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SIMULATION OF TIME TO FIRST WATER APPLICATION FOR THE FIRST INTERSTATE BANK FIRE

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ABSTRACT

On May 4, 1988 a fire occurred after hours on the 12th floor of the First Interstate Bank building, a 62 story steel-frame office tower in Los Angeles California. The sprinkler system in the building was not operational. The fire spread though the 12th floor and extended to the 13th, 14th, 15th and part of the 16th floor before it was under control by the fire department. Discrete event simulation is applied here to evaluate the time for firefighters to access to the 12th floor, the fire origin. GPSS/H is used to analyze lognormal distributions developed to represent the firefighter task data. These results are compared to those using triangular distributions, as well as data collected concerning the fire department response to the World Trade Center on 9/11.

1 INTRODUCTION

The goal of this paper is to describe how a fire attack evolution can be modeled using Discrete Event Simulation (DES).

In a previous study, the Kolmogov-Smirnoff test was used to establish that time and motion task data of firefighter tasks collected using video fit lognormal distributions (Till 2001). This data was used to verify the discrete event simulation modeling method against a time and motion test performed by the Louisville (USA) fire department (Till and Strong 2001). This paper uses this data and method to compare results with an actual fire response.

The First Interstate Bank fire has been extensively studied from a fire safety engineering standpoint. These include studies of heat release over time, building system response, and the causes of the fire itself (Klem 1988, Nelson 1988).

Using DES for time duration studies of fire department evolutions enables, "what-if" analyses to be performed to compare options for building design using fire sizes developed in the heat release rate models. In this paper, only the firefighter movement is discussed.

2 INCIDENT

The initial fire department response is summarized in Table 1. The time for firefighters to dismount apparatus, don equipment, and proceed to the fire floor is estimated to be 21 minutes. The sprinkler system in the building did not operate. Elevators were also unavailable for fire department use, so all vertical travel was performed using stairs.

Table 1 - Firefighter intervention

Time	Time (Elapsed)	Event
10:25		Fire Initiated (est.)
10:38		A Category "B" assignment dispatched (2 Task Forces, an Engine, a Squad and a Battalion)
10:39	0 min.	First Engine Company on Scene.
11:43 (est.)	4 min.	Fire Department Enters Building
10:51		12th Floor fully involved
11:00	21 Min.	Fire Suppression Crews Reach 12th Floor (engines 9 and 3). Standpipes connected at 11 and 13th floors. Inadequate water supply to continue (PRV adjusted).
11:15	34 Min	Engine Companies 9 and 13 connect to standpipe in Stairway 5 and advance on the fire floor. Floor fully involved at this time.
11:23		Extension to 13th Floor reported
11:40		Extension to 14th Floor reported
12:39		Heavy fire on 15th Floor, - danger of lapping 16th.

3 CONCEPT

The procedure is a method for evaluating the time duration for certain fire department operations. The method combines a time for firefighters to get off an apparatus, move through a structure, and apply water to the fire. The procedure uses discrete event simulation to compute time durations for stretching attack lines.

DES is a general method used to model real world processes that can be decomposed into a set of logically separate events. In a DES model, each event in the process is assigned a duration, in the form of an associated statistical distribution. As the DES model is run, events are executed at a scheduled time. The result of each event is an accumulation of statistics, and the scheduling of other events that logically follow the completed event at some specified future logical time. In this way, variations in time for individual events are combined to determine an overall process time.

DES has the flexibility to address:

- Variations in the time required to perform individual tasks
- Tasks Performed in Sequence
- Tasks Performed in Parallel

4 MODEL DEVELOPMENT

The starting point for modeling fire attack movement using a DES model is the determination of the sequence of tasks that fire fighters must perform. The procedure models exterior and interior operations (tasks) of firefighters after they arrive at the scene. The tasks modeled in a particular simulation depend on available equipment, staffing, and the tactics used. Standard operating procedures and how staffing is utilized can be incorporated within these procedures. Thus, it is necessary to obtain information about fire department equipment and tactics to determine the appropriate sequence of tasks to model. In addition, internal and external site information must be obtained so that architectural obstacles can be incorporated into the model.

The site layout is shown in Figure 1. The site information necessary for this particular model is relatively simple, as is the equipment and tactic information. The basic necessary site information necessary on is the distance between the command post (the site of the first apparatus arrival) and the stairs, and the building height information (number of stories).

