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SIMULATION MODELLING IN SUPPORT OF EMERGENCY FIRE-FIGHTING IN NORFOLK

Alan C. Cowdale

Operational Analysis Element
Air Warfare Centre
Thomson Building
Royal Air Force Waddington
Lincoln, LN5 9WA, ENGLAND

ABSTRACT

In the fall of 2002 the Fire Brigade Union within the United Kingdom proposed a ballot on strike action in support of a wage demand. Consequently the Ministry of Defence agreed that in the event of strike action, emergency assistance to the local authorities would be provided by deploying military staff to man fire-fighting equipment and to provide command and control functions. The military Detachment Commander for the County of Norfolk region was faced with a number of issues regarding basing of assets and asset management. This paper describes how simple simulation modelling was used to provide insights into the type of issues that the military would face in undertaking this role. Two models were developed; one using SIMUL8 to investigate asset utilisation, and the other using VisualBasic to generate a master event list for use in mission planning and control centre training.

1 INTRODUCTION

On September 12th 2002 the Fire Brigade Union within the United Kingdom proposed a ballot of its 55,000 members on strike action in support of a wage demand. Consequently the Ministry of Defence (MOD) agreed in the event of strike action to provide military emergency assistance to the local authorities by providing staff to man Breathing Apparatus Rescue Teams (BART), Green Goddesses, Regional Equipment Support Teams (REST) and to provide command and control functions.

The Royal Air Force (RAF) was allocated the lead for the Norfolk Region. The designated RAF Detachment Commander for this region was faced with a number of issues regarding basing of assets and asset management. Simulation modelling is a tool which has potential to address these problem domains, and consequently the Operational Analysis team within the Air Warfare Centre volunteered to provide scientific support to the Norfolk Detachment Commander during the initial planning for the deployment.

2 UNDERSTANDING THE PROBLEM

The County of Norfolk is in Eastern England and covers an area of 5275 km^2 (2037 miles^2). Within the County, Norfolk Fire Service operates from 40 full and part-time stations (Figure 1). In 2002 it had a fleet of 52 water tenders and a number of specialist vehicles such as aerial ladder platforms and water foam carriers. The Office of the Deputy Prime Minister (ODPM) reports that 10998 incidents were attended by the Norfolk Fire Service during 2001.

The Detachment Commander had been allocated 167 personnel together with 8 Green Goddesses, 3 BART and 10 REST to support the Norfolk area. The key issue facing the Detachment Commander was where should the assets to be based to provide the best emergency cover.

Asset basing and resource allocation are classical problems for using mathematical modelling and simulation. There are numerous examples of simulation models being developed to support these issues within the emergency services. These models however tend to be used to assist studies to address issues regarding improving the efficiency of existing systems rather than acting as an interactive tool to assist in the rapid planning of a new system.

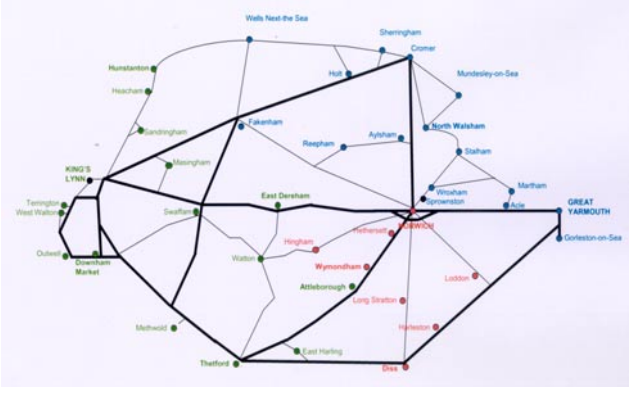

Figure 1: Fire Station Locations

3 SIMULATION MODEL DEVELOPMENT

Although overall operating policy and procedures were being developed at a national level, the Detachment Commander was faced with the problem of implementation within the local conditions. During the later days of September 2002 the policy and procedures were maturing at an almost daily basis. As a result it was necessary to develop models and tools which could be quickly developed and modified in order to remain relevant. In order to retain the flexibility to be timely and responsive, it was decided to develop two models in parallel. One model was developed using SIMUL8 to explore asset allocation issues (Figure 2), and one using VisualBasic Applications within an EXCEL Spreadsheet to act as a discussion tool for addressing tactical issues (Figure 3).

As with most simulation models, the validity of the output will be heavily depended on the quality of the input variables. Fortunately, a considerable amount of fire related statistical data was readily available from the ODPM and from Department for Transport, Local Government and the Regions (DTLR). The two models were therefore developed utilising look-up tables containing key historical fire related statistics.

1. The number of fire related incidents was generated by sampling from a Poisson Distribution with the mean value set to the expected number of incidents per day.
2. The time of each incident was sampled from an hourly time frequency distribution.
3. The type of incident was sampled from an incident frequency table.
4. The location of the incident was sampled from the location frequency table for that particular incident type.
5. The duration of the incident was obtained by using the distance look-up table for the distance between the incident location and the selected Green Goddess depot. The duration was obtained by calculating the time taken to travel the distance between the fire and the depot at maximum speed, and then scaling by a factor determined by the time of day to account for traffic congestion.

