

## Lofty Lingo Boils Down To Dissection of Traffic

### Computer model may unravel mysteries of congestion

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Homing in on some of the deep mysteries of commuting life, science is edging ever closer to what some consider the Holy Grail of highway engineers: a "unified theory of traffic."

Experts at the Institute of Transportation Studies at the University of California at Davis are offering the latest advance today in the form of a new computer model of what specialists call "multiphase vehicular traffic flow."

You might call it by more colorful jargon if you happen to be among the daily hordes trying to cross the Bay Bridge and other regional choke points, where traffic moves, if at all, in herky-jerky starts and stops -- sometimes even when the road appears to have capacity to spare.

Trying to unravel the complex mathematics of real-world traffic jams is perhaps not quite as grand a challenge as finding the elusive unifying "theory of everything" sought by physicists. But it's still "a very difficult area of research," said veteran transportation engineer Adolf May, professor emeritus at UC Berkeley.

Ultimately, transportation scientists say, developing better computer models of traffic will aid commuters: Engineers use the models to design more efficient freeways, decide whether and where to add new lanes and find other ways to speed the flow.

While physicists must contend with the oddities of the quantum world, students of the highways have their own challenges, many of which involve working out the elusive psychological factors that influence traffic patterns.

Some classical "macro" views of traffic depict it as a kind of plumbing system, in which cars all meld into a more-or-less free-flowing liquid, and highways are likened to pipes, where the flow can be interrupted by accidents and other blockages much the same as the drain on a kitchen sink.

Others take a "micro" approach that emphasizes the individual behavior of "particles" -- drivers in their cars. In this way, issues of driver psychology come into play.

The new research, led by civil engineer H. Michael Zhang of the UC Davis Institute of Transportation Studies, represents an attempt to tie several elements together in a single computer model.

Details are being presented today in Washington, D.C., during the annual conference of the Transportation Research Board, a part of the National Academy of Sciences. About 1,800 presentations are scheduled during the five-day event.

Such studies tend to be tightly focused and highly technical. But while Zhang's work is couched in the rarefied language of traffic mathematics, he is considered to be one of the few scholars working to bring a broader picture

into focus.

"He's making some very nice contributions in trying to reconcile different strands of thinking and different theories," said Hani Mahmassani, a professor of transportation engineering at the University of Texas at Austin who helped organize this week's conference. "It's a very important role in developing a unified view."

People have been trying since the late '40s to model traffic mathematically,

producing several computer models widely used by highway planners and transportation agencies worldwide. And yet none of the models fully captures the daily chaos drivers encounter on the road.

"There are a lot of things going on that you have to try take into account," Zhang said. "People stop and go. People block lanes. There's congestion upstream, which moves backward through lines of traffic like water waves."

"I doubt any model could ever perfectly replicate what's happening out there," he said, "but I have tried to find a model that captures some of these aspects."

The new model is a refinement in what is known as "follow-the-leader theory." For Zhang, some of the key questions have to do with what occurs when one driver is following closely behind another, and something happens to cause the lead driver to slow down.

It doesn't take a Ph.D to predict that the follower will slow down, too, in order to avoid a crash. The hard part comes in predicting just how the slow-down will happen -- and then finding a way to incorporate that into a set of equations.

"People behave differently depending on whether they perceive traffic to be accelerating, decelerating or if they are just coasting along at a constant speed," Zhang said.

In free-flowing traffic, when vehicles are all traveling at roughly the same speed, traffic becomes extremely orderly: Distances between cars shrink to a comfortable, stable margin of safety, and drivers tend to discount minor changes in speed of the vehicle they are following.

But when traffic begins to clot for whatever reason, drivers tend to respond much more actively to changes in speed and vehicle spacing. These overreactions tend to worsen the blockage, which works its way backward until stop-and-go sets in.

Once that happens, it takes a considerable recovery phase while drivers try to make up for lost time, causing flurries of lane-changing and abrupt speedups that can lead to still more snarls.

But barring further disasters, sooner or later traffic sorts out again into fast and slow lanes -- inducing drivers to resume their calmer, free-flowing behavior that generates the most efficient traffic flow.

None of that may seem too surprising, but "it's very difficult to work it all into a model without making a lot of simplifications," Zhang said.

In his new model, Zhang introduces a variable for "driver response time," which fluctuates depending on vehicle

spacing and driver perceptions of whether traffic is speeding up or slowing down. The idea is to endow the mathematical model with the power to take into account changes in driver behavior during the so-called "phase shifts" on the highway.

Zhang's numerical simulations suggest he may be onto something, even though it will take a lot more study, and some time-consuming observations of real-world highways, before his theoretical musings and model-building will prove their worth.

"Psychology is important," Mahmassani said. "You do find sometimes a breakdown of traffic flow even when numerically you are below capacity."

Highway managers in Europe already are beginning to take such factors into account, using elaborate systems of traffic flow sensors and electronic roadside displays to try to minimize psychology-induced traffic jams. In one simple example, traffic tie-ups can be systematically minimized just by giving drivers advance warning of a minor problem ahead, which helps reduce the tendency to overreact at the first sign of trouble.

In Northern California, transportation planners are keeping close watch on such high-tech experiments as population and traffic woes continue to mount.

The problem is coming up with a computer model powerful enough to handle the sort of near-chaos that occurs virtually every weekday on urban highway systems as clogged as that of the Bay Area.

For now, said Jim McCrank, Caltrans district division chief for operations in Oakland, engineers have little choice but to rely on time-tested intuition.

"There just isn't a model that can handle the Bay Bridge," McCrank said. "But the engineering staff usually can figure out what's going on, based on a lot of experience."

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