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IMPROVING FIRE STATION TURN-OUT-TIME USING DISCRETE-EVENT SIMULATION

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ABSTRACT

Fire station turn-out-time is vitally important to firefighters' ability to provide lifesaving services. Turn-out-time consists of two phases: first, dispatch by a controller in a 911 call center; second, turn-out, in which controllers notify the responders, and responders prepare for the emergency by donning their personal protective equipment and boarding their emergency vehicle. The National Fire Protection Agency (NFPA) suggests a two-minute turn-out-time, yet fire stations do not always meet this goal due to several factors. This case study considered configuration, procedural, environmental, and behavioral factors at a single fire station using discrete-event simulation with the aim to decrease turn-out-time. Implementing a procedural and behavioral change allowing phase two to commence before phase one was completed decreasing the simulated turn-out-time by 24.3%. This change increases the ability for the case study fire station to provide lifesaving services and meet the NFPA goal.

1 INTRODUCTION

Every moment is critical for emergency responders as they attempt to prevent negative outcomes. Mattsson and Juas (1997) found that responses delayed by five minutes could allow overall damage to increase by 97-percent for tightly coupled events such as structural fires, road accidents, or drowning cases. Similarly, the arrival of responders in 5 minutes instead of 7 can double the probability of survival in heart attack victims (Pell, Sirel, Marsden, Ford, & Cobbe, 2001). Emergency response professionals know the importance of a timely response and must be able to arrive on scene quickly, yet the systematic factors that contribute to the delay have received little attention in the literature (Weninger, 2004).

Fire stations are required to meet minimum response times to be accredited ("Center for Public Safety Excellence | Home," n.d.). The measured response time consists of: first, dispatch by a controller in a 911 call center; second, turn-out, in which controllers notify the responders, and responders prepare for the emergency by donning their personal protective equipment and boarding their emergency vehicle; and third, traveling to the emergency location. NFPA guidelines for the first two phases of response time is two-minutes. A 2015 study of an Air Force fire station found their turn-out times were met only 47% of the time ("An Analysis of Fire and Emergency Services Aggregate Response Times," 2015). This fire station serves as the case study for this research.

Given the observed difficulties to exit the fire station within two-minutes, this study sought to understand--through simulation--the procedural, environmental, behavioral, and configurable factors that affected the first two phases and to discover what changes can be implemented at the fire station to meet the two-minute guideline.

2 METHODOLOGY

A time-and-motion study was conducted at the sample fire station. Task times of the activities were fit to probability distributions and incorporated into a baseline simulation model created with Rockwell's ARENA software. The baseline model was then validated by comparing simulated response times to his-

torical data. After validation, alternative models with specific system modifications were built incorporating procedural, environmental, behavioral, and configuration changes to the system. Each model was simulated 300 times showing the fire station's likelihood of meeting the two-minute guideline. The alternative model changes included:

- Re-organizing dispatch procedures to include a pre-warn notification system
- Re-configuring fire station layout
- Remote access to fire station garage door opening system and responsibility realignment

3 RESULTS/DISCUSSION

Baseline model validation was conducted using a Student's t-test. The baseline simulation data was compared to five years of data collected by the fire station for the actual time it took the fire station to complete the first two phases. The results of the test, $t(299)=2.33, p=0.59,$ indicated that the baseline model and reality are statistically equal.

Running the simulations in ARENA identified the critical nodes within the system. These critical nodes were used to create alternative models. The alternative models successfully identified improvement areas that enable responders to successfully meet the response times. Re-organizing dispatch procedures to include a pre-warn notification system yielded a 24.3% decrease, providing remote access to the garage door opening system provided a 3.0% decrease, and reconfiguring the fire station layout generated a 1.2% decrease in response time.

This study showed the value of incorporating procedural, environmental, behavioral, and configurable factors when determining fire station design and operational measures to provide the emergency responders to supply the life, limb, and property saving services expected of them.

4 FUTURE WORK

This research used discrete-event simulation to determine a fire stations ability to meet specific guidelines. This concept can help inform engineering design efforts of new emergency services facilities by allowing decision makers to assess the effectiveness of a design to meet a pre-determined level of service. This would allow for designs that contribute to the overall effectiveness of the system. Future studies should apply this method to other facility design efforts and operational procedures.

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