OA4202 Final Project Executive Summary
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EXECUTIVE SUMMARY

As a final project for the Networks and Flows Fall 2011 course, OA4202, Captain David J. Cote, USMC and Major Thomas F. Dono, USMC modeled and analyzed the Monterey Fire Department Network on the Monterey Peninsula using a minimum-cost-maximum-flow algorithm. Through a series of experiments that simulated interdicting Fire Stations and simultaneous fires, the results of this study validate and reinforce and the current distribution of fire-fighting assets as regulated by the Monterey Fire Department.

BACKGROUND

The Monterey Fire Department provides emergency fire protection services contractually for the Army Defense Language Institute, the Naval Postgraduate School and the small town of Sand City. The Monterey Fire Department employs 53 permanent personnel and has recently completed a merger with the Pacific Grove Fire Department. Through regular collaboration with the nearby Fire Departments in Seaside and Pebble Beach, the Monterey Fire Department provides fire protection services to all the citizens on the Monterey peninsula.

MEASURES OF EFFECTIVENESS

This study uses two Measures of Effectiveness (MOEs) to evaluate the strength, resilience and efficiency of the Monterey Fire Department Network. First, Allocation of Forces (AOF) is the distribution of fire truck stations from which a full complement of forces originates. Coupled with the distribution of fire probability locations and urgencies, AOF can be used to allocate appropriate resources to mitigate risk. A more important MOE is Response time, (RT). RT is the elapsed time, measured in minutes, that a complement of forces takes to arrive at a fire site. Response Time becomes more significant from a performance goal perspective when viewed in the context of the accepted fire responsiveness standards of the National Fire Protection Agency. These

standards are recognized across the United States and most Fire Departments set Standards of Coverage performance goals based on these standards. The Monterey Fire Department is no exception. Both measures of effectiveness, AOF and RT have utility to the Monterey Fire Department in providing optimized coverage regions, resource distribution schemes and mitigation of risk.

MODEL

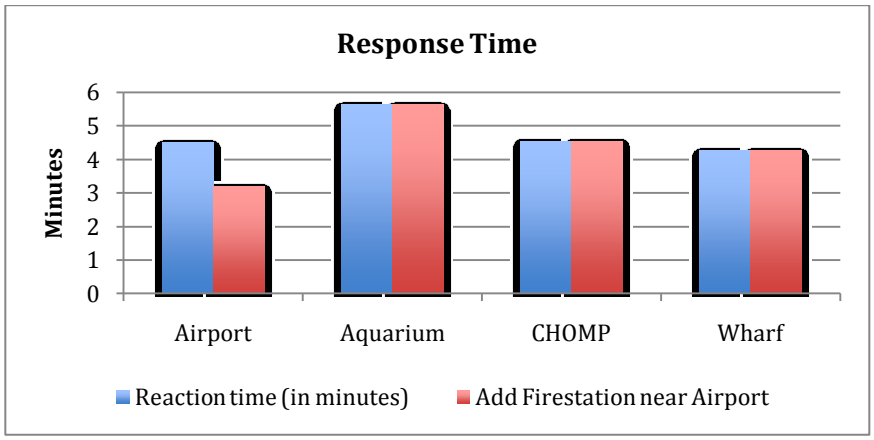
This study uses a model to simulate the flow of fire-fighting assets to fire locations across the Monterey Peninsula. Like any model, this exercise requires a careful balance between modeling realism and preserving robustness. There are several design decisions that do not precisely reflect reality which include homogenous fire trucks, four fire demand sites and a constant fire demand of five trucks.

The Fire Network Graph used for this study consists of nodes that represent the seven Fire Stations, the four fire sites and other nodes of interest. The edges consist of the roads connecting these nodes. The edge cost equals the great circle distance (in statue miles) between nodes divided by the posted MPH speed limit on the road for which the edge simulates. The driving force of the network is the demand for fire trucks at a fire.

