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Mass Evacuation Planning for the Halifax Peninsula

Why DalTRAC Did This Study

Extreme weather events are becoming more frequent, and flooding is the most common type of natural disaster in Canada. Halifax provides the ideal setting for an evacuation study: it is located on an active hurricane path which has caused devastation before; and the peninsula has few exit points which can generate unprecedented traffic and operational complexity in an evacuation scenario.

This study explores the workings of a mass evacuation. Our models detail the evacuation process, evaluate traffic evacuation scenarios and evacuation improvement strategies, and highlight countermeasures which can help inform efficient evacuation planning.

What DalTRAC Recommends

Carrying out mass evacuations from disaster-prone areas is a difficult task with many operational challenges in egress and corresponding traffic congestion. Evacuation planning is a critical part of emergency response for disaster-prone cities, particularly for historical, and coastal cities such as Halifax which have few exits and narrow roads. DalTRAC recommends that the municipality develop a comprehensive mass evacuation plan inclusive of all people and modes. Effectiveness of countermeasures depends on the structure of the transportation network and demographic characteristics of a region. Evacuation plans for Halifax should include both single and combined countermeasures for implementation if needed in an evacuation scenario.

What DalTRAC Did

DalTRAC developed a Mass Evacuation Decision Support (MEDS) tool to analyze and improve mass evacuation processes for the Halifax Peninsula. The study develops a large-scale traffic simulation model to test and evaluate contrasting evacuation scenarios and countermeasures, considering two shelters, namely Charles P. Allen High School and Nova Scotia Community College Akerley Campus. The figure on the following page provides a visualization of our traffic evacuation microsimulation model and evacuation traffic flows in Halifax.

What DalTRAC Found

One of the variables that our model predicts is evacuation time. This is the time required to evacuate the last person in the city due to hurricanes or floods. We found that it requires 22 hours to evacuate 65,000 passenger vehicles from the peninsula with an assumption of no disruptions to traffic on the road.

The model found that a flood of 3.9m water level relative to Canadian Geodetic Vertical Datum of 1928 (CGVD28) increases the evacuation time to 23 hours due to the flooding of several road links on the peninsula. We have also tested mass evacuations considering the possibility of collision occurrence. Depending on the locations and patterns of collisions occurrence, it may take 23 to 33 hours (50% increase compared to 22 hours) to evacuate the same amount of traffic from the peninsula. Results of the traffic evacuation simulation model indicate that auto-based evacuation requires a larger clearance time and creates heavily congested traffic conditions when everyone gets onto the road simultaneously during a mass evacuation. This highlights the importance of alternative evacuation planning, including transit and/or countermeasure enabled evacuations.

To improve the evacuation processes, we modelled two countermeasures: (i) bus-based evacuation; and (ii) staged-evacuation. We identified marshal point locations and optimum bus routes to use transit and school busses for evacuations efficiently. Results indicate that evacuation time can be reduced to 17 hours (22.7% less compared to

Figure: Visualization of the traffic evacuation microsimulation model, traffic evacuation and congestion in the Halifax transport network

22 hours) if a fleet of 322 transit and 88 school buses are used to carry people during an evacuation. This is because it enables a 7.7% reduction of passenger vehicles from the road, resulting in less congestion and delays reaching shelters. Our models also explored the evacuation time for a staged-evacuation scenario that phases the entire evacuation demand spatially and/or temporally. To facilitate phasing of evacuation demand, we have developed a vulnerability-based prioritization model which assesses the social, geophysical, and mobility vulnerability of populations across four planning districts of the Halifax Peninsula including Halifax Downtown (DT), North-End (NE), South-End (SE), and West-End (WE). Our model identified the vulnerability of four planning districts in descending order: DT > NE > WE > SE. These districts were evacuated accordingly within our evacuation simulation model. Results show that considering the vulnerability-based prioritization does not negatively impact the evacuation time. Rather, it reduces the evacuation times by 2.68% to 70.37% across the four planning districts when compared to an evacuation without the countermeasure applied.

The MEDS tool is the first of its kind that addresses uncertainties and risks associated with a mass evacuation. The tool is useful for emergency professionals to understand what types of strategies are effective, how to plan the countermeasure implementation process, and what potential consequences are associated with countermeasure implementation. This tool can also assess evacuation scenarios in other areas, as the information required by the modules are readily available in almost all other jurisdictions. The tool will be particularly effective in planning evacuations using all modes available in other areas as it offers the flexibility to include additional modes of transportation within the evacuation plans. The tool can also be used for smaller community evacuations which would require consideration of the household as the smallest spatial unit for trip production in the simulation. Even the evacuation of a concentrated demand zone (e.g., stadium evacuation) can be modelled using the MEDS tool.

Dr. Ahsan Habib is a transportation professor in the School of Planning and Department of Civil and Resource Engineering (cross) at Dalhousie University. He is the founder of the Dalhousie Transportation Collaboratory (DalTRAC), a CFI-sponsored multidisciplinary research unit. Currently, Dr. Habib is the Director of the School of Planning at Dalhousie. He received his PhD in Civil Engineering from the University of Toronto in 2009. His research interests include travel behavior analysis, travel demand forecasting, urban system microsimulation, and planning for the future of mobility. Dr. Habib and the DalTRAC team has recently been awarded a Climate Action and Awareness Fund (CAAF) grant in the amount of $3.62M for a 5-year project that aims to enhance the Canada scientific capacity to advance theoretical and empirical foundation of integrated transport, supply chain and emission modelling. He believes multi-modal options are the key to ensuring Canadian cities build sustainable transportation networks.

Dr. Jahedul Alam is a Postdoctoral Research Associate at Dalhousie Transportation Collaboratory (DalTRAC), Dalhousie University. He received his MASc. and PhD in Civil Engineering from Dalhousie University in 2016 and 2021. His research focuses on transportation systems simulation, emergency evacuation planning and modelling, transport network, and emission modeling. He is currently working in the CAAF project and conducting research on integrated, bottom-up transport, supply chain, and emission modelling systems.

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