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Calibration and validation of a dynamic assignment model in emergency conditions from real-world experimentation

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Abstract

Calibration and validation of dynamic assignment models to simulate urban road transport systems in ordinary conditions are still an open issue. This problem is further emphasized in the case of transport systems analysis in emergency conditions, as there are no standardised methods and there is a lack of experience of real-world applications.
The paper presents a DA model and a procedure able to simulate transport supply and transport supply – travel demand interaction of an urban road transport system in emergency conditions. The transport supply models are calibrated and validated through traffic data observed during a real-world evacuation experiment conducted in the town of Melito di Porto Salvo (Italy). The DA model has been applied in order to reproduce the observed real-world evacuation experiment and a set of indicators for testing the performance of a road network in emergency conditions is estimated.
We think that the findings reported in the paper represent a contribution in the field of transportation systems analysis in emergency conditions at urban scale. The specified and calibrated DA model and the applied set of indicators can be a useful tool to support the planning and management of road networks and mobility in emergency conditions.

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Keywords: dynamic assignment models; cost functions; path choice; calibration and validation; evacuation; urban area.

1. Introduction

The paper focuses on Dynamic Assignment (DA) models to support evacuation planning and it is motivated by the consideration that, although the market and research literature offer a large variety of DA models developed in recent years (some of them present very advanced specifications from a theoretical point of view), there is a

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lack of experience concerning calibration and validation in evacuation conditions. This is due to two reasons. The first is operational: collecting field data is both burdensome and costly, because it is not possible to monitor human behaviour in real evacuations and because it is expensive to set-up a real-world evacuation experiment. The second is conceptual: human behaviour in a evacuation experiment is not the same as that in a real evacuation, because, in the first case, people are aware that there is no real disaster approaching. There is a debate about the validity of field data collected in real-world evacuation experiments; however, our opinion is that DA models need to be calibrated and validated against field data, even if they come from a real-world evacuation experiment.

A comprehensive literature review leads us to the following consideration. Available DA models (see as example Papageorgiou, 1990; Akamatsu, 2001; Peeta and Ziliaskopoulos, 2001) present very advanced specifications containing a sizeable number of parameters. This makes calibration and validation possible only in some particular contexts in the sphere of ordinary conditions, but, extremely hard in emergency conditions such as those that may be forecasted in some disaster scenarios.

The paper presents a DA model able to simulate supply and supply-demand interaction of a road transport system in ordinary and emergency conditions. The model is specified in its components which are link and node models and path choice model. Models are calibrated and validated using field data observed during a real-world evacuation experiment performed in the town of Melito di Porto Salvo (Italy). The specification is valid for ordinary and emergency conditions, the calibration and validation is in emergency condition.

The work is part of a research project, titled SICURO, carried out by the Laboratory for Transport Systems Analysis (LAST) of Università Mediterranea di Reggio Calabria (Italy). The general objective of SICURO was risk reduction in urban areas in terms of exposure through the definition and implementation of evacuation procedures (Russo and Rindone, 2007). The results concern the development of models, procedures and guidelines for evacuation travel demand simulation (Russo and Chilà, 2007), for transport supply and demand-supply interaction simulation (Vitetta et al., 2009, Musolino and Vitetta, 2011), for path design of emergency vehicles (Vitetta and Quattrone, 2011).

The paper is structured into five sections. In section 2 the literature review concerning DA models for urban road transport systems analisys in emergency conditions is presented. Section 3 describes the DA models system. Section 4 describes field data acquisition and presents calibrated model parameters. Conclusions are reported in the last section.

2. State of the art

Several DA models for emergency conditions are available on the market or have been developed as research prototypes. Many of them were originally developed to simulate transportation systems in ordinary conditions and then adapted to the above purpose (Di Gangi et al., 2003; Vitetta et al., 2009).

DA models for emergency conditions started to be developed in USA after the partial meltdown of the reactor at the Three Mile Island nuclear power plant in 1979. In the 1980s a first generation of models for supporting evacuation planning was developed. There have been continuous advancements in the research on DA models during the last two decades, which has led to a large number of models being implemented to support operative transport planning in ordinary conditions. After 9/11, great efforts were made not only to adapt existing models but also to develop dedicated models to simulate transportation systems in emergency conditions in order to support evacuation planning.

The applications of DA models in emergency conditions may be classified according to three purposes which are demand management, network design and simulation of an evacuation plan.

Demand management applications concern departure time definition in order to reduce congestion phenomena and minimize evacuation time. Demand management for evacuation of nuclear plants and an arms depot in executed in (Goldblatt, 1996). Several demand time profiles are defined, simulated through DA models and compared with the simultaneous departures scenario in urban areas (Sbayti and Mahmassani, 2006; Liu Yue et al., 2008). Network design applications concern path optimization and management in emergency conditions