Chapter 16

Enhancing Humanitarian Logistics and the Transportation of Relief Supplies: Integrating System Dynamics and Vehicle Routing

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ABSTRACT

This chapter describes a system dynamics model developed for forecasting, prioritization, and distribution of critical supplies during relief operations in case of a hurricane event, while integrating GIS information. Development of alternates’ routes selection through vehicle routing procedures and the results incorporation into this system dynamics model allows decisions about the operation in case of a major catastrophe and any preparation for future events. The model developed is also able to (1) establish people’s decision and transportation characteristics that determine evacuation time; (2) simulate the behavior of key variables due to the relation between hazard level and people’s decision to evacuate; (3) estimate for each natural hazard level the time frequency to order and the order size of each relief supply to be needed in shelters and points of distribution; and (4) reveal which routes cause more delays during relief supplies distribution.

INTRODUCTION

Due to a wide variety of factors that influence emergency logistics, it becomes a challenge to optimize critical resource logistics and distribution during a hurricane event. Therefore, identifying, inventorying, dispatching, mobilizing, and transporting critical supplies throughout emergency relief operations are necessary to preserve life affected by these events.

System dynamics can account for the interrelations and dynamics of evacuated people, traffic flow, response time, inventory level, reorder points, transportation and supplies demand, among other elements. In addition, the creation of an information technology framework helping to collect data in real time about conditions of roads and supply levels in shelters and points of distribution during the event could effectively help improve the operations of the agencies in charge of emergency relief. This methodology allowed the integration of GIS information resulting from vehicle routing procedures run in TransCAD® that attempted to simulate the performance of relief supplies distribution.

The dynamic relief demands in affected areas and the immediate outcomes of humanitarian logistics aid intervention could in turn be used to decide how to adequately distribute necessary resources at their disposal. Which in turn will help to correct any mistakes in the dispatching to distribution centers and in turn to shelters and points of distribution. Development in hazardous areas and increase in a hurricane event are gradually more along with corresponding rises in traffic volumes. Therefore, traffic disruptions during critical commodities distribution in emergency relief, is an increasing problem, becoming costlier and more important to mitigate. The Dynamic Transportation and Humanitarian Logistics' Model (DTHL) considers the disaster implication in transportation for hurricanes (Cruz, 2013, 2014). In addition, sensitivity analyses are illustrated to show how this integration took place and what were immediate results that contribute to the assessment of emergency relief operation in real time.

BACKGROUND

System Dynamics

The basis of system dynamics is to consider all “things” as a whole and comprehend how all the objects in the system interact with one another. The interactions between objects and people occurs through feedback loops, therefore, a change in one variable, influences other variables over time, and in turn impacts the original variable and so on (Forrester, 1961). System dynamics is interdisciplinary, and it is discussed in the theory of nonlinear dynamics and feedback control systems built on mathematics, physics, and engineering (Sterman, 2001). The understanding of the basic structure of a system, and the understanding of this behavior that it can generate is what system dynamics attempts to do (Azar, 2012).

System dynamics has been also employed in modelling distribution complex systems. Such is the case of modelling a newer healthcare supply network causal loop diagram where authors analyzed and predicted the growth pattern of a healthcare logistic network (Battini et al., 2013). The use of system dynamics can also be extended to mobile broadband market where authors modeled the dynamic behavior of wireless ecosystem (Thakker et al., 2013). And the dynamics of social care workforce could be comprehended through system dynamics through the identification of the key feedback loops and
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