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Modeling Hurricane Evacuation Traffic—Evaluation of Freeway Contraflow Evacuation Initiation and Termination Point Configurations

INTRODUCTION

Over the last five years, the Departments of Transportation (DOTs) in 12 coastal states threatened by hurricanes have developed plans to implement contraflow traffic operations on freeways during evacuations. Although contraflow is widely viewed as a major advancement that allows highway agencies to increase evacuation effectiveness, it is not without its drawbacks. Among the recognized shortcomings of contraflow evacuations include:

- It eliminates inbound movement of traffic into the evacuation zone.
- It has the potential to be confusing to drivers and increases the likelihood of dangerous traffic conflicts.
- It often restricts the ability of evacuees to make routing choices to reach their destinations, including the closure of exit and entry points along the intermediate contraflow segment.
- It requires increased levels of manpower and material/equipment for both the implementation and operation of the evacuation as well as the need for longer lead times to configure roadways for its use.

Another limitation of contraflow is the lack of actual evacuation experience. This research was undertaken to help DOTs and emergency management agencies better prepare for the use of contraflow.

OBJECTIVE

Specific research objectives were developed to address important issues for emergency preparedness officials, including:

- the temporal and spatial patterns by which traffic congestion develops and abates along the segments, and
- the way in which varying levels of traffic demand impact operational characteristics of contraflow segments.

The research was divided into two separate but overlapping projects. The first focused on issues associated with the contraflow entry area; the second focused on the vicinity of the termination where vehicles exited the segment.

SCOPE

The scope of this study was restricted by the amount of information currently available. Few studies have collected traffic flow parameters in detail during an evacuation. Among these were efforts to evaluate the characteristics of traffic operation within and near contraflow evacuation segments. This report summarizes the results of two of these projects, focusing on the operational effects of the initiation point design of the New Orleans, Louisiana I-10 segment and the termination designs planned for several Atlantic and Gulf Coast states.

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METHODOLOGY

The basic methodology used in this research involved the development of contraflow evacuation simulation models to estimate traffic flow, average speed, density, delay time, and the amount of time required to discharge contraflow during an evacuation. Since the contraflow operation in Louisiana encompasses a relatively small area, the Corridor Simulation (CORSIM) 5.0 microscopic simulation model was used to achieve the research objectives. Although the results gained here are based on simulation testing that could not be quantitatively validated against field data, there is strong reason to believe that results are valid, particularly in light of the qualitative data that were collected during the evacuation for Hurricane Ivan in the fall of 2004.

The terminal design assessment that used models to evaluate termination points involved a multi-design study in which simulation models for six different types of design categories were developed. The six "families" were created to represent key characteristics of 13 terminations planned in seven hurricane-threatened states. The output data from all of these various models were used to quantify traffic conditions (i.e., queuing, delay, travel speed, travel time, and total number of vehicles exiting segments) in the vicinity of the termini and to compare the relative performance and benefits of various designs under different traffic demand scenarios.

CONCLUSIONS

The results of these studies revealed several interesting findings about the contraflow evacuation plans. Among the most significant conclusions was that many current plans for evacuation initiation and termination points may likely restrict the ability of these segments to be used to their maximum effectiveness.

The evaluation of the proposed termination configurations provides strong evidence for two concepts. First, in order to work effectively, contraflow termination designs should incorporate split rather than merge designs. The second was the advantage that can be gained by systematically decreasing volume on contraflow evacuation routes. Research showed that volume decreases of 25 percent prior to the termination reduced the delay associated with the merge lane-drop by between 20 to 60 percent depending on the configuration type (this remains, however, a four- to eight-fold increase over the split configuration delays). A 50 percent decrease in traffic volume reduced merge-associated delays by 80 percent (however, a two-fold increase over the delay versus the split design).

The evaluation of the New Orleans contraflow initiation point demonstrated several concepts relative to the loading on contraflow segments. The most important was the critical role played by the entry point in effectively utilizing the segment and reducing the duration of congestion prior to contraflow lanes. Since the inception of contraflow evacuation, emphasis has been placed on termination designs because it has been assumed they would dictate the effectiveness of the segment. However, research clearly demonstrates that the capacity of the segment can also be controlled to a great degree by the capacity of entry point. In fact, research suggests that the New Orleans design, which is similar to the designs of many other states, will actually create a bottleneck that should lead to congested traffic conditions upstream of the crossover.

RECOMMENDATIONS

Two main recommendations are made from this study. The first is to better load traffic into the contraflow lanes in New Orleans to maximize the utilization of the segment. It is suggested that traffic could be added at points after the crossover or, more desirably, loading schemes be reconfigured to spatially spread the loading of the segment over several ramps prior to a crossover. The second is that evacuation traffic on contraflow segments should be spread out as much as possible. This can be done by routing traffic into all available directions, rather than just onto a few primary routes. The third is that designs of contraflow terminations should split rather than merge traffic whenever possible. The research showed that congestion and delays are increased as much as ten-fold when four freeway lanes were merged into two. While merges are possible under lower volume conditions, plans that spread traffic volume spatially throughout the available road infrastructure will likely be more successful.