
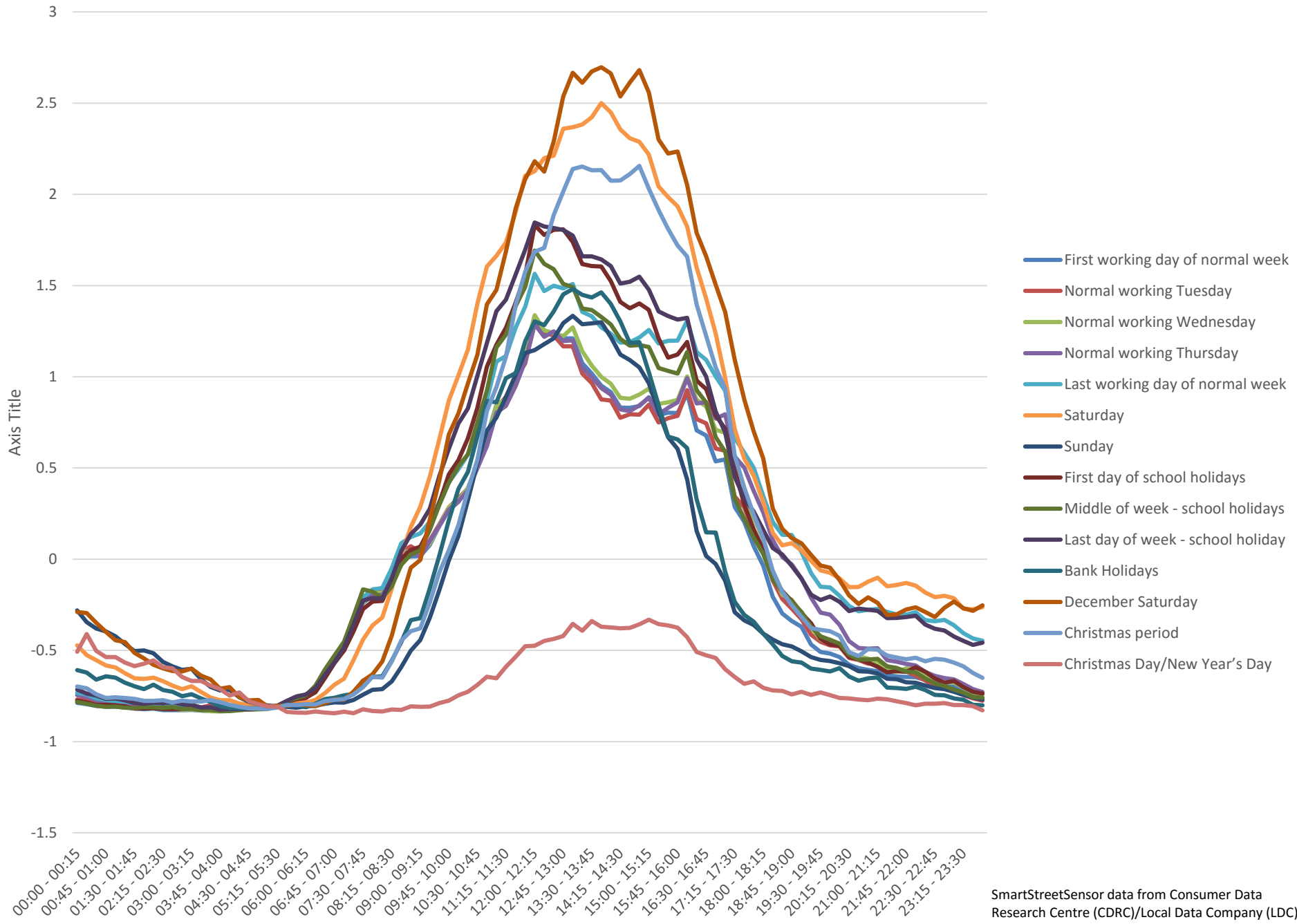Major retail centres of national and regional significance

