Police Scotland OR Challenge – resource and response optimisation

Context

Police Scotland aim to respond as quickly as possible to incidents reported to them by the public, in order to provide a good service, reduce the chance of serious harm and maximise investigative opportunities. In the city of Glasgow, when an incident gets reported, it immediately gets categorised as immediate, prompt or standard, depending on the severity of the incident. Thereafter, the control centre must decide when to send an officer and from which police station of the three police stations in the city they should be sent from when responding to the incident. However, given a finite supply resource (Police Officers) and demand that fluctuates in volume and severity across time and space, planning the allocation of resources is complex. Too many officers allocated to a shift at the wrong time is a waste of valuable resources, and does not deliver value for money. Moreover, if too few officers are allocated to a shift we are unable to respond to incidents quickly resulting in a poor service. A visual representation of three time stages are provided in the form of a heat map Figures 1-3. In these figures, the red regions indicate many incidents while the green regions indicate only a few incidents. The red dots on the map indicate the three police stations from which officers may be sent.

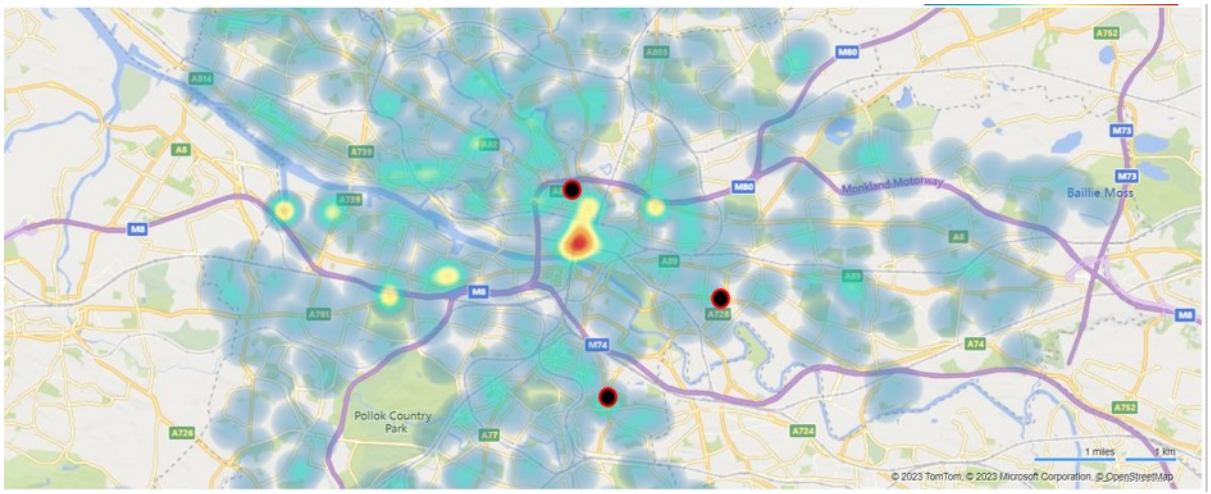

Figure 1 - A heatmap of incidents for the early shift.

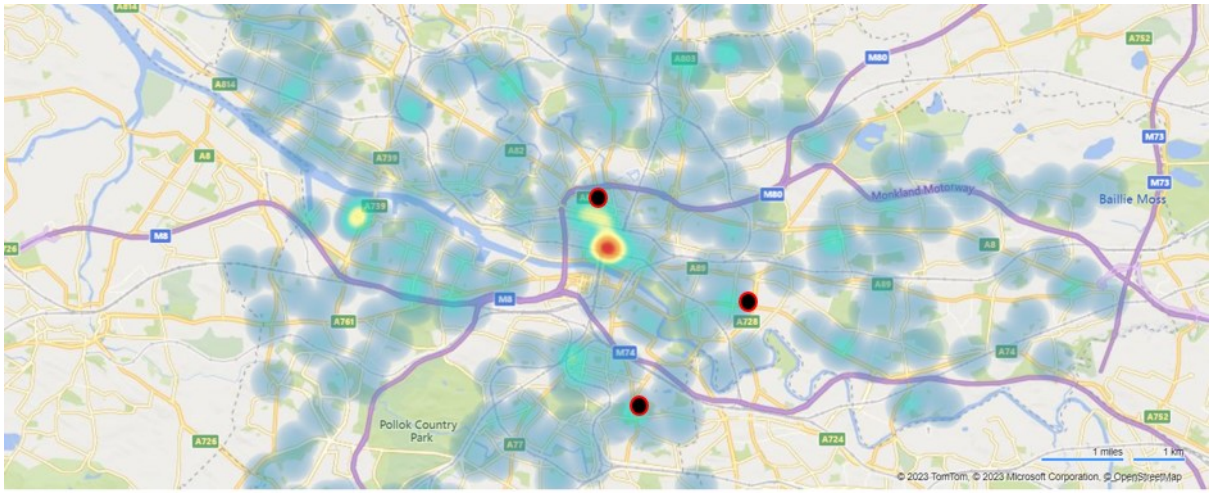

Figure 2 - A heatmap of incidents for the day shift.