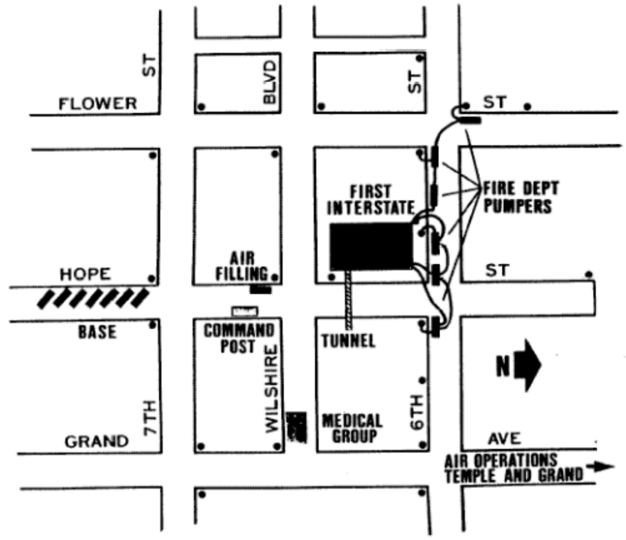

Figure 1 - Vicinity - First Interstate Bank (Routley 1988)

4.1 Task Development and Data

The tasks and task sequence necessary to get a fire crew to the fire floor are shown in Table 2.

Table 2 -First Interstate Simulation Time – Tasks Described Using Triangular Distributions

Task	Min	Mode	Max
Alight Truck	3.0	11.1	25.0
Don SCBA	38.0	67.0	136.0
Remove Tool	7.0	21.5	43.0
Proceed to Stairs (150m)	25	77	1154
Climb 10 Flights	37.5	120	375
Rest Break	99	171	243
Climb 1 flight	6.2	13.8	52.0
Connect hose to riser	13	21	59
Climb 1 flight	6.2	13.8	52.0
Set up hose in stair	60	90	120
Rest Break	99	171	243
Connect Nozzle	13	31	49
Charge Hose	8	24	55
Total	415	832	2606
Total (Minutes)	7	14	43

Data on task duration, descriptions and sequences can be collected by video taping firefighter training evolutions. These tapes can be reviewed and individual tasks identified. Data obtained from the Australian Fire Brigade Intervention Model (Australasian Fire Authorities Council 1997) or any other appropriate source can also be used.

Statistical distributions for each task were selected and the Kolmogorov-Smirnoff (K-S) test was used to ensure that a lognormal distribution accurately and adequately described the task duration data. The Kolmogorov-Smirnov (K-S) is a goodness-of-fit test (Ayyub and McCuen 1997). It is used to test whether a particular population conforms to a particular theoretical distribution.

An example fit is provided in Figure 2. In this case therefore, the "alight truck" distribution is described using a lognormal distribution developed as output from the Stat::Fit program (Geer Mountain Software Corporation 1996).

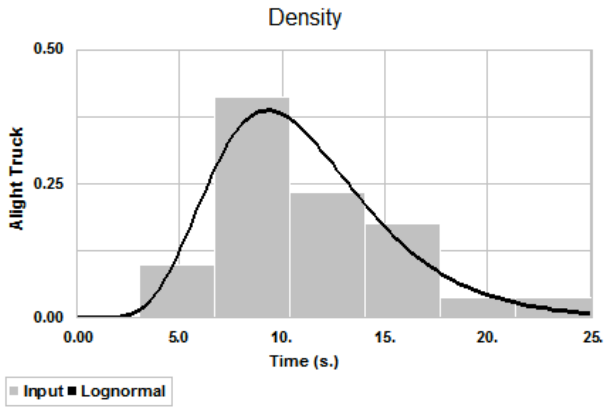

Figure 2 - Example histogram and fitted lognormal distribution

Data obtained from the Australian Fire Brigade Intervention Model was used to supplement the collected data. Although Validation to the lognormal distributions described could not be performed, it was assumed that the distributions would also take the form of a lognormal distribution.

4.2 Model Distributions

All distributions were available in the form of lognormal distributions. Experiments using Triangular distributions were also used to explore the development of a simple method of determining the overall time that could be used more easily. The minimum, mode and maximum values for each task are listed in Table 2.

5 RESULTS AND DISCUSSION

The mean results for the triangular and lognormal task data were 14 and 20 minutes respectively. The reported intervention took 21 minutes. The simulation using lognormal results provided results closer to that of the actual fire than that of the triangular distribution.

The simulation was run for 1000 transactions. The results of the simulation are shown as a frequency distribution in Figure 3. The simulation mean time of 20 minutes (1200 s.) with a standard deviation of 270 seconds (4.5 minutes).