Example(s): Meadowhall Shopping Centre, Sheffield; West Quay Shopping Centre, Southampton; Bluewater Shopping Centre, Greenhithe
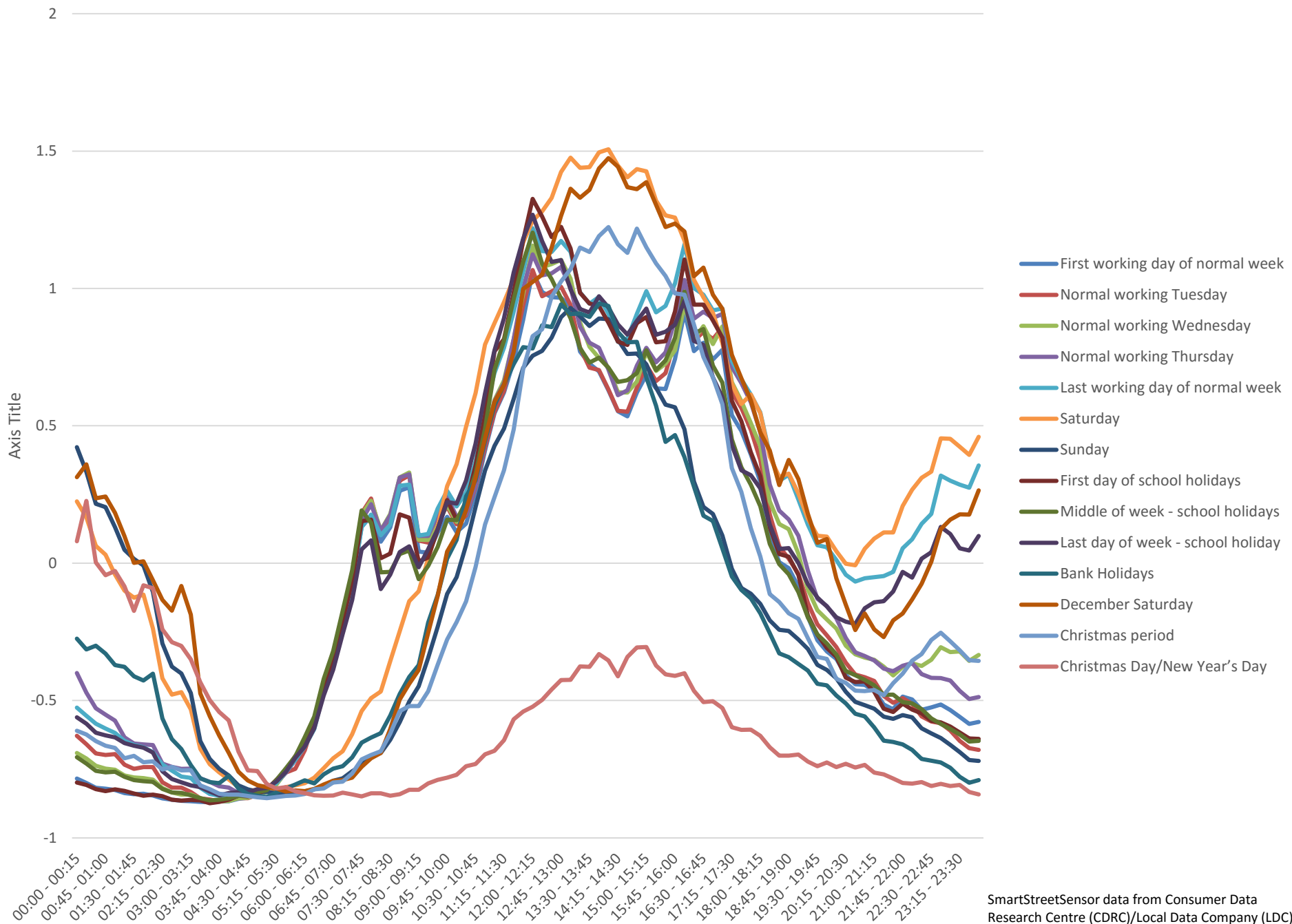