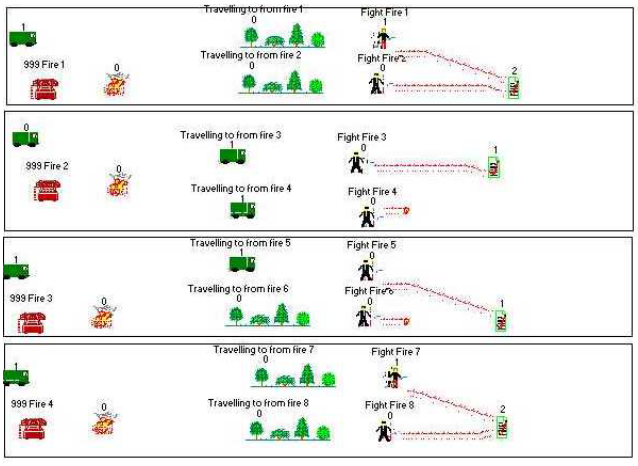

Figure 2: 4 Fire Station Model

Daily Event Generation For Fire Related Incidents in County of Norfolk

Factor	30
Seed	2345
Max Speed	40
Incidents	17

Dereham

Event	Slot	Hours	Minutes	Incident	Location	Action	Duration (minutes)
1	0.002853	0	2	small fire in a car	Heacham	Kings Lynn	39
2	0.075498	1	18	false alarm	Great Yarmouth		
3	0.232051	8	6	small fire in refuse	Norwich	Norwich	0
4	0.373229	14	4	automatic false alarm	Norwich	Norwich	0
5	0.384206	14	19	fire in grassland	Aylsham	Norwich	60
6	0.416892	15	3	automatic false alarm	Great Yarmouth		
7	0.497984	16	37	non-fire	Norwich		
8	0.500526	16	39	small fire in a car	Thetford	Thetford	0
9	0.504755	16	44	automatic false alarm	Great Yarmouth		
10	0.528124	17	7	small fire in refuse	Wymondham	Norwich	60
11	0.566313	17	42	non-fire	Holt		
12	0.706436	19	41	false alarm	Cromer		
13	0.751418	20	18	automatic false alarm	Thetford	Thetford	0
14	0.79044	20	50	fire in refuse	Acle	Norwich	36
15	0.832775	21	25	non-fire	Norwich		
16	0.911318	22	32	small fire in a car	Sprowston	Norwich	6
17	0.937306	22	56	automatic false alarm	Swaffham	Dereham	36

Figure 3: Spreadsheet Analysis Tool

4 MODEL RESULTS

The Norfolk Fire Service web site reports that the Service attended 10998 incidents during 2001, of which 9309 were fire related. Since the models assume that fire related incidents occur randomly throughout the year, then on 95% of occasions the daily number of fire incidents in Norfolk would be expected to be between 15 and 36. The SIMUL8 model illustrated that the 8 Green Goddesses were very unlikely to ever be fully utilised. Consequently the key issue was unlikely to be not having sufficient engines to attend an incident, but was going to be the ability to provide a timely response.

By examining the expected total mileage covered by the Green Goddess engines over a full year it was possible to obtain the optimal sites for basing the assets. The resultant site locations for all incidents are given in Table 1.

For logistical reasons (catering, living accommodation and vehicle maintenance) it was considered highly desirable to operate from locations close to existing MOD establishments. In the Norfolk area, these comprised bases at Coltishall (near Norwich), Swanton Morley (near Dereham),

Table 1: Annual Mileage Estimates

No of Depots	Optimal Site Locations	Total Annual Mileage – All Incidents
1	Norwich	415614
2	Norwich / Kings Lynn	234404
3	Norwich / Kings Lynn / Great Yarmouth	176576
4	Norwich / Kings Lynn / Great Yarmouth / Thetford	139160

Table 2: Annual Mileage Estimates

No of Depots	MOD Establishment Locations	Total Mileage	Percentage of Optimal
1	Norwich	415614	100%
2	Norwich/ Swafham	274986	85%
3	Norwich/Swaffham / Thetford	243470	73%
4	Norwich/Swafham/ Thetford/ Dereham	235796	59%

Swaffham and Thetford. Table 2 illustrates the total annual mileage if engines were based at the MOD establishments, and the percentage increase in total mileage when compared with the optimal locations identified in Table 1.

Consequently the model illustrated that the proposed basing at Military Establishments was likely to be inefficient, with expected travel distances for the 4-depot model almost twice that for the optimal basing.

The optimal basing has sites located at the main urban areas of Norwich, Great Yarmouth and Kings Lynn. MOD establishments tend to be in more rural, and clustered towards the centre of the County. Consequently significant distances have to be covered travelling to the urban areas where the highest incidents tend to be reported.

