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Modeling, Simulations Can Help a City Offer More Efficient Exodus

By SHARON BEGLEY
Staff Reporter of THE WALL STREET JOURNAL
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The only time Mark Chussil sent innocent people to their deaths was last winter, when an apparent terrorist bombing of a major bridge in Portland, Ore., led him to order everyone to get the heck out of town in case more attacks were imminent. As evacuees sat in gridlock, a toxic cloud of chlorine gas -- released by accident or design, no one knew -- killed hundreds at their wheels.

Luckily, it was only a simulation. As I wrote after the London subway bombings, more city officials are practicing crisis response with computer-based exercises such as the one Mr. Chussil, a co-founder of Crisis Simulations International, ran with officials of Portland and nearby towns.

The 100-mile-long traffic jams in Texas during last week's real-life exodus ahead of Hurricane Rita produced nothing so horrific. (It still isn't certain that they caused the deaths of 23 elderly evacuees when their bus exploded.) But the chaos shows that officials have a lot to learn about optimal evacuation strategies and that few decision makers know the science of evacuation.

Under realistic conditions, a freeway carries about 2,000 vehicles per lane each hour past any given point. Doubling the number of lanes by making southbound ones northbound, as on I-45 from Galveston to Dallas, is therefore a crucial first step. Houston officials ordered the reversal only at midday Thursday, after vacillating for more than a day.

That "contra-flow" will increase a road's capacity 60% to 70%, calculates traffic engineer Avi Polus of Technion-Israel Institute of Technology, Haifa. It doesn't double capacity because left-hand exits, drivers' confusion over going the "wrong" way and signs turned backward gum up the works.

To increase outbound capacity further, says Prof. Polus, officials must also convert entrance ramps on the reversed lanes into exit ramps, so cars can "drain" off the freeway and keep traffic on it moving. They must post police or barriers to keep vehicles from entering contra-flow lanes in a way that will cause head-on collisions. And they have to change the flow on crossroads and feeder roads to carry traffic away from the freeway.

Using secondary roads as adjuncts to highways or to drain cars efficiently from the freeway requires changing traffic signals to give priority to evacuees. Fiddling with red lights one at a time might appeal to Nero, but to make an evacuation work it needs to be done from a central control station, which few cities have.

And it can't be done on the fly. For one thing, traffic signals at highway exits are typically controlled by the state, but those on arterial roads are under municipal control. Officials must

figure out how to coordinate the two systems and switch to emergency mode well in advance. Houston officials admit that contra-flow was not even part of their emergency planning. If it had been, says Prof. Polus, "it shouldn't take more than two or three hours to convert freeway lanes to a contra-flow" and change the traffic signals, exit ramps and feeder roads.

Even further in advance, build turnouts on highway medians so out-of-gas vehicles could pull over. Staggered every 10 miles or so, they would give people ample opportunity to get out of the way when their gas gauge flirts with "E."

Staging departures by Zip Code also reduces the chance that the traffic will tip from smooth flow into the dreaded "density wave" that produces stop-and-go traffic (or, on I-45 last week, just stop). "It may be faster to wait," says engineer Hani Mahmassani of the University of Maryland, College Park, who has developed algorithms for determining which roads to reverse and when.

Modeling the roads around Fort Worth, Texas, he finds that staggering departures cuts the "network clearance time" -- how long it takes to get everyone to his destination -- 47% to 57%. "Not only do you not have people waiting in hours-long queues at bridges and other bottlenecks, but you also avoid overloading the system in a way that cuts its capacity," he says. The only time staging offers no benefit is when traffic is in constant free flow (I leave it to you commuters to count how often that happens).

Whether people will wait their turn to flee is an open question. That's why computer simulations are crucial to emergency planning: They show the consequences of that and a myriad of other what ifs. They also let officials practice the mental nimbleness crucial to thinking under fire, and see when their natural reactions backfire.

Simulations also show what happens when assumptions implode. Many hospitals' emergency procedures for disasters "assume the presence of police to keep order," says CSI's Mr. Chussil. "What if hundreds of frightened people want to enter the hospital, and the police are handling traffic control and evacuation?"

Bottom line: If you have six lanes of freeway (of which three are contra-flow), then at 2,000 vehicles an hour per lane and 2.5 people per vehicle, you can get about 600,000 people out of a city every 24 hours. You can load more people into each car or use buses and trains, but evacuating 1.5 million souls will take two to three days. Getting people out of harm's way if there is no advance warning (after, say, a radiological bomb) is just not in the cards.

One final word of advice: motorcycle.

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