Image: S9 1EP, WZ: E33009173

High female participation in the workforce, which is young and with above average levels of Black and Asian ethnicities. Very high representation of students and part-time working. Retail and wholesale exceeds all other activities. Travel to work distances are short and percentages travelling on foot or by bicycle are high. This group includes major national and regional retail centres, including large purpose-built out of town and in-town developments.
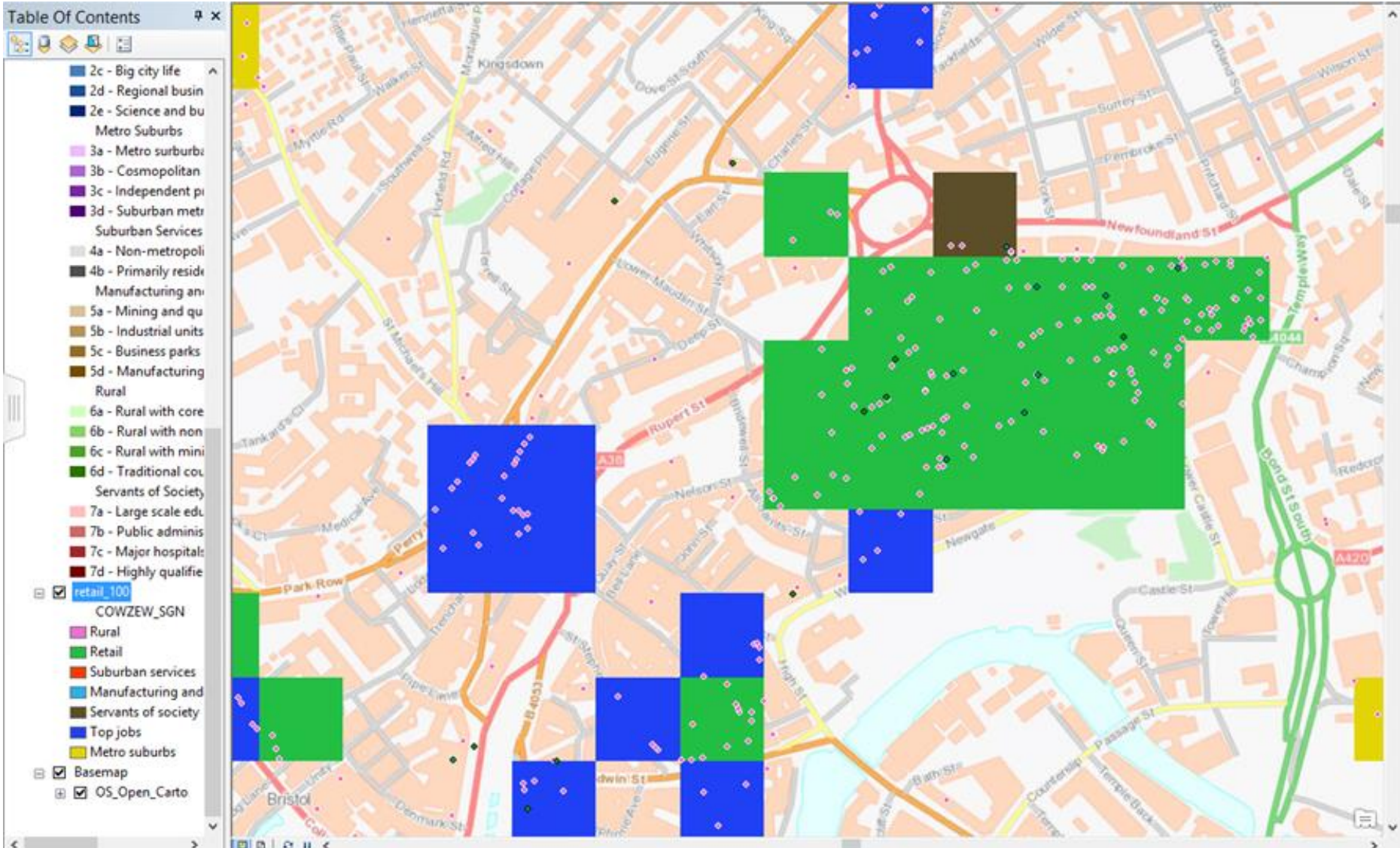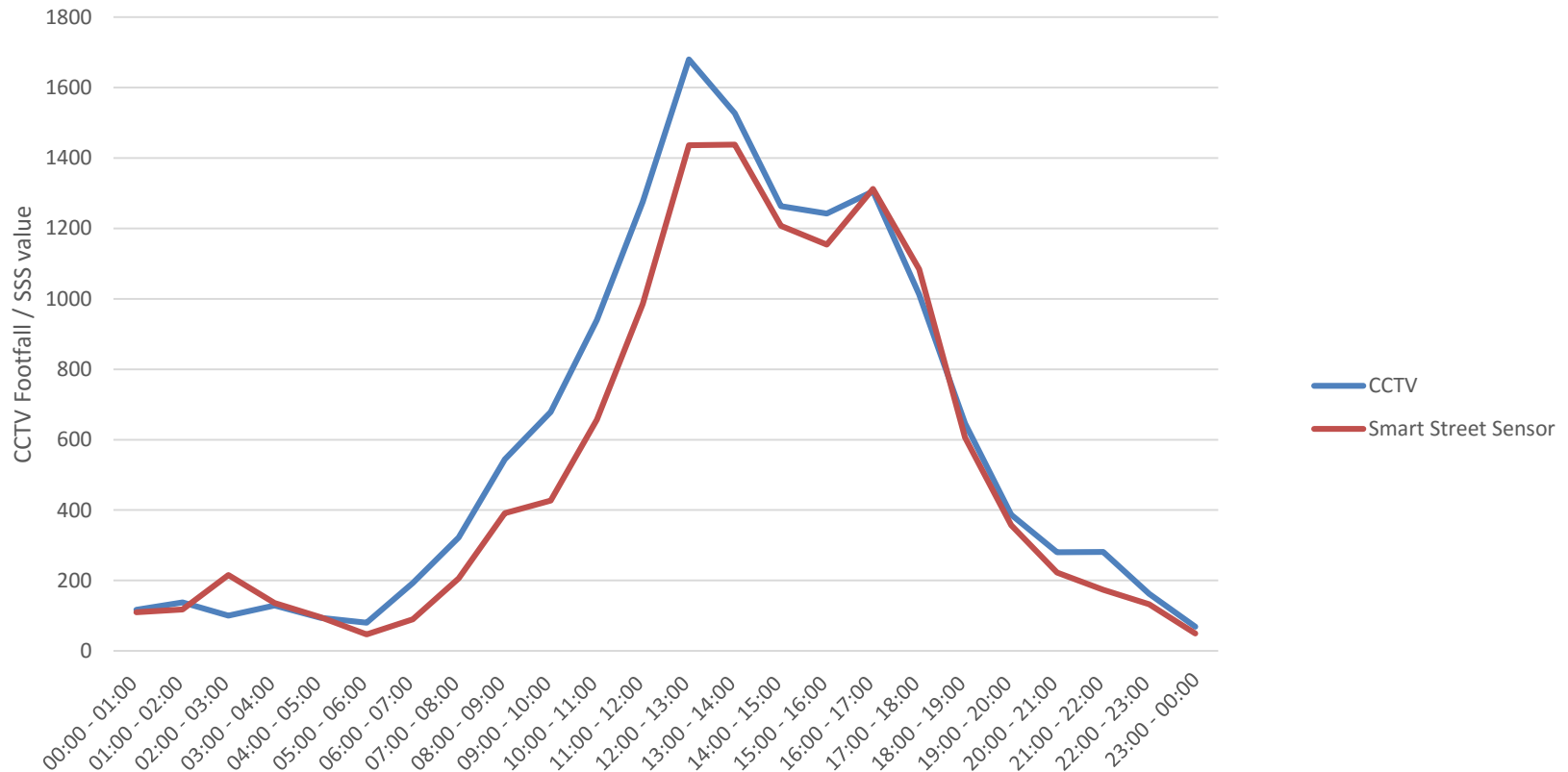
Traditional high streets