Norfolk Fire Service Cover Standards intend to have an engine arrive at a reported incident in:

1. congested urban area within 5 minutes
2. smaller towns within 8-10 minutes
3. rural areas within 20 minutes

This standard of cover is achieved by maintaining 52 water tenders and support vehicles at 40 locations throughout the County of Norfolk.

The Green Goddess engines were built in the 1950s, and were last used in significant numbers during a 9 weeks national Fire Service strike over the winter of 1977/78. The Green Goddess engines do not have the performance standards expected of modern vehicles. In particular, the vehicles have stability limitations when cornering, which could have significant problems on more rural roads in the county. Consequently the engines were restricted to a top-speed of 45 miles per hour.

At an average speed of 45 miles per hour, the 4 depot scenario of Norwich, Thetford, Swaffham and Dereham would be able to reach around 57% of incidents within 20 minutes. Extending the arrival time to within 30 minutes, increases the coverage to around 86% of incidents. The geographical areas giving the greatest problems for achieving a prompt response time were the rural areas along the northern coastal region of the County.

5 STAKEHOLDER DEVELOPMENTS

On 3 October 2002 the stakeholders for the Norfolk Detachment held a meeting to discuss the progress of fire-fighter training, and logistical issues. The difficulties likely to be faced by the detachment with the proposed basing options were briefed, and the meeting agreed to base engines on the outskirts of Kings Lynn rather than from Swaffham.

Basing in Kings Lynn saves around 25000 miles a year (Table 3). It should be noted that the move does not directly address the issue of attending fires in the urban areas in the east of the County around Great Yarmouth. However the meeting acknowledged the difficulties faced in this region and decided to investigate the possibility of "cross-border" cover from the neighbouring Suffolk Detachment.

Table 3: Fire Only Mileage

Depots	Mileage – Fire only incidents
Norwich/ Kings Lynn /Great Yarmouth / Thetford	109682
Norwich/ Swaffham/ Thetford/ Dereham	194562
Norwich /Kings Lynn / Thetford / Dereham	169426

At an average speed of 45 miles per hour, the 4 depot scenario of Norwich, Thetford, Dereham and Kings Lynn would result in a considerable improvement over the previous basing option, being able to reach around 74% of incidents within 20 minutes. Extending the arrival time to within 30 minutes, increases the coverage to around 91% of incidents. The areas outside the coverage tended to be in the rural areas, typically in the north of the county.

6 ANNOUNCEMENT ON INDUSTRIAL ACTION

On 18th October the Fire Brigades Union published the results of the National Ballot on strike action and announced a series of 6 national strikes. The Retained Firefighters' Union (ie the part-time fire-fighters) elected not to join the industrial action. The decision by the Retained Firefighters' Union not to join the industrial action significantly eased the problems faced by the military. The Retained Firefighters operate out in the rural areas of the County. Consequently the military Green Goddesses were only now required to provide emergency cover to the urban areas of the County. The previous modelling had illustrated that this should be a manageable problem in terms of both provision of service and timeliness of response. As a result the main effort from the Detachment Commander was now directed towards training of the military staffs to meet the practical problems associated with fire-fighting.

7 ANALYSIS OF ACTUAL FIRE INCIDENTS

Following negotiations the first three strikes were postponed, while an independent review of fire-fighters pay

and conditions was undertaken. Ten days of industrial action were eventually undertaken between 13-14 and 22-30 November 2002. During this ten-day period a total of 210 fire related incidents were reported, which was around 20% lower than that predicted from the model. While the level of malicious false-alarms were higher than predicted, these were greatest at the start of the industrial action, and returned to expected rates as the period progressed. The national and local media gave considerable coverage to the dispute both prior to and during the industrial action. Since the Green Goddess crews were only perceived as providing emergency cover, the media related publicity heightened public awareness of fire risks within the home and at work.

During the days of industrial action the number of reported incidents were generally less than that predicted by the modelling. While this could have been due to the increased public awareness of fire risks, the period was also covered by a particularly heavy period of rain. This bad weather may well have influenced the lower than expected number of arson attacks. Although the number of malicious false alarms (particularly early on in the period of industrial action) increased above historically predicted rates. This increase in malicious false-alarms had however been anticipated as a "lesson learnt" from the previous national dispute in the 1970s.

8 CONCLUSION

The analysis illustrates that relatively simple simulation modelling can provide valuable support to the decision making process. The analysis proved useful because the simulation staff were directly involved in the discussions surrounding the key decisions. As a result the models could be modified to meet the developing requirements and to provide quantitative input to the decision makers.

Data collected during the industrial action illustrated that the simulation models proved to be overly pessimistic, probably as a result of increased public awareness of fire related risks and a period of particularly bad weather.

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AUTHOR BIOGRAPHY

ALAN COWDALE is the senior scientific advisor at the Air Warfare Centre in Lincolnshire, U.K. He holds a BSc in Mathematics from the University of Southampton and an MSc in Operational Research from the University of Birmingham, and is a Fellow of the Operational Research Society. He has undertaken a wide range of simulation projects for both the Royal Navy and Royal Air Force in connection with assessing weapon system performance and effectiveness.