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Systems Engineering Procedia 5 (2012) 295 – 300

Procedia Systems Engineering

International Symposium on Engineering Emergency Management 2011

Research on Emergency Resource Dispatching Model Based on Cost-Benefit Analysis

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Abstract

Benefit is usually the exclusive target in emergency management. But sometimes the cost needs to be thought of because it may be unworthy if the response is excessive. In the engineering of emergency management resource dispatching is an important problem, the objective of which is not only to transport resource to meet the demand as soon as possible, but also to get the high benefit with low cost. At the same time the potential emergencies need to be considered when dispatching resource for the demand because the derivative emergencies may happen at once. In this paper the mathematical programming model is proposed about the demand that has happened and that of the potential emergencies. The benefit and the cost are considered related to the time and the amount of resource. At last the algorithm of the model is discussed and future research is given.

Key words: Emergency management; Resource dispatching; Cost-Benefit Analysis; System Engineering;

1. Introduction

It's clear that the process of emergency management has been seen as engineering because it's consisted by many activities such as the location of the saver, the store of resource, the dispatching of resource, and so on [1]. Also many branches of the government are involved and several kinds of instruments may be used. The branches need to collaborate to make the process of the emergency management well-off. Besides the object of emergency management is to get the whole success because the derivative emergency often occurs and many kings of danger are interweaved. In the system, resource dispatching is an important activity because no activity can go on without resource. The time that resource reaches the demand and the amount are the most important factors related to the efficiency of emergency management.

There is much research in emergency resource management about single stage [2, 3] and multi-stage [4], deterministic requirement[5] and uncertainty requirement[6], and so on. Resource allocation model with time factor was proposed on the base of queuing theory and location theory. Following the certain Location Set Covering

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2211-3819 © 2012 Published by Elsevier Ltd. Selection and peer-review under responsibility of Desheng Dash Wu.
doi:10.1016/j.sepro.2012.04.046

Problem, Vladimir Marianov and Charles Revelle [7] adopted the Queuing Probabilistic Location Set Covering Problem to calculate the probability that all servers in a given region were busy. Mamnoon Jamil et al [8] considered the Stochastic Queue Center Problem, which sought to locate a single facility in an M/G/1 queue operating environment. In brief, this service facility must return to the service center before it was going to serve again. Aiming at the actual course of fire extinguishing in a city, Chuanliang Jia et al[9] presented the resource allocation model based on multi-stage fire extinguishing progress. When large fire happened, resource must be dispatched from several firehouses. The model resolved the problem that the demand of resource changed in different phases. Sherali, H.D. and Subramanian, S [10] considered the case that two emergencies or more may happen in the same district. Then emergency facilities and resource cannot satisfy the demand. Aiming at such a problem, they presented the opportunity cost of service and proposed the dispatching model of service vehicles on the base of it in order to make opportunity cost minimum. The outcome showed that the scheme to dispatch the nearest available vehicle to the emergency may not be the optimal choice under the condition of this uncertain demand. It differed greatly from that of previous incident response models. Kaan Ozbay et al [11] also considered the simultaneous potential traffic incident during disposing of one traffic incident. So the probability of simultaneous emergencies must be considered. They proposed the probabilistic programming models for response vehicle dispatching and resource allocation in traffic incident management. In [12] the cost and benefit of emergency management are discussed and the definitions of them are proposed. The cost includes the damage cost and the response cost. The benefit includes the visible benefit and the invisible benefit. Then the way to quantify the cost and benefit is given with loss of life expectancy because some kinds of the cost and benefit can't be calculated directly. Then the degree of safety is studied. But in the paper the quantitative analysis is weak and the comparing of the cost and benefit is not thought of.

Because sometimes the cost needs to be thought of besides the benefit of the work in the practice of emergency management, they should be compared in order to make the decision of the degree of resource dispatching. At the same time the potential need should be considered. In this paper, the cost and the benefit of emergency management is studied in the mathematic model for resource dispatching in which the potential emergency is also discussed.

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2. Problem description

Usually the object of emergency management is to lessen the loss as far as possible, including the lives, the property and so on. So the government often does its best to deal with the emergency no matter how much the resource is put into the work. It helps the work smoother with the absolutely abundant resource and shows the responsibility of the government. But the shortcoming of the manner comes into being in recent years because much of the resource is wasted and the running of too many enterprises is influenced. Sometimes little loss is lessened in the price of much more resource, even the lives. For example, a special kind of medicine may be produced for some disease and after the emergency management too much is remained. Because the medicine can't be used for other diseases, it may only be wasted and even do harm to the environment. So the proper response is needed instead of excessive response. The cost and the benefit of emergency management should be discussed based on Cost-Benefit Analysis.

In Cost-Benefit Analysis, all kinds of the cost and the benefit are studied and the cost should be no more than the loss. It's to maximize the safety with the least cost. The cost includes the direct cost and the indirect cost. For example, the loss of the lives and property, the resource used for response and the impact on other enterprises are the direct cost while the effect on the mental of the people and the public opinion is the indirect cost. Similarly the benefit includes the direct benefit and the indirect benefit. Especially the indirect cost and benefit may work in quite a long time. All kinds of cost and benefit should be quantified and be compared. Usually the cost and the benefit are also related to the amount of the resource used and the time that resource reaches the demand. Sometimes the time is more important than the amount of the resource because the sensibility to the emergency means the responsibility of the government.

Also the potential demand should be studied when dispatching resource for the emergency that has happened because emergency may continue to happen after that one. So some resource should be reserved for the potential demand or much loss will occur because no resource reaches it in time. Then the cost will be much more than the benefit of doing with the emergency that has happened. So part resource in a saver may be dispatched to the