Legend:
- First working day of normal week
- Normal working Tuesday
- Normal working Wednesday
- Normal working Thursday
- Last working day of normal week
- Saturday
- Sunday
- First day of school holidays
- Middle of week - school holidays
- Last day of week - school holiday
- Bank Holidays
- December Saturday
- Christmas period
- Christmas Day/New Year's Day

SmartStreetSensor data from Consumer Data Research Centre (CDRC)/Local Data Company (LDC)

Top jobs

SmartStreetSensor data from Consumer Data
Research Centre (CDRC)/Local Data Company (LDC)

Assigning profiles/magnitudes to grid cells
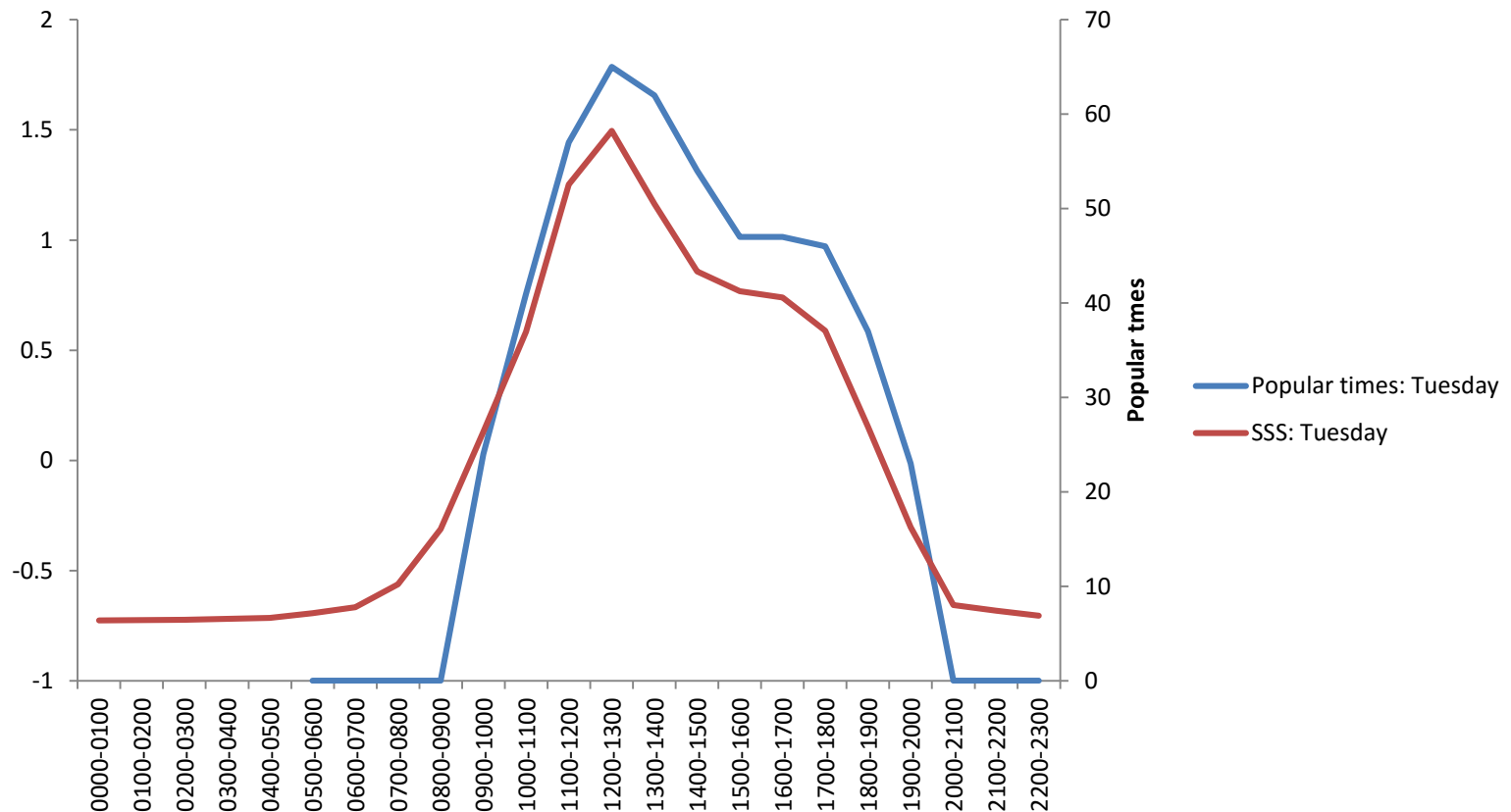
Calibration: CCTV and SmartStreetSensor data

Calibration: Google Popular Times and SmartStreetSensor data

Domains

Origins
Usual residents
Special populations
Visitors

Destinations
Workplaces
Education
Health
Retail
Leisure
Transport hubs

Background
DfT - 19 NTM periods
Traffic England – Day types

What constitutes a case study?

- The use of Pop247NRT population estimates to inform the research, practice and/or policy of one or more partners
  - Develop data libraries for study area
  - Use SurfaceBuilder247 to generate population estimates for specific times/places
 - Integrate and analyse population estimates in case studies with partners