Figure 3 - A heatmap of incidents for the night shift.

Challenge

Your challenge is to use the incident dataset provided, alongside the locations of three stations, and optimise a resource plan. What this means is that we'd like you to determine the optimal number of officers required at each station for each day of the week so that we can respond to as many incidents as possible, within the specified time limits. There is a degree of freedom in how you achieve this, within the limits of the data and rules outlined below.

Data

The data are provided in a single .xlsx file as two sheets. The first sheet contains the data related to the incidents, while the second sheet contains some information about the three police stations. The data are defined as follows:

URN: the URN for each incident.

Day: the date that the incident took place.

Hour: the hour that the incident took place.

Priority: the priority of the incident. 'Immediate' are the highest priority, followed by 'Prompt' and then 'Standard'.

Lats/Longs: the location of the incident or police stations.

Deployment time: the time, in hours, that the incident will take to be resolved.

Station no.: the station number.

Rules

There are a number of rules that must be followed when deriving your solution:

- *Resolving incidents*: an incident is resolved when an officer has travelled to the incident (see travel time below), and the deployment time has elapsed. Once this has occurred, the officer is then free to attend another incident. An Officer sent to an incident at the end of their shift (e.g. hour 23), may resolve that incident (even if it takes them into the next day). This means that if an officer is scheduled

to end their shift at 07:00 and they are assigned to an incident at 6:55, even if the deployment time exceeds ten minutes, the officer can still respond this issue;

- *Response time*: we need to respond to incidents as soon as possible, based on their priority. 'Immediate' incidents must be responded to within 1 hour, 'Prompt' within 3 hours, 'Standard' within 6 hours. So if an 'Immediate' incident occurs at 11, it must be responded to by 12, and if a 'Standard' incident occurs at 14, it must be responded to by 20. This response requirement carries overnight, so if a 'Prompt' incident occurs at 23, it must be responded to by 2 the next day. All incidents must be resolved, even those which are not responded to within the above limits. 'Responded to' in this context means that an available officer has been allocated to that incident and has travelled there;

- *Travel time:* all officers are available to start their shift at the base station which you have assigned them to, and the time it takes them to get to an incident is the distance between their base station and the incident, calculated as the crow flies at a flat rate of 30mph;

- *Respawning*: once an officer has travelled to and resolved an incident (the deployment time has elapsed), they 'respawn' (appear) at a police station and can be redeployed instantly from their base station. In other words we do not need to consider the time it takes for the officer to travel back to the base station. Note that this is a simplifying assumption.

To give an example, imagine Officer A was responding to an incident 15 miles away from their base station at 2pm. It takes them 30 minutes to travel there (30mph), so the time is now 2:45. It takes them 45 minutes to resolve the incident, so the time is now 3:15. New incidents will have been reported at 3pm which the Officer can now respond to (or earlier incidents, if there are some outstanding);

- *Allocation of Officers*: Officers are allocated to base stations (one of three), on whatever basis you like. Once you have assigned an officer to a base station, they can be assigned to incidents;

- *Officers*: there is no maximum or minimum number of officers you can allocate to each base station.

Shift patterns

To begin with, the shift patterns at set as follows for all days: This is the total number of officers available each day at each time. You must decide how you allocate these officers to base stations.

Shift	Timeframe	No. of Officers
Early Shift	0-7	15
Day Shift	8-15	25
Night Shift	16-23	40

Priorities and considerations

What you are aiming to uncover here is the optimal number of officers that should be allocated to each base station, in order to respond to incidents in line with their priority, but without allocating so many officers that we frequently run a surplus (Officers at their base station waiting for incidents).

You do not lose the challenge if, on occasion, you are unable to respond to all incidents within the required time. However, you will be expected to justify your optimisation choices, and this will feature. You may consider keeping track of how quickly on average you are able to respond to the different types of incidents and how far your officers need to travel.

Testing and evaluating your model

- Proof that an Officer was sent to each incident, that the number of Officers per shift was not exceeded, and that no time travelling occurred (e.g. an Officer attended an incident before their previous incident had concluded);

- The % of Immediate, Prompt and Standard incidents you were able to respond to within the target time;

Additional considerations

After you have optimised the base station problem as described above, why not try the following:

- **Optimise shift numbers**: instead of the 15/25/40 split provided, can you optimise a better shift distribution? Please note: this means a shift pattern for the whole week, not individual days.

- **Reduce officer numbers**: are you able to optimise the shift patterns and base station allocation to the point where you can reduce the overall number of officers?

- **Travel between incidents**: if you would really like a challenge, then why not allow Officers to travel *between* incidents, rather than respawning at their base station? All other rules, including deployment time and shift patterns, still apply.