PREDICTIVE MODELS FOR EVALUATING OPERATIONAL PERFORMANCE OF HURRICANE EVACUATION STRATEGIES

Praprut Songchitruksa, Ph.D., P.E.
Associate Research Engineer, Transportation Operations Group
Texas Transportation Institute, Texas A&M University System
Ph: (979) 862-3559 Email: praprut@tamu.edu

This presentation will begin with the discussions on key considerations for modeling transportation-related impacts from hurricane evacuation and why the mesoscopic dynamic traffic assignment (DTA) modeling approach is suitable for quantifying operational performance of transportation networks from different hurricane evacuation strategies. The DTA model was calibrated for a combination of traffic patterns and hurricane evacuation scenarios of the Houston-Galveston region. The outputs derived from the DTA simulation model were then used to calibrate a set of prototype models for predicting evacuation performance measures such as evacuation travel times and average travel speeds.

The following items were considered when choosing the appropriate model for modeling transportation-related impacts from hurricane evacuation:

- Scope and scale of the model;
- Changes in demand and supply conditions;
- Multimodal needs during evacuation;
- Evacuation route choice behavior;
- Traffic control strategies;
- Input and output requirements of the model;
- Ability to model intelligent transportation system (ITS) technology components and uncommon strategies;
- Off-line versus on-line evaluation needs; and
- Data availability and resources.

The DTA simulation results indicated that the average network-wide evacuation travel time using existing infrastructure (expanded I-10 and US 290) will be approximately 30% lower than those experienced during the Hurricane Rita's evacuation. The results also indicated that the evaculane strategy on I-10 and US-290 can save up to 2%-5% in the average evacuation travel time in the high and very high demand scenarios. In addition, when the evaculane strategy is deployed in conjunction with the partial contraflow on I-45, this combination can reduce the average network-wide evacuation travel time up to 5%-7% without the need to implement the full-scale contraflow operation.

The results from the simulation model were used to develop predictive models for providing quantitative assessment of Houston-Galveston traffic conditions as a result of evacuation. Regression models were calibrated for predicting travel time and speed during evacuation under different demand scenarios and evacuation strategies. These prototype models can provide the required predictions for both network-wide and facility-based levels. Interested readers can find more details about these models in a recent report by Texas Transportation Institute (1).

For instance, the analyst can use Equation (1) to predict hourly average speed on US 290, I-10, and I 45. The functional form of the Equation (1) is a modification of the widely-used Bureau of Public Roads (BPR) volume-delay function. DE/C ratio approximates the volume-to-capacity (v/c) ratio, which in this case corresponds to the ratio of evacuation demand to route capacity for a given evacuation strategy.

The equation for predicting average speed on route i at hour j is of the following form:

$$V_{ij} = \frac{V_f}{1 + \exp\left(\alpha_{ij} + \beta_{ij} \ln \frac{D_E}{C} \right)} \quad (1)$$

where

Vij= Average speed (mph) of all vehicles traveling on route i at hour j. Route i refers to one of the three major freeways evaluated in this study, i.e. US 290, I-10 and I-45. Hour j ranges from 1 to 24 (24-hour prediction period); Vf = Free-flow speed (mph). Vf used in the calibration is 72.6 mph, which is the maximum hourly average speed observed from the simulation study; DE = Expected evacuation demand over 24-hour period for the Houston-Galveston region (vehicles); C = Approximate ratio of the expected supply capacity to the base case capacity; and = Model coefficient estimates from the regression analysis of simulation results. The coefficients were calibrated separately for each route i and hour j.

To estimate the value of C, consider the capacity of the US 290 evacuation route as an example. Under the base case, the capacity is best approximated by the narrowest segment (a bottleneck that restricts traffic flow), which is a 2-lane-wide segment. Now, let us consider the evaculane (EL) as an alternative strategy. This strategy would add one de facto travel lane to this route. Therefore, the C ratio can be estimated as 3/2 = 1.5.

The prototype predictive model is currently implemented in a spreadsheet-based format using MS Excel. The prediction includes the evacuation travel time network-wide as well as the hourly average speed profiles on US-290, I-10 and I-45. These models are currently implemented in a spreadsheet-based format. Future potential improvement to the models will also be discussed.

REFERENCES

1. Henk, R. H., P. Songchitruksa, S. P. Venglar, S. Samant and G. Lim. Prototype Design for a Predictive Model to Improve Evacuation Operations. Technical Report 0-6121-1, Texas Transportation Institute, College Station, TX, 2011.