Study area
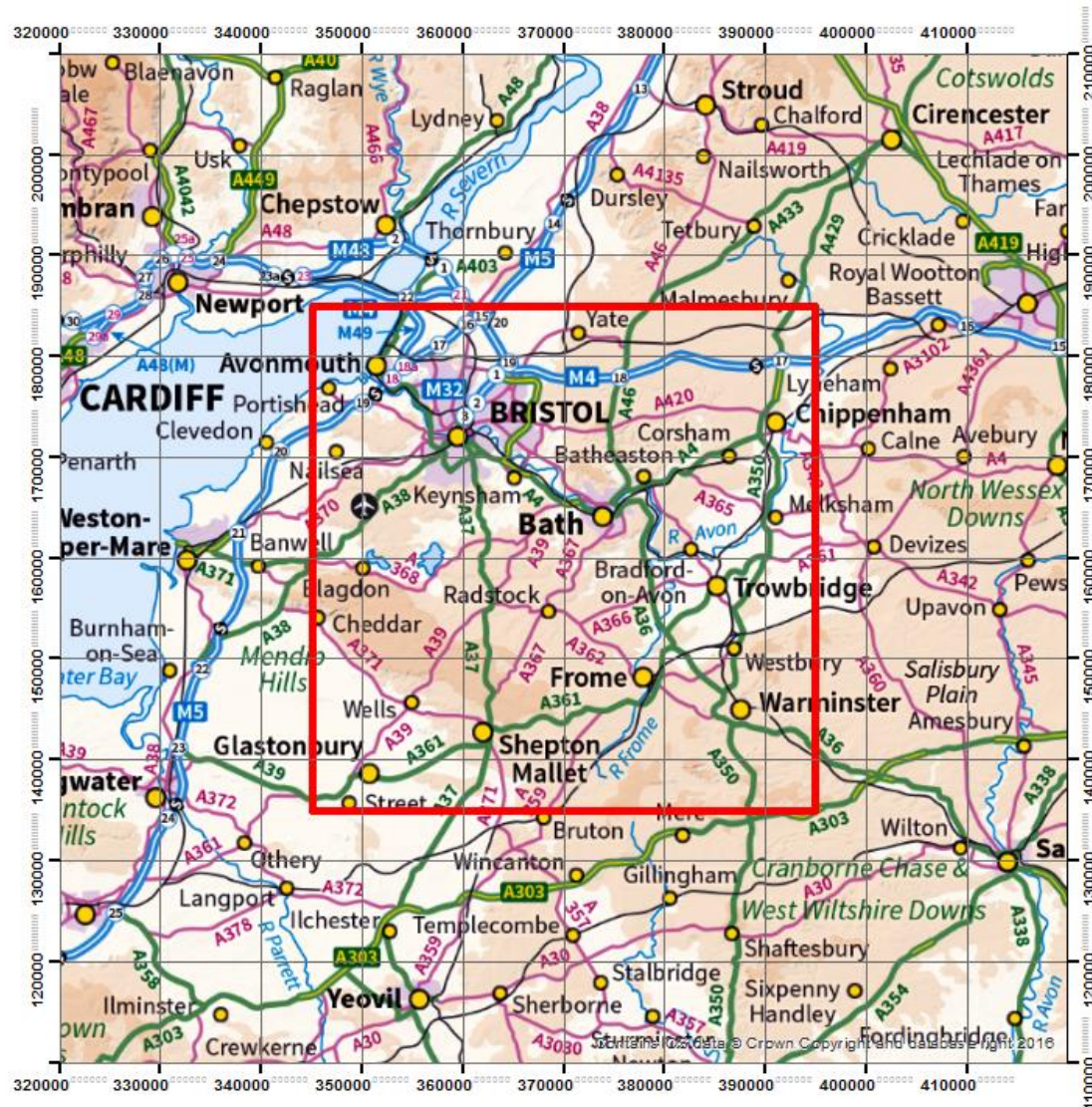
Case study 1: PHE

- Scenario modelling for nuclear power plant (NPP) licensing and planning
- Evaluation for use in PHE role in radiation emergency response
- PACE: PHE's Probabilistic Accident Consequence Evaluation software
  - Release parameters (type, amount, length of release etc.)
  - Meteorological factors (wind direction, speed etc.)
  - Population density (age, currently static night-time data)
- Seed PACE with Pop247NRT space-time specific population estimates
  - by age, on site/in-transit, visitor/resident, time of day, type of day e.g. normal, term/not-term, school holidays, public holidays, unusual events etc.) for 1 year (nominally 2016)
- Evaluate potential health outcomes

