The Development and Use of the United Kingdom Home Office Fire Cover Model

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ABSTRACT

The paper describes the further development of the United Kingdom Home Office Fire Cover Model and its use in providing advice to the Joint Committee on the Standards of Fire Cover. The Committee was tasked with reviewing the arrangements made by the Local Authority Fire (County) Brigades for providing fire appliance attendance to fires and other emergency incidents. The Home Office wished to consider the effect on resources required if various possible changes were made in the current arrangements. The model was used to assess the effects in a sample of four brigades.

INTRODUCTION

There are three main functions of the fire service in the United Kingdom (1):

i) the extinction of fires and protection of property and life in case of fire

ii) special services

iii) fire prevention

The arrangements made by fire brigades to provide the rapid response necessary in i) and ii) are known as "fire cover". The planning of fire cover is based on categorising areas by fire risk and recommending a specified minimum level of brigade attendance for each risk area. There are four categories of risk: A,B,C,D; corresponding approximately to commercial and industrial city complexes, centres of large towns, built-up areas of towns and rural areas. Especially high risks and remote rural areas are treated as special cases. For each risk area there is a recommended first attendance. For A risk, it is two pumps (1st attendance fire appliance) within a maximum period of five minutes, and one further pump within eight (for B risk, 1 in 5 plus a second in 8; for C, 1 in 8 to 10; and for D, 1 in 20). For special services, such as road traffic accidents and for known small fires such as those on waste ground or in derelict buildings, brigades use their discretion.

The fire cover arrangements described above followed recommendations made in the report by the Joint Committee on Standards of Fire Cover (JCSFC) in 1958 (2). The Committee was reconvened in 1980 to consider whether there was a need to modify the arrangements recommended by their predecessors. As part of their information gathering, they requested the Operational Research Division of the Scientific Research and Development Branch (SRDB) of the Home Office to advise on the likely outcome of various policy options. SRDB had a long tradition of working in the Fire Cover area (formerly as the Scientific Advisory Branch, SAB) and a number of models had been developed so the task was undertaken with some confidence.

One type of model calculated fire brigade attendance times from pump dispositions and fire occurrance. A second type calculated fire losses from attendance times (loss/attendance). By combining the two models a relationship between fire cover strategy and fire losses was obtained. This was then minimised to obtain the most cost/effective fire brigade arrangements. So far only the first type of model has achieved full acceptability.

In an early model, described by Hogg in 1973 (3), fire was modelled as existing in states (confined to object, confined to room, beyond room and beyond building) with time independent probabilities of transition determined from the data collected. It took account of the first pump at each station and the first at each fire and provided output in terms of arrival times of the first pump.

A further model looked into the relationship between the amount of fire spread after the arrival of the first pump and the arrival time of the second and subsequent pumps (4). As the work progressed the difficulties of formulating realistic loss/attendance relationships became more evident, and the emphasis of the work turned to improving these. However the inherent problems and the difficulty of obtaining sufficient and reliable data left doubts in the minds of researchers and potential users. In 1980 reseach responsibilities in the Home Office were reorganised and SRDB took over responsibility for this area of work. Although it was at that time apparant that loss/attendance models had limited credibility, this aspect was not necessary to adequately cope with the committee's request.

DEVELOPMENT OF THE MODEL

In the SAB model queuing theory was used to model the process of a sequence of calls (the customers) being attended by the nearest available pumps (multi-servers). This process is complex since the initial attendance to calls depends on the nature of the call and risk category (as outlined above).

The model took into consideration the variable call rate throughout the day by splitting the day into six four-hour periods (during which a constant call rate was assumed). A road network of the principle roads used by pumps responding to incidents was set up for brigade areas by defining "nodes" at major road junctions and fire stations. From the lattice road system, travel times were assessed and fed into the model. By calculating the likelihood of the nearest appliance being available it was possible to compute attendance times for a year's calls. The final part of the model attempted to convert the fire brigade attendance times into direct financial loss - the loss/attendance relationship.

In view of the objective of assessing alternative fire cover standards considerable development was considered necessary. In particular, the loss-attendance, as mentioned, was not essential, and was removed. The resultant response time model had the advantage that the results could be easily validated.

The original SAB model used population statistics to estimate the likely number of fires. Although some statistical evidence was put forward to suggest that population was a good predictor for fire incidence, it was far from conclusive. A Statistical survey carried out of 14 U.K. fire brigades for the JCSFC for 6 months provided details of the location of all incidents, which were used to feed the SRDB model.

