RESOURCE ALLOCATION PROBLEMS DURING DISASTERS: POINTS OF DISTRIBUTION PLANNING AND MATERIAL CONVERGENCE CONTROL

by

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An Abstract of a Thesis Submitted to the Graduate

Faculty of Rensselaer Polytechnic Institute

in Partial Fulfillment of the

Requirements for the degree of

DOCTOR OF PHILOSOPHY

Major Subject: Civil Engineering (Transportation)

The original of the complete thesis is on file
In the Rensselaer Polytechnic Institute Library

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December, 2011
(For Graduation December 2011)

ABSTRACT

As recent disaster experiences have shown, there is an urgent need for significant improvements in the efficiency of humanitarian logistics. These improvements are not only to avoid logistical failures ensuring an efficient and reliable flow of critical supplies to the disaster area, but to guarantee a delivery process that takes into account economic (i.e. transportation, inventory, location) and social considerations (i.e. human suffering). This dissertation contributes to the improvement efforts by developing analytical formulations to *analyze the resource allocation problem in the planning of distribution systems*, from two different perspectives.

The first perspective considers the *planning of points of distribution* (PODs) in terms of the locations and resources required to expedite the flow of supplies to the affected population. This part of the work proposes an approximate formulation—that requires a minimum number of inputs—as a planning tool to estimate the number of Points of Distribution (PODs), their number of servers and the frequency of distribution strategy required in the midst of a disaster. Specifically, the inputs required from the region affected are the area and an estimate of the population in need. The formulation is intended to minimize total social cost, which is defined as the summation of costs of *(i)* locating the PODs, *(ii)* manning the servers at the PODs, *(iii)* transporting supplies to the PODs, *(iv)* walking to the PODs, *(v)* waiting times at the POD, and *(vi)* risk costs associated with the distribution strategy. Walking, waiting and risk costs are introduced to account for the impacts on human suffering. The analyses performed show the importance of an appropriate POD network as a necessary condition for the success of PD-HL response operations, as they are the ultimate link to the beneficiaries after a disaster in the humanitarian supply chain.

The second area of work developed strategies *to optimally allocate resources to control material convergence*. Material convergence refers to the flow of supplies and equipment to the impacted area. The fundamental issue is that the sheer magnitude of it—particularly the component of low priority supplies (e.g., unsolicited donations)—distracts mission critical resources from other important tasks. This work develops a mathematical formulation that serves as a planning tool for the control of material convergence. The objective is to maximize the net benefits extracted from the different

flows reaching the impacted area by optimally allocating resources for the tasks of control, handling and processing of the flows. The control mechanism suggested is comprised of a multi-stage access control system that takes into consideration the dynamic effects of supply and demand to determine the priority of different items. Depending on their priority, goods may be granted or deny access to the system. Numerical experiment results show the importance of considering material convergence when planning humanitarian supply chains, the amount of resources required to handle these flows, and the benefits of implementing control strategies.