Example of four distinct plumes generated under different meteorological conditions for a single accident sequence at a hypothetical NPP in Bristol study area
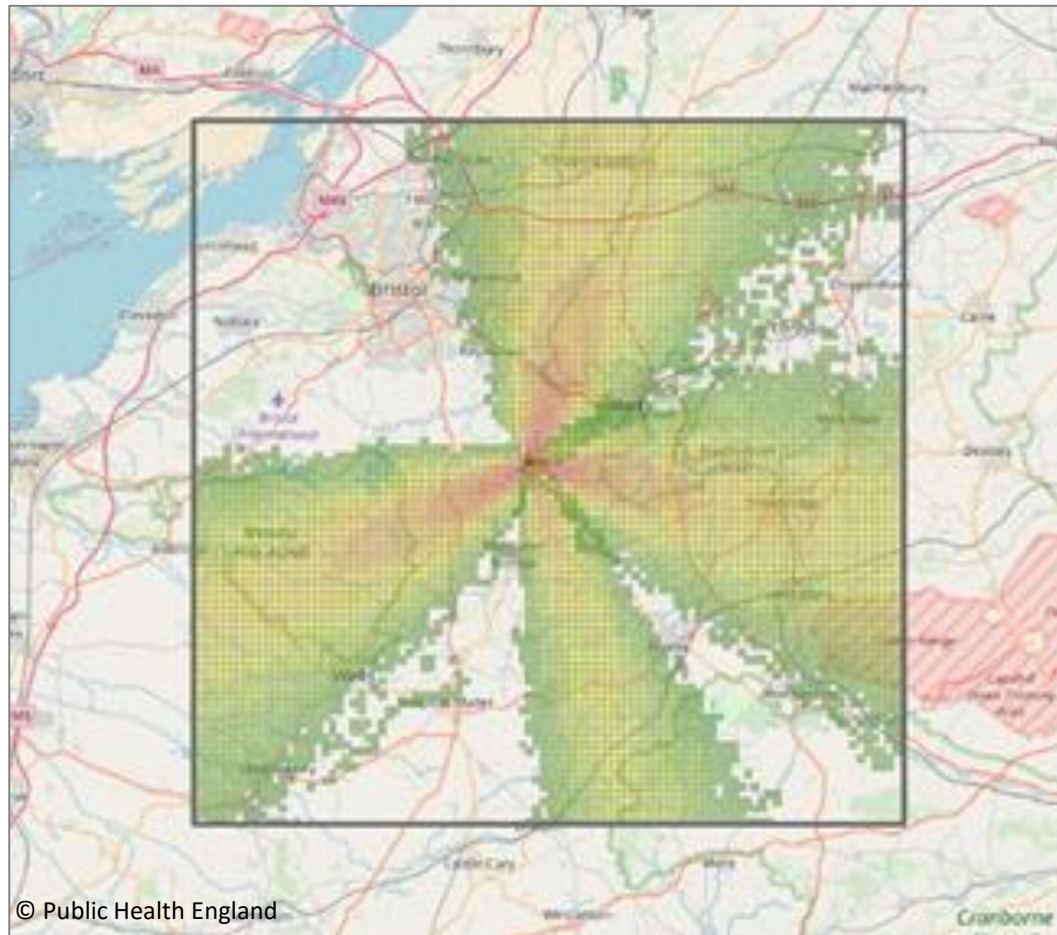
Example output: probability of the mean number of fatalities in each grid square being greater than 0.1, with a static adult population assumption