EXPERIMENTS AND RESULTS

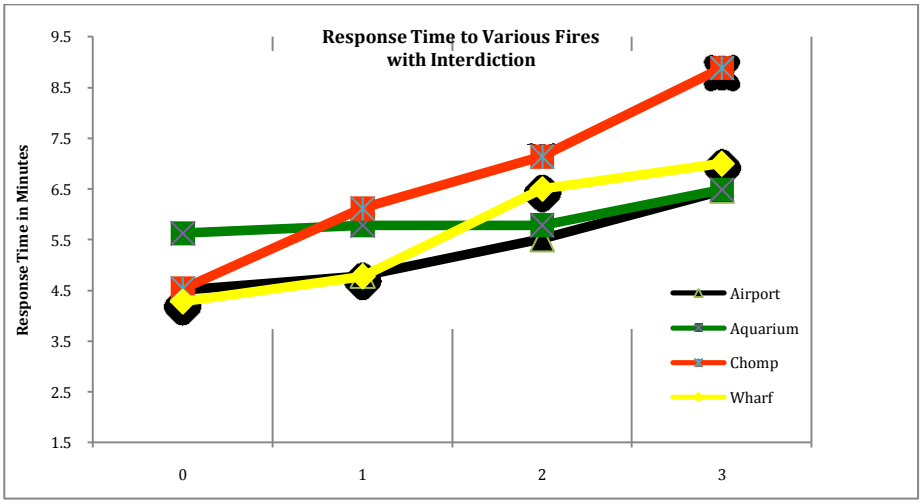
The design of experiments for this study consists of four phases of increasing complexity. First, the response time to each Fire Station is recorded when all Fire Stations are full strength. Next, a new Fire Station was added in the geographic proximity to the Monterey Peninsula Airport with a supply of two trucks. Graph 1.1, depicts the results of Phase I and II. Adding a station with two additional trucks only reduces the Reaction Time for the Airport. Furthermore, all response Times are less than six minutes, which exceeds the performance goals of the Monterey Fire Department.

Graph 1.1



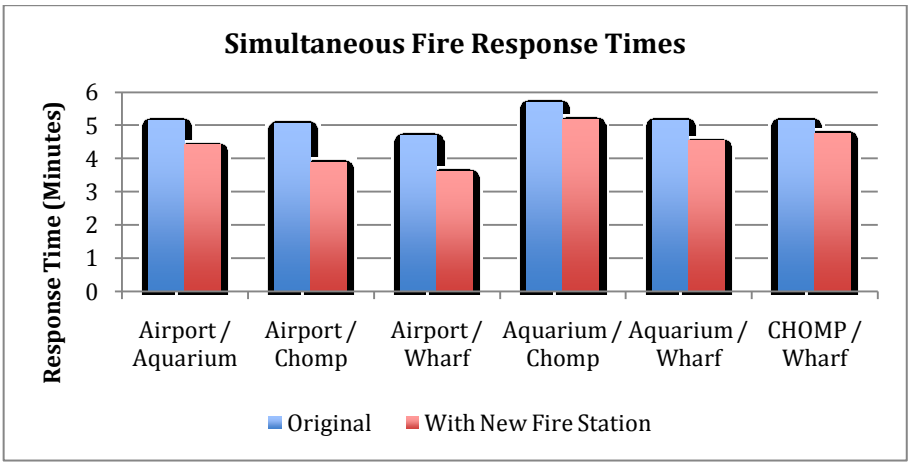
Next the fire stations are interdicted one at a time to simulate unavailable stations or degraded assets. The times to each fire site are recorded for one, two and three stations becoming unavailable. Graph 1.2 depicts the results of Phase III. The Aquarium location is the most resilient to attacks and CHOMP is the least resilient to attacks.

Graph 1.2



Finally, the model is used to measure the maximum response time at fire sites when two fires occur at each every possible pair of fire sites. Graph 1.3 depicts the results of Phase IV. Despite a requirement to respond to two fires, the force can still arrive to all fire sites in an average time of five minutes.

Graph 1.3



CONCLUSIONS AND FURTHER RESEARCH

The findings of this research suggest that the Monterey Fire Department has a near optimal "Battlefield Setup." The response times to four given fire sites is better than statutory target performance goals. The findings reinforce the strength, resilience, and optimality of the Monterey Fire Department system.

Further research and model improvements could focus on the effort to make the model more reflective of reality by adding more nodes and edges. Other model improvements could include multi-commodity parameters to account for different vehicle requirements, changing personnel, budget fluctuations, stochastic fire demands and the integration of adjacent and supporting forces from cities beyond the immediate Monterey peninsula area.