

Simulation Modeling and Analysis of Fire Fighting Operations in the State of Kuwait

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ABSTRACT

Emergency services, including firefighting operations, are complex processes and involve several activities in different stages that function together to achieve a main goal of preventing destruction in human life, property, and environment. This study uses discrete event simulation (DES) to model and improve firefighting operations in the state of Kuwait. The main objective is to reduce the response time required to reach an accident place. It is a life-saving criterion that needs to be considered. This study is conducted by collecting thorough data of fire operation department over a period of five years and accordingly creating a valid simulation model to analyse the system under current operational conditions nationwide. Analysis of variance (ANOVA) was used to identify factors that were statistically proven to have positive effects in reducing response time. A simulation model was used as a medium to carry out these experiments. The results of simulation model were validated at 95% confidence level. The effectiveness of the analysis is examined by incorporating related parameters from the ANOVA model into simulation model. The response time was reduced from seven minutes to three minutes on average per incident per fire station.

Keywords: Design of Experiments, Emergency Services, Fire Stations, Location Models, Simulation

1. INTRODUCTION

Firefighting operations are the most critical elements in emergency services of a city. The main objective of a firefighting system is to save human life and to minimize damage to property. Response time is a critical factor in the effectiveness of the firefighting services since well-set response time standards can minimize

the risk to people and property loss. Response time is defined as the time from the receipt of a call of a fire incident to the arrival of the firefighting service to the incident site. Many researchers, such as Huang, Liu, and Chandramoli (2005); Indriasari, Mahmud, Ahmad, & Shariff (2008); Erden & Coskun (2010); and Wei & Juncheng (2012), have conducted studies on optimal siting of fire stations in various

DOI: 10.4018/IJSSCM.2015040103

metropolitan areas and agreed on response time of five minutes or less for effective firefighting services. In this research, we aim to achieve this target by reducing the response time and improving firefighting system efficiency in the State of Kuwait.

In Kuwait, firefighting activities are initiated at the Central Operations General Department-777 (COGD-777) which is located in the Ministry of Interior. The control is then transferred to the fire department, which involves with the subsequent activities. In this paper, we have concentrated on the analysis of firefighting activities to minimize related delays, which significantly affect humanitarian services to the community. One of the main problems in delays is the tardiness in the arrival of the firemen to the incident place. This can occur due to many processes that must be performed before moving the firemen to the incident place. Systematic data was collected from records of the fire departments as well as actual statistics on the time of the incident. A simulation model was developed to study the firefighting system in detail and to determine the effects of implementing different changes on system performance. The simulation model was constructed using Arena software. The results of the system were validated at a 95% confidence level. This means that the simulation model is valid representation of reality, which qualifies it to be used as medium for diagnostics and improvements. Analysis of Variance (ANOVA) was used to assess the significance of several improvement elements on the reduction of response time to an accident place. Factors that are shown to be significant are re-installed into the validated simulation model to assess performance in minutes of operation. The proposed system reduced the response time from seven minutes to three minutes, which was a significant achievement for life saving operations.

2. BACKGROUND

Firefighting operations and related activities has been studied by several researchers. These studies can be classified into two categories: First category includes studies related to determination of optimal numbers of fire stations in a region and studies related optimum locations of fire stations. The second category includes studies related to analysis of the firefighting operations and possible improvements. While several research papers have appeared in the literature on the first category, including optimization of fire station locations to minimize response time, there are limited studies in the second category of problems that specifically deal with detailed analysis of the operation of firefighting systems. Some of the studies related to optimum location of firefighting stations, determination of optimum number of fire stations, analysis and improvement of fire station operations, and response time minimization are presented here.

Hogg (1968) discussed some methods of optimal siting of fire stations. He used operation research tools to determine optimal locations for fire stations under various constraints. Fitzsimmons (1973) discussed allocation of emergency ambulances to fire stations to improve firefighting operations. Hendrick & Plane (1975) analyzed the relationship between response time and travel distances in various regions in Denver. They used a simulation model to analyze the performance of various fire companies. Plane and Hendrick (1977) presented a mathematical programming model to optimize the location of fire companies for the Denver Fire Department. Halpern, Sarisamlis, & Wand (1982) have analyzed manning level needed for firefighting operations based on data obtained from a structured interview. He tried to improve firefighting activities by proper manning levels. Analysis is made to determine relationship between manning level and the time needed to extinguish a fire. Avella, Benatib, Cánovas, Dalbyd, Di Girolamoe, Dimitrijevicf, Ghianig, Giannikosh, Guttmani, Hultbergj, Fliegek, Marinl, Márquezm, Ndiayen, Nickelo,

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