Locating police bases to minimise response time to immediate 999 incidents using ArcGIS

Data provided by South Yorkshire Police

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Doing more with less

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South Yorkshire Police (SYP) reintroduced Neighbourhood Policing teams in the autumn of 2017 (Whitehouse, 2018). No additional money was made available for the change in resourcing and as a result there are now fewer officers available to respond to 999 immediate incidents.

Is your emergency an immediate incident?

Call handlers determine whether you require a police officer arriving with blue lights based on the following:

- Incident is ongoing, offenders on scene
- The presence of weapons
- Threat of injury or to life
- Protection of a scene for the collection of evidence
- The caller is vulnerable e.g. disabled

Travelling with blue lights poses a risk to both the public and officer's safety and it is necessary that SYP can both justify the grading of the incident as immediate and respond quickly.

Analysis Questions

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Based on immediate incident demand:

- Where are the best places for response hubs to be located?
- Should they be existing or new locations?
- What distances are involved – max and mean?

In consultation with SYP 19 current police stations were identified as suitable response bases for vehicles and are classed as existing locations. This work stipulates that police officers start their response journey from a police station/hub.

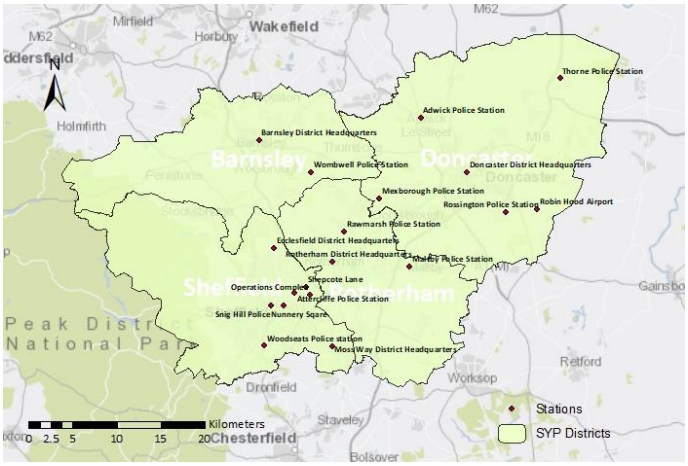

Figure 1, SYP Districts and existing station locations

Data pre-processing

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Location-Allocation in ArcGIS

This study used the Network Analyst extension in ArcGIS to complete the modelling. This requires three datasets:

1. A road network. This enables more realistic distances to be measured rather than using the Euclidean measure.
2. Candidate sites for the stations to be located. Current station sites were used when modelling existing locations. Node points from the road network were used to simulate a blank canvas to generate new locations.
3. Spatially distributed demand. SYP provided immediate incident count data per LSOA for months within the 2017/18 financial year. These were added to centroid points for each of the LSOAs.

These three datasets are then used to examine a variety of scenarios using two location-allocation models.

Location-Allocation Models

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ReVelle and Eiselt (2005) describe location analysis as "siting facilities in some given space" (2005, p1).

The aim of the service or facility will determine the most appropriate allocation model to use. Both p-median and maximal-covering were used here.

P-median

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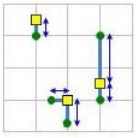
P-median aims to find locations that minimise the distance (or time) taken to access the service provided. Weighting can be added to increase significance of higher demand (Tomintz et al, 2015).



(ESRI, 2018)

Maximal – Covering

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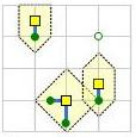
Maximal - covering aims to ensure service facilities are sited in locations that mean no user will be further away from the service than a given distance (or time) (Tomintz et al, 2015).



(ESRI, 2018)

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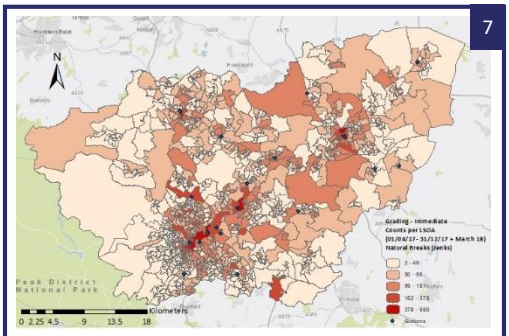

Figure 2, Immediate demand counts per LSOA

The immediate incident data per LSOA plotted as a choropleth shows areas within the town/city centres of the four main urban areas of South Yorkshire as having higher counts. Across the area counts range from 2 to 980.

This indicates that there is unequal demand across the county. By using both the p-median and maximal covering models it is possible to model outcomes that show the locating of stations based on this varied demand as well as buffered distance.

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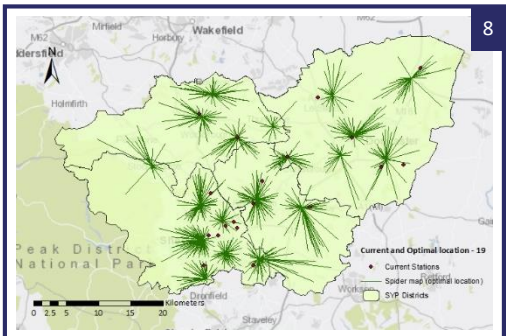

Figure 3, Current verses 'optimal' locations for 19 police stations, p-median

As the demand centroids are weighted, longer distances to low level immediate count centroids are evident, particularly in the north-west spider near the border of Barnsley and Sheffield. It is also interesting to note that 4 current stations are located very near to areas chosen by the model.

If these locations were implemented it would reduce the maximum distance travelled from 18.43km to 12.80km and the mean distance would reduce by nearly 0.75km to 3.34km.

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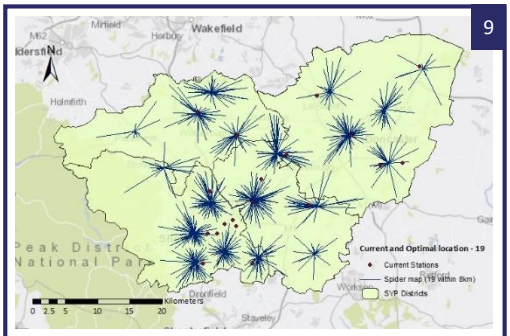

Figure 4, Current verses 'optimal' locations for 19 police stations, maximal-covering within 8km

Here demand has been allocated to 19 stations and those stations must be within an 8km cut-off. This has placed stations (the centre of the spider) in areas with lower demand. These locations would allow officers to attend all centroids within 10 minutes (at 30mph); however, some stations will have lower amounts of demand (north-west spider).

Location-allocation models are a useful tool to add to the extensive local knowledge SYP have of their force area and offer the opportunity to examine a range of scenarios.

References

ESRI, 2018, Location-allocation analysis, ArcMap, [Online]. [Accessed 4 June 2018]. Available from: http://desktop.arcgis.com/en/arcmap/latest/extensions/network-analyst/location-allocation.htm

ReVelle, C.S., Eiselt, H.A., 2005, "Location analysis: A synthesis and survey", European Journal of Operational Research 165 (2005) 1–19

Tomintz, M., Clarke, G.P. and Alfadhli, N., 2015. Location-allocation models. *Geocomputation. A practical primer*, pp.185-197.

Whitehouse, P. 2018. Neighbourhood policing could hit force's other performance. The star. [Online]. 23 April 2018. [Accessed 4 June 2018]. Available from: https://www.thestar.co.uk/news/new-neighbourhood-policing-could-hit-force-s-other-performance-1-9129101

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