The SAB model "ran" on a computer in "batch" mode and produced a large amount of hard copy output. When the model had been successfully transferred to SRDB's VAX 11/780, the program was made fully interactive, allowing the user to make changes at the keyboard to the number of fire appliances and type of manning at a station and various other parameters. The output was reduced dramatically and now simply provides a recapitulation of the input data and the attendance times by risk category as follows:

Output from the SRDB Fire Cover Model
Percentage of Occasions when standards broken

Risk Category	First Pump	Second Pump	Third Pump
A	6%	12%	2%
B	0%	5%	-
C	1%	-	-
D	0%	-	-

This shows typical results from the model. In this theoretical example, 6% of all A Risk first appliances failed to arrive within the standard of 5 minutes. Further, in this example all D Risk attendances and the first pump in B Risk areas attended incidents within the standard.

In addition, the model produces a further table which has the same format as the above, but shows the "average time by which the standard is broken" (for those occasions on which the standard is broken).

MODEL USAGE

Since it was not practicable to study all brigades (there are 54 brigades in England and Wales), it was agreed that a small sample of "typical" brigades should be examined with the model. In order to make use of the detailed information provided by the Statistical Exercise on incident location, the brigades studied were chosen from among the fourteen in that survey. Further, the original SAB model was tested out by consultants (from the Local Government Operational Research Unit) in 1976 on 11 fire brigrades. Therefore LGORU (who were contracted to carry out the data collection) were able to provide travel time matrices (which needed a little modification) for these 11 brigades.

The final choice of four brigades was simply the overlap in brigades studied previously by LGORU and those which took part in the statisical survey. The four brigades studied were :-

(1) Cleveland

(2) Greater London

(3) Greater Manchester

(4) Hertfordshire

These brigades were very different in many respects and had quite different risk maps. Cleveland is unusual (5) as it contains much C and D risk along with the largest area of Special Risk in the UK made up for the most part of 22 Major Chemical Plants. Greater London is mostly A and B risk. Greater Manchester exhibited a very high incident rate, has a good deal of C risk and some B risk but much less A risk than London. Hertfordshire contains no A risk, very litle B, some C but is predominently D risk.

The model was validated against the "actual" by means of the "percentage of occasions the standards were broken". In all cases the figures were within 5% of those actually recorded. Initial validation of Cleveland, the first study, showed that the nodal density should be linked to risk category, which proved to be vital in final validation.

The model was used to assess the resource implications of alternative standards of fire cover. For example, one question was "Would sending a second appliance to arrive within 10 minutes to C risk areas require further appliances (and men)?".

The model showed that it would but that it was virtually impossible to achieve this aim in some areas without a considerable station building programme. Another question was "Would a reduction from 3 to 2 appliances in A risk areas mean that current resources would result in overprovision?". The model showed that this was not so, as in general the third appliance had a first attendance role in an adjacent station's area. These and other questions were examined by the model providing a useful insight into the question "what would happen if?".

CONCLUSIONS

Use of the Fire Cover Computer Model has demonstrated that the resource implications of different Fire Cover Standards vary from brigade to brigade, depending on two major factors:-

i. the "busyness factor"

ii. the "geographical factor"

The former simply reflects the rate of incidents, whilst the latter pertains to road configurations, risk map definition, and station and pump location. It seems likely that brigades which reflect comparable "busyness" and "geographical make-up" will exhibit similar resource implication characteristics. However, many brigades may be considered unique for the following reasons:-

i. Brigade Area has costal border.

ii. Many Special Risks in brigade area.

iii. Brigade contains many natural barriers (eg. rivers).

It has also demonstrated the usefulness of an operational research approach and a computer model in providing information to a policy committee. The success of the work has lead to a request being to us to investigate the potential for developing a loss/attendance model. This is currently in progress.

Further, the computer model is well suited to tackle fire cover problems at a more local level, enabling fire brigades to " get the best from the resources available ". It has been suggested that not only could fire brigades consider the allocation of major pumping appliances to stations but could also examine the disposition of special appliances, such as turntable ladders, emergency tenders and the like.

REFERENCES

1. Review of Fire Policy, Home Office, 1980

2. Report of the Joint Committee on Standards of Fire Cover, HMSO, 1958.

3. Losses in Relation to the Fire Brigades Attendance Times, J. Hogg SAB Report 5/73.

4. A Model of the Growth of Fought Fires, R.Rutstein and R.J. Barnes SAB Report 1/75

5. Cleveland County Research and Intelligence Report: Fire Brigade Statistics- Initial results from a six months study of incidents, D. Peace