

FIRE STATION, ZUTPHEN, NETHERLANDS

GIS in Response Time Analysis

Response time is key to fire fighting. Urbanisation and changes in land use demand continual assessment of the spatial distribution of fire stations and fire risk within the framework of costs/benefits. Since these problems have a spatial component, GIS systems are being used to solve them. The author demonstrates through a case-study in the Dutch city of Zutphen the capabilities of GIS in optimising location of fire-stations.

Is the area effectively covered by fire stations and, if not, how should fire stations be distributed? How should optimal distribution of stations be determined? What traffic problems may be faced at various moments of the day? These are all questions confronting fire brigades. To test the suitability of GIS systems in answering such questions we used MapInfo Professional and its applications Vertical Mapper and RouteFinder, manually digitised a road network from a map (it is important to check topology!) and identified fire risk in a risk-area map. The analysis resulted in a drive-time, a response-time and an excess-time map. The mapping process is schematically outlined in Figure 1.

Reflex Time

Time is the decisive factor in any fire fighting. The total reflex time (time between convey and actual fire fighting) may be differentiated into:

- dispatch time: time between call and notifying fire station
- turnout time: time between notification and leaving fire station
- drive time: time between leaving station and parking fire engine in vicinity of fire
- excess time: time necessary to move from fire engine to fire
- set-up time: time necessary to set up equipment.

In Zutphen, turnout time is differentiated according to type of vehicle and time of day (Table 1); volunteers offer assistance outside working hours. Turnout time plus drive time gives response time.

Drive Time

Drive time depends on speed, and this depends largely on type of road travelled by vehicle from station to fire. We distinguish three classes: highways, collectors and local roads. Speed standards differ between the USA and Europe; for this study we used the "best-fit" values indicated in Table 2. To improve accuracy we checked theoretical against recorded drive-time values. Figure 2 shows Voronoi drive-time polygons within a range of three to fifteen minutes of a fire station. The drive-time model created using GIS software can be transformed to a response-time model for the creation of response-time maps by resetting the drive-time properties. Fire risk and drive time are the two determinants for optimal location of fire stations, and this depends largely on land use. For example, residential areas generally run lower risk of fire than city centres, allowing for longer response times. Fire-risk levels for each vehicle type can be indicated by mapping response-time standards as risk areas (Figure 3). To compare the actual situation with the standards, raster-to-vector conversion was applied and excess times, positive and negative, calculated by subtracting response-time standards from calculated response times (Figure 4, left). Positive excess times indicate shortcomings with respect to standards. Generally permitted is an excess of +20%. The effects of station location can also be estimated from the response-time model.

Response Time

For example, addition of a second fire station to the west of the existing one shows a substantial improvement in response time (Figure 4, right). Table 3 shows the size of areas having one and two fire stations and a positive excess time of one to four minutes. The addition of one fire station results in a reduction in area with positive excess time from 260.2 to 179.1, that is an improvement of 81.1ha. In particular, there is a substantial reduction in area with crucial excess of three and four minutes. The addition of a second fire station does not greatly reduce positive excess time in the south-west (Figure 4). A further run of the response model might show that a third fire station near the intersection between the southern and central highways would reduce positive excess time. Cost-benefit analysis would then indicate feasibility. Reduced turnout times would also lower excess time; one minute, which corresponds to the US NFPA 1710 standards, results in less need of a second fire station, although taken into account here must be the difference of two minutes between working and after hours.

Concluding Remarks

The excess-time map can be modified so as to clearly show areas insufficiently covered. From the size of these areas the impact on different locations can then be quantified. The above examples refer to the use of the first fire engine during working hours. Not shown are runs carried out for the first engine at one fire station, after hours for second fire engines, and rescue and emergency vehicles at one station during and after working hours. This straightforward analysis can quickly deliver much information, making it useful as a quick scan.

Acknowledgements

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Further Reading

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<https://www.gim-international.com/content/article/gis-in-response-time-analysis>