© Public Health England
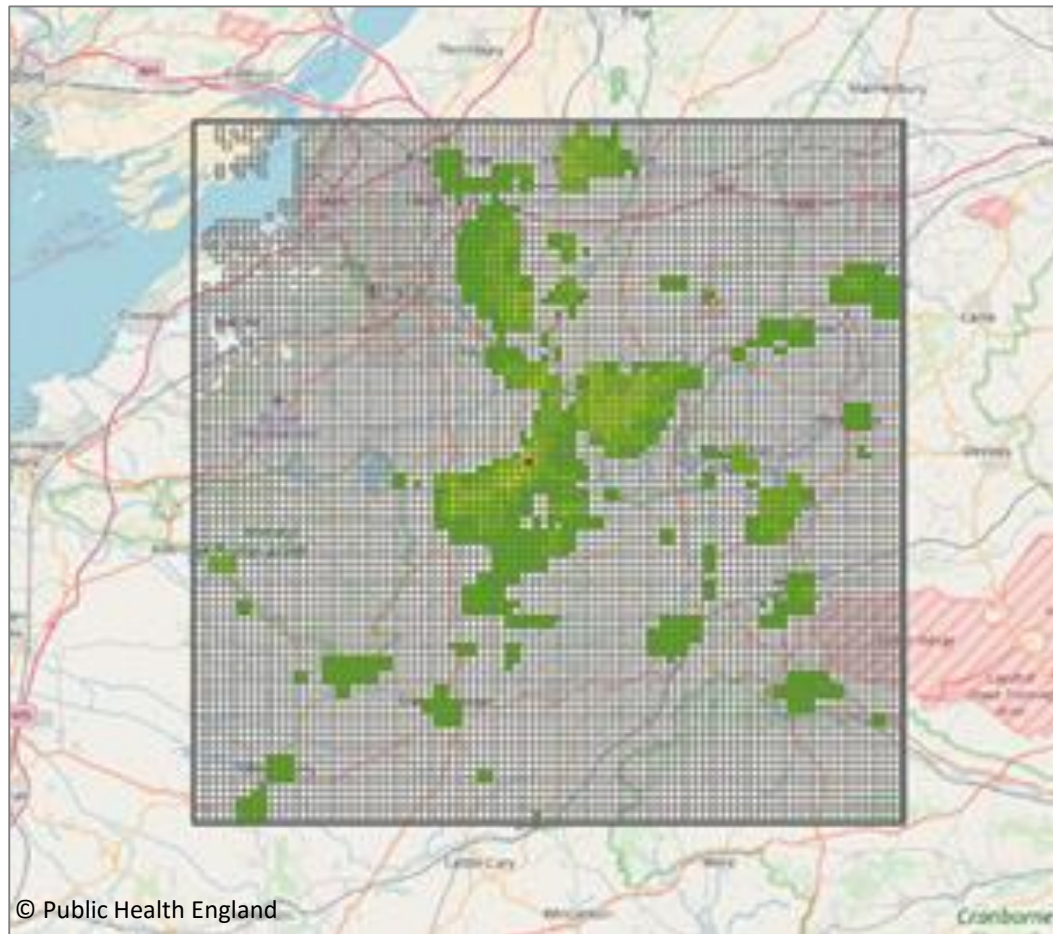
Case study 2: HSE

- Comparison of insights gained from using Pop247NRT and HSE's National Population Database (NPD) models
- NPD
  - Developed and maintained by HSE
  - GIS-based model of population
  - Population estimates for objects (buildings, transport network), for themes (e.g. residential, workplace) and specific time periods (e.g. daytime term-time)
- Implement both models and compare outputs - either for PHE case study or for HSE-led case study (workplace-based incident)

Case study 3: Dstl

A feasibility assessment to indicate:

- Whether the Pop247NRT models might be used in other (data poor) countries?

- Which datasets are essential?

- Which methods can be readily translated and implemented in other data settings?

- What are the barriers to implementation?

Timeline

Feb-Dec 2017	Jan-Apr 2018	Apr 2018	Apr-May 2018
Data library preparation	Case studies	Stakeholder workshop	Reporting/ data depositing

Planned outputs

- Methods/tools
- Data libraries
- Processed population estimates
- Data and findings from case studies
- Policy brief + podcast, incorporating findings from stakeholder workshop
- Project report(s)
- Contributions to conferences, seminars, other events
- Academic papers

Dissemination/communication activities

- Partner meetings (04/04/17 @Dstl; 08/11/17 @UoS + email)
- Contributions to conferences/seminars/events:
  - Dstl/NGA Workshop on Place Intelligence, London, Aug 2017
  - SmartPop Seminar, Brussels, Oct 2017
  - European Forum for Geography and Statistics Conference, Dublin, Nov 2017
  - [GIS Research UK Conference, Leicester, April 2018]
- Stakeholder Workshop (April 2018)
- Website, Twitter feed

Stakeholder workshop

- 26 April 2018, PHE (Chilton, Oxfordshire)
- Aims
  - Showcase data, methods, tools, case studies
  - Identify opportunities and challenges in implementing these for decision-making and policy formulation
  - How to scale-up, within and beyond partners' sectors
- Participants
  - c. 35 total: 15 project team + c.5 invitees per partner
- Outputs
  - Policy brief + podcast

Projected policy/non-policy impacts

- Policy and practice
  - Raised awareness within/beyond partners
  - Collaborative development of methods/tools
  - New understanding of population distributions
  - Examples of use of outputs in policy/practice
  - Identification of implementation challenges
  - Longer-term: more efficient and effective decision-making/ planning/policy
- Academic
  - Enhanced methods/tools for analysing NEFD & existing datasets
  - Data libraries and processed layers (open where possible)
  - Insights into population distributions
  - Of interest to any researchers/practitioners generating or using population estimates + ONS (Census Transformation Programme)

Acknowledgements

Pop247NRT

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