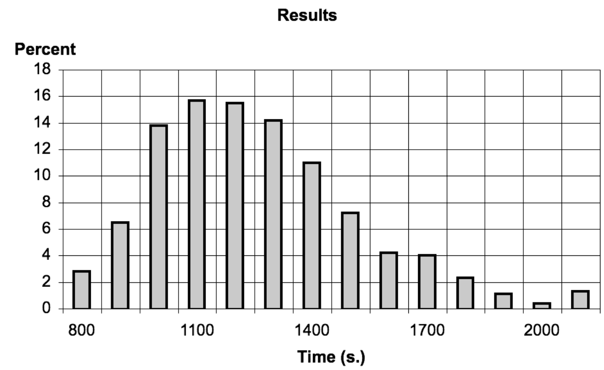

Figure 3 - Simulation results - lognormal input data

Blocks within GPSS were used to determine the time to climb the stairs. Approximately 10 minutes were required to climb the stairs, including a rest break.

Other information specific to stair climbing was also gathered. The study of the World Trade Center (WTC) response stated "Generally a firefighter can climb a stairway at a rate of about 1 floor per minute…Fatigue becomes a factor after approximately 12 floors of climbing, and fatigue caused by climbing diminishes the functional capabilities of the emergency responder to carry out operations once they reach the fire floor" (Lawson and Vittori 2005).

In this case, approximately 12 minutes was estimated for firefighters to navigate the stairs. This compares well with the simulation of 10 minutes.

The WTC study included data for stair climbs higher than 12 stories also. It is assumed that these results would include fatigue. "Based on the data gathered, it is estimated that climbing rates varied between approximately 1.4 minutes per floor for personnel not carrying extra equipment to approximately 2.0 minutes per floor for personnel wearing firefighters' protective clothing and carrying extra equipment. These estimates have an error of +/- 0.5 minutes per floor" (Lawson and Vittori 2005).

WTC data for climbing includes fatigue would present a range for 12 floors of 18-30 minutes. Clearly this would have an influence on the modeling of fires in a building higher than 12 stories.

6 CONCLUSIONS

A concept and procedure for estimating time for initial fire attack in the First Interstate Bank was described. The results of a simulation using the lognormal input distributions as input agreed well with actual events. The triangular distributions provided results that underestimated the amount of time for the firefighters to reach the fire floor and mount an attack.

Discrete Event Simulation can be used to estimate the time for an initial fire attack. It also may assist in assessing the value of proposed features, such as "fire hardened" elevators for firefighter use.

Future work could evaluate the influence of such factors as the delay in building alarm on the fire growth when firefighters reach the fire floor. It could also evaluate the influence of other features such as suppression success had the fire been on a higher floor, or the influence of elevator operation by firefighters if it were available. Simulated attack on a floor higher than 12 stories must to incorporate the influence of fatigue on firefighter operations.

REFERENCES

Australasian Fire Authorities Council. 1997. Fire brigade intervention model, Version 2.1, Victoria, Australia.

Ayyub, B. M. and R. H. McCuen. 1997. *Probability, statistics, and reliability for engineers.* New York:CRC Press.

Geer Mountain Software Corporation. 1996. Stat:Fit software manual*,* Kent, Connecticut.

Klem, T. J. 1988. First Interstate Bank Fire, Los Angeles California, May 4, 1988. Fire Investigation Report, National Fire Protection Association, Quincy, Massachusetts.

Lawson, J. R. and R. L. Vettori. 2005. Federal building and fire safety investigation of the World Trade Center disaster - the emergency response operations (draft), NIST NCSTAR 1-8, National Institute of Standards and Technology, Gaithersburg, Maryland.

Nelson, H. E. 1989. An engineering view of the fire of May 4, 1988 in the First Interstate Bank Building, Los Angeles California, Technical Report NISTIR 89-4061, US Department of Commerce.

Routley, J. G. 1988. Interstate Bank building fire, Los Angeles, California*,* USFA-TR022, US Department of Homeland Security.

Till, R. C. 2001. A building evaluation technique for fire department manual suppression. Ph.D. thesis, Department of Fire Protection Engineering, Worcester Polytechnic Institute, Worcester, Massachusetts. Available via <http://www.wpi.edu/Pubs/ETD/Available/etd-1220100-153824/> [accessed April 1, 2007].

Till, R. C. and Strong, D. 2001. Evaluating fire department access using discrete event simulation. In *Proceedings of the Interflam 2001 Conference,* ed. S. Grayson, 1083-1092. London, England: Interscience Communications.

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Robert Till is an Associate Professor in the Department of Public Management at John Jay College. He is involved in teaching and research in fire science. He received his PhD. in Fire Protection Engineering from Worcester Polytechnic Institute in 2001. His dissertation addressed the evaluation of buildings for fire department intervention using discrete event simulation. Robert is also a member of the Society of Fire Protection Engineers (SFPE) Fire Department Operations Task Group, the ASME A17 Task Group on Use of Elevators by Firefighters, and the National Fire Protection Association Standard for Fixed Guideway Transit and Passenger Rail Systems (NFPA 130) Committee.