**Large-scale Evacuation Simulation with MATSim: Application to Hamburg**

**D. Durst[1], G. Lämmel[2], H. Klüpfel[3], G. Walenciak[4], A. Zipf [4], and K. Nagel[2]**

[1]Feuer- und Rettungswache der Stadt Kerpen, 50125Kerpen, Germany

[2]Technische Universität, ILS, 10623 Berlin, Germany

[3]TraffGo HT GmbH, Bismarckstraße 142a, 47057 Duisburg, Germany

[4]Rupprecht-Karls-Universität, Institut für Geoinformatik, Heidelberg, Germany

**Abstract** This paper presents results on the simulation of the evacuation of Hamburg Wilhelmsburg. In the simulation, 25,000 agents were distributed in the area of the Elbe island, where Wilhelmsburg is located. The model used is MATSim (www.matsim.org). The simulation was part of a comprehensive assessment taking into account public transport (by local trains and busses), foot traffic to shelters, and motorized individual traffic on the one hand. On the other hand, also capacities of shelters and infrastructure, first responders, and information dissemination was taken into account. The traffic simulation module was used to determine the overall evacuation time for motorized individual traffic. Since the movement to shelters and the transportation by public transport (local trains and busses) is independent thereof, the maximum of the times for the different evacuation modes can be considered the overall evacuation time.

This time can be compared to the time obtained by the simulation of the risk scenario and the available safe evacuation time. In our case, the assumed scenario was a dike failure and a subsequent flooding.

## Introduction: Safety, Risk, and the Need for Simulation

Safety is a basic need for individuals and societies. Safety can be roughly defined by: existing risk < acceptable risk. It can also be discriminated from security by dealing with non-intentional threats. In this paper, the potential threat is a natural hazard: a submarine earthquake in the Indian Ocean causing a Tsunami wave hitting the coast of Sumatra, Indonesia and the city of Padang. The risk, and consequently also the safety if the acceptable risk is specified, can be quantified based on the following formula:

(1)

The damage is denoted by *D*, the coping capability by *C*, and *P(t)* is the probability of the wave. In case of a tsunami, the physical safety or life of people are at risk. Evacuation is one means in ensuring the safety, especially to avoid the risk and threat to human life. Evacuation reduces the damage. Another strategy would be to build tsunami safe buildings which would increase *C.* This is beyond the scope of this paper. We focus on the evacuation.

The condition for a safe egress is RSET < ASET, where ASET is the available safe egress time and RSET is the required safe egress time. In this paper, we present the calculation of RSET (based on a microscopic multi-agent simulation). ASET is provided by inundation simulations that show the consequences of an earthquake off-shore the island of Sumatra (Indonesia) for the coastal city of Padang. The overall egress time is one major criterion for assessing an evacuation plan. Such a plan addresses – among many other issues – evacuation routes for the endangered population. There are many models that find optimal routing strategies (i.e. minimizing RSET) for a given road and walkway network. In the case of large-scale inundation, the network changes with time. Links or edges (i.e. roads or lanes) become impassable due to flooding. The evacuation simulation based on a dynamic network works only as long the advance warning time is known beforehand, though. When this is not the case, the optimal routing strategy might increase the risk for some persons on some stretch of way. This issue is addressed in the next section on utilities of evacuation strategies. Implementation details are given in section , experimental results discussed in section 4. The paper concludes with a discussion of the simulation results (section 5) and a conclusion and recommendations (section 6).