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A conceptual road network emergency model to aid emergency preparedness and response decision-making in the context of humanitarian logistics

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Abstract

This paper presents a discussion on the application of different techniques (e.g. network reliability and logistics concepts) for emergency management. Special attention is given to decision-making support in the context of roading networks before, during and after stress emergency situations. It is understood that the complexity of emergencies can quickly overwhelm organizations and personnel and ultimately lead to poor decision-making and loss of life and wealth. In this respect, a method is proposed to both support network analysis and resource allocation to fix road networks prone to disasters. A Road Network Emergency Management model has been designed to assist technically-sound preparations and decision-making during emergencies. Case study results indicate that the chosen techniques and the proposed model can help organizations to better manage emergencies; however, they do not satisfy all the resource, personnel and governmental managerial needs identified for dealing with real emergencies. In this context, a new field of study, namely Humanitarian Logistics, is proposed in an effort to fill the conceptual gaps observed in many previous studies of Emergency Management.

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Keywords: Emergency management; decision-making; roading organizations; resource deployment cost modeling; disaster response

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1. Introduction

Over the past decade, Emergency Management has rapidly grown to be a topic of great concern at both academic and practical arenas. The increasing number of disasters around the world as well as the existing complex interdependencies among systems (e.g. water, power, transportation, sewage) has driven researchers and practitioners towards the proposal and development of novel approaches to manage emergencies. Among numerous objectives, life saving and economic disruptions reduction can be pointed out as the two main objectives when dealing with stress laden situations such as natural and man made disasters. Overall, governments and private organizations are focused in developing and applying response and recovery methodologies to meet the abovementioned objectives.

The scientific and technical literature presents a series of approaches for emergency management. For instance, [1] and [2] have developed sophisticated representations of evacuation systems using mathematical and probabilistic modeling. Transportation researchers have endeavored in response planning to set the best possible resource allocation and identification of bottlenecks in the transportation systems. Also, studies from [3] [4] and [5] have contributed to identifying key changes to infrastructure systems, which are expected to improve the response to disasters by minimizing the need to repair damage and speeding response. Finally, research and practice have also been conducted towards setting emergency response procedures and protocols [6] [7] [8] and [9], emergency management training to deal with potential events through scenario simulation [10] and [11] and organizational resilience assessment [12] and [13].

Despite the great range of academic research mentioned in the last paragraph, it is debatable whether or not such approaches are effective and efficient in dealing with the complexities associated with most emergencies. Poor emergency responses observed in real disasters (e.g. the 2004 Sumatra Earthquake and Tsunami and 2005's Hurricane Katrina) can be attributed to limited application of available methods and/or a lack of suitable methodologies. In this paper, we focus on further developments of emergency management theories as recent researches have indicated that available tools and methodologies are individually efficient, but fail to holistically support decision-making in the broad context of disasters [14] and [11].

Against this backdrop, a conceptual Road Network Emergency Management method is proposed in this paper. On one side of the spectrum, the proposal takes advantage of the current state of the art from both practical and theoretical fields. So, academic theories and models are considered to address emergency management needs within practical approaches, such as the Reduction, Readiness, Response and Recovery approach adopted in New Zealand [15] or the National Incident Management Systems approach adopted in the United States of America [16]. On the other side of the spectrum, challenges in developing and applying the proposed model in practical situations are discussed using case study simulations.

The paper has been divided into four sections. The next section presents the theoretical basis for the proposed method. In the third section, the Road Network Emergency Management method is presented, along with a case study simulation to evaluate the method. In the fourth section, a new research field (namely, Humanitarian Logistics) is proposed and outlined, taking account of the studies and results achieved over the last decade in the field of Emergency Management.

2. Theoretical background

Key concepts from the scientific literature have been considered in order to support the proposal of the Road Network Emergency Management model. This theoretical background includes well established fields in the transportation environment such as network reliability, path selection and cost